PUBLIC REQUEST TO ADDRESS
THE BOARD OF SUPERVISORS
COUNTY OF LOS ANGELES, CALIFORNIA

Correspondence Received

			The following individuals submitted comments on agenda item:	
Agenda #	**Relate To**	**Position**	**Name**	**Comments**
59.		**Favor**	RANDAL HERNANDEZ	Letter of support includes petition signed by over 1,000 county residents who also support the updated wireless facilities ordinance
		Oppose	AJ Elterman	Ladies and Gentlemen, Due Process Rights in this urgent public interest issue are too vital to ignore for commercial interests. Please adopt the redline for Titles 16 and 22 the Fiber First L.A. has submitted, and do invest in resources and/and use federal funds to provide superior and safe fiber optic broadband connections rather than the slow, unreliable, expensive, unregulated, and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Your opposition is also needed to protect us from telecom wildfires such as the 4 major ones in Southern California in the past 15 years caused by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Clearly, cell towers must not be placed close to homes, schools and daycare centers. The claim that hundreds of new small cell antennas are required for 911 calls in case of an emergency if there is no electricity, is false and cannot be used as an argument for the subject amendments because 911 calls would depend solely on the macro towers that receive backup power per CPUC Order. The pdf attached above and linked below is excellent for more in-depth reasons to oppose the proposed Planning and Zoning Amendments. fiberfirstla.org/_files/ugd/2cea04_e8bbd0bb2b764b2dbdb3007e356d7471.pdf Thank you for acting in the best interest of the people of California. By doing so and opposing policies that endanger people, all living beings (as uncontrolled and rampant microwave radiation does) and the environment, you will have also done a great service and set an excellent precedent for the people of all the other states of our country that are apt to face such hazardous and unsustainable proposals sooner or later. Sincerely, AJ Elterman

As of: 1/11/2023 8:29:24 AM

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			The following individuals submitted comments on agenda item:	
Agenda #	**Relate To**	**Position**	**Name**	**Comments**
59.		**Oppose**	Alan Miller	The L.A. County Board of Supervisors (BOS) must apply and safeguard the due process rights of all by voting NO to the proposed changes to Titles 16 and 22 of the L.A. County Code. The BOS can't ignore due process while exposing the People to dangerous radiation emitted from cell towers. The BOS is mandated to comply with CEQA and consider public input as a matter of due process. I support adoption of the redline mark-up version for Titles 16 and 22 that Fiber First L.A. submitted. Implementing slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods is a foolish policy. Nothing is of greater immediate concern than the increasing threat of wildfire due to fires associated with telecom wireless facilities. Major wildfires in Southern California and other parts of the State have ignited, in whole or in part, by telecommunications equipment electrical failures, welding incidents, collapses and a variety of other causes. Cell tower fires are electrical fires that may be in remote places (i.e., ridgelines, peaks) that are difficult for firefighters to reach and fight. Grid power must be cut, which can take up to 60 minutes. The BOS should vote no or bear the responsibilities and liabilities for increasing electrical and wild fire risks. If you read the tower industry design codes and criterion for engineering you will know that emergency communications rely on designated macrotowers engineered for the purpose, with backup power per the California Public Utilities Commission Order. To claim otherwise is dangerously misleading to the public. Vote NO.
			Alejandro X Villalobos	
			Alexander Griffin	
			Alia Muadin	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Alison Denning	Dear Supervisors,

Please vote NO on item # 80 changes to titles 16 and 22.
My name is Alison Denning I write you today on behalf of myself and the many members of our community who are worried about a 5G transmitter showing up outside our homes without notification which gives us a chance to be heard on the matter.
I live in Mt Baldy, and part of the year in Pomona which is in LA County. I am hyper electromagnetically sensitive having been injured by radiation 12 years ago. With the exception of the brief travel between the two homes I am unable to participate in any public activity. The prospect of the proliferation of small cells will render it too unsafe for me to leave Mt Baldy at all.
Recently, the FCC lost a lawsuit on EMFs (electromagnetic fields as emitted from cell towers/small cells) and health effects, as they had ignored the science and took industry advice only on the safety standards or guidelines. The suit proved there is no safe level of wireless radiation exposure for children or the environment, including plants, animals, birds, tress and insects. Adults too, but plaintiffs were temporarily prohibited from including them in their win, but may be able to soon sue the FCC as the industry/government collusion and corruption in creating the standards unravels. However, lawsuits against carriers, installers, manufacturers and municipalities for health effects to our children from wireless radiation exposure are going to now be very easily won due to this recent win against the FCC/industry. But lawsuits are expensive, lengthy, and an undesirable way to shape or create legislation. and absolutely NO ONE wants their child to get cancer that could have been prevented with responsible legislating.
The proposed changes to Titles 16 and 22 of the Los Angeles County Code are inhumane, could be a death sentence to some of us currently living with illness and to our children and surely will make previously healthy people, electrosensitive, or worse and give people cancer. If any of you or a loved one currently suffers from loss of energy, headaches, kidney, liver, digestive, lymph gland, heart, blood problems, cancer or any other serious or not so serious health problem but are not sure why, you may have to look no further than to your friendly neighborhood cell tower, WIFI, smart meter, cordless phone or cell phone for your answers. 5G however, will exacerbate nearly all health problems we currently are experiencing and would be illegal were it not for the lies the wireless industry and FCC continue to fabricate on this issue. We should all be able to have a say in where a cell tower or "small cell" is placed. And BTW, small cell = big radiation, it is much higher in frequency, power density and could have very different pulse modulations than 4G which is bad enough. The changes to titles 16 and 22 would eliminate our right to be informed, let alone be able to block one of these deadly transmitters prior to installation, even if it was to go up right outside our children's bedroom windows.
I repeat, as the FCC lawsuit proved, there is NO SAFE LEVEL OF WIRELESS RADIATION FOR CHILDREN. This finding could in fact make the county liable when our children get sick from their up close and personal exposure to one of these uninvited transmitters to be placed outside of our homes without informed consent, should the suggested changes to rules 16 and 22 be implemented and lawsuits are brought. We must hold off on rolling out the red carpet for 5G transmitters appearing overnight right outside

				children's bedrooms until the FCC has stepped up to the plate, reviewed the current science on this issue and re- written the safety guidelines to incorporate it, as per court order. Here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence or adverse effects on health, 4 amicus briefs and the final ruling... thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/ Here is also a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed. cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/ Now that we have the 2021 ruling from the FCC lawsuit, it is entirely possible that LA County could be liable for millions, if not hundreds of millions of dollars in lawsuits should the proposed changes to titles 16 and 22 be enacted and our children become sick. It is in the best interest of the county and us citizens for you to vote NO on the proposed changes, at least until such time as the FCC has ruled on this matter. There are alternatives to 5G high speed internet, video calls, etc., that do not involve cancer and other serious illnesses and that is through hard wired, fiber optic communications. In fact there is also federal money available for this safe alternative. Fiber optics delivers fast, high quality, high speed internet and voice calls with no health problems. The federal funds available for fiber optics do not require the wireless industries requested changes to titles 16 and 22. Please vote for fast internet for all, fairness and equality, health and safety for our children and vote NO on the proposed changes to titles 16 and 22 but say YES to federal funding for fiber optics! Respectfully, Alison Denning
			Amy Huntington	I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.
			Amy Startz	I categorically oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Jan. 10 and safeguard our due process rights, maintain local control and adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. It is never okay to install cell towers or small cells outside residents' homes without prior notice, public hearing or opportunity to appeal, without fire or safety scrutiny and without regard to critical environmental protections that keep us all safe. I urge you to implement the following protections regarding the installation of wireless communications infrastructure:

				?? Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. ?? Adopt the Redline: I urge you to adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A. Rather, invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. ?? Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions would allow cell towers to be too close to homes, schools and daycare centers. ?? Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. You must prioritize the health and safety of residents and protection of the environment. Please vote no.
			amy wasserzieher	Vote No
			Andrea Mercier	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.The redline changes from Fiber First LA provide better protection for LA County. The LA County Planning Department must be required to prepare an Environmental Impact Report (“EIR”) to consider potential environmental

					impacts, including increased fire risk and impacts to historical resources on ALL telecom permit applications as they relate to Titles 16 and 22 of the County Code. These Amendments will increase Fire Risk. Four of the last major local fires have been initiated, in whole or in part, by telecommunications equipment. These proposed revisions/amendments by L.A. County contain nothing about fire safety. Do not remove our long standing protections of CEQA - California Environmental Quality Act, NEPA - National Environmental Policy Act, and NHPA - National Historic Preservation Act, that protect us and our neighborhoods. The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false. With loss of electricity, all 911 calls will depend solely upon the macro towers that have already been backed up per the California Public Utilities Commission (CPUC) order. Wireless broadband uses ten times as much energy as fiber optic broadband, therefore significantly increasing our carbon footprint. Wireless is slow, easily hacked, unreliable, expensive, unregulated and hazardous for our neighborhoods and open spaces. Fiber Optic broadband is fast, secure, safe, less expensive and uses significantly less energy than wireless. The Supervisors should be investing resources and taking advantage of federal dollars to provide superior future-proof fiber optic broadband to the premises (home, office) for everyone in Los Angeles County. The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; this misinformation is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these? These Amendments would give away the County’s ability to decide whether a proposed facility is necessary and in a proper location. The LA County Board of Supervisors are citizens' first and only line of defense against any irresponsible placement and construction of telecommunications equipment; it is not true that your hands are tied. This is supported by Congress, the FCC and the Courts.
				Ann Thanawalla	Dear County Board of Supervisors, Santa Monica recently tried to push

					through a Verizon MUP IN OUR PARK POOR CITY at Memorial Park. The MUP calls for REMOVING the shade trees and installing a 400sq foot structure on our already park squeezed citizens in addition to attaching utilities to the park lights. Were these shenanigans taking place in other LA cities or were we the testing ground for these new and terrible proposed County revisions to Title 16 and Title 22? The public pushed back and the topic isn't expected to return until summer. Please vote NO on the proposed amendments to Titles 16 and 22 of the LA County Code. Cell towers and small cell facilities do not belong outside our homes nor do they belong in our neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. Fires are regularly lit in alley ways across the county. Where is the safety plan? Reverse the Categorical Exemptions to CEQA in Titles 16 & 22 so County Code fully complies with CEQA and adopt the proposed redline changes to Titles 16 & 22 as submitted by Fiber First LA.
				Anne-Christine von Wetter	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. 3
				April Hurley MD	I ask that Supervisors realize, as elected leaders of Los Angeles County (and mothers), that most people are unaware of the lucrative ventures that seriously threaten the health of our children and grandchildren. Through expertly managed deception, powerful telecom, data, intelligence, technology, chemical, PhRMA, and finance interests (+/- military contracts) are controlling the media narrative, academia, regulatory agencies, and the attention of the population.

				We've lost our blue skies and clean air to abusive weather manipulation, the dispersal of electromagnetic nanotechnology and incendiary heavy metal particulates over our playgrounds, farms and forests. Geoengineering schemes have turned toxic waste into toxic profit and fire sales. We are unknowingly drowning in invisible but lethal EMF pollution. Electric vehicles, WiFi coverage, and Bluetooth technology are "cooking" us, damaging our cellular physiology with invisible but intense microwave exposure. Sufficient broadband delivery can be achieved through fiberoptic cables without the serious threats (to health, freedom, privacy) hidden for especially undesirable agendas: total surveillance, total control of every human, our bodies, our activities, our lives, and ultimately, our thoughts. Please always vote to protect the most vulnerable, the children, and reduce all levels of toxic exposures that impact human health. Please understand that you must defend your constituents and future generations. Help eliminate 5 and 6G small cells, "smart" devices/meters, and electric/autonomous vehicle deployments harming the residents within your district. Please oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Vote NO on Jan. 10 and safeguard due process rights, maintain local control and adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. April Hurley MD 40 yr experienced physician for parents and children 848-231-9819 CarefulMedicine.com
			Ashleigh Magee	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: I urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. We should invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time

					for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers.
				Avery Nelson	Please use fiber optic broadband rather than wireless radio frequency radiation. Smart phones and wireless routers cause life threatening tachycardia and heart failure for me as well as severe neurological effects. I connect my computer directly to Ethernet and use a land line phone plus a flip phone for emergencies only. The health of many humans will be destroyed by this amendment.
				Baldomero Capiz	
				Bart Winston	I strongly encourage the L.A. County Board of Supervisors to safeguard due process rights by voting NO to the proposed changes to Titles 16 and 22 of the L.A. County Code. It's important that the supervisors honor the following protections: • Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. • Adopt the Redline: please adopt the "redline" for Titles 16 and 22 that Fiber First L.A. submitted. I encourage you to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Thank you!
				Beate Nilsen	It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; this misinformation is being perpetrated by the telecoms and echoed by our own uninformed Planning Departments. These Amendments would give away the County’s ability to decide whether a proposed facility is necessary and in a proper location. We want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. Cutting off debate, eliminating public input and ignoring environmental laws is unjustified. Why are other cities and counties adopting much better and more protective codes than these? We want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I hope the Board of Supervisors has read, and will adopt, the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. Wireless broadband, shockingly, uses 10 X as much energy as fiber optic broadband, both significantly reducing energy resources & increasing our carbon footprint. Wireless is more expensive, while being slower than Fiberoptic, it's easily hacked, it's unregulated, and the huge layout of millimeter-wave devices in front of homes and businesses - plus abt 50,000

				satellites flying around cluttering outer space - is hazardous for our neighborhoods and public spaces (and for certain airplanes). The Supervisors should really think abt investing resources and taking advantage of federal dollars to provide superior future-proof fiber optic broadband to the premises (home, office) for everyone in Los Angeles County. It's much safer than the overarching "neediness" of thinking a film download speed of seconds will provide happiness to the masses. In fact, I've read abt 4 different "simple" phones in just the last week, for people who want to get back to Living in Reality, and not be enslaved by Apps. thelightphone.com/ mudita.com/products/phones/mudita-pure/ "Above Phone" and punkt.ch/en/products/mp01-mobile-phone/ Disturbingly, these proposed revisions/amendments by L.A. County contain nothing about Fire Risk or fire safety. Four of the last major local fires have been initiated, in whole or in part, by telecommunications equipment. The LA County Planning Department must be required to prepare an Environmental Impact Report ("EIR") to consider potential environmental impacts, including the increased fire risk and impacts to historical resources on ALL telecom permit applications as they relate to Titles 16 and 22 of the County Code. The LA County Board of Supervisors are Citizens first, and the only line of defense against irresponsible placement and construction of telecommunications equipment; it is not true that your hands are tied. Please vote NO.
			Benjamin Stevens	These are unsafe due to the radiation they emit.
			Bernard Chevalier	The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Please, Board of Supervisors, adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect us From telecom wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers.
			Beth Goode	I do not recall signing a petition in favor of this. I do not believe I would. I'd like to see my signature on any petition claiming I did. I do not support any rollout of a 5-G network.

				Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Betty Winholtz	All of CA is watching what LA is doing on this issue. Safeguard due process: do not give away our rights to know before a project is approved. Get federal dollars to invest in superior broadband. Adopt the redline of Titles 16 and 22 from Fiber First LA. Do I need to remind you about the fires started by telecommunications equipment? The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Bibi Caspari	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I have EHS, Electromagnetic Hypersensitivity which in the state of California is legally considered a disability. I don’t want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Bonnie Smith	
			Brenda Martinez	Boyle Heights Neighborhood Council 2130 E. First Street, Suite 110 Los Angeles, CA 90033 April 25, 2022 Attn: Board of Supervisors Hilda Solis, Holly J. Mitchell, Sheila Kuehl, Janice Hahn and Kathryn Bargeer RE: Wireless Facility Ordinance Tittle 16 &22 of the Los Angeles County Code (Motion-2004) Honorable Board of Supervisors, Thank you for your careful consideration of who is best to make decisions about the Wireless Facility Ordinance. We The Boyle Heights Neighborhood Council strongly oppose to Title 16 and Title 22 Ordinances. We urge you to

delay passing these ordinances and allow time to incorporate needed amendments.
This ordinance, as drafted, eliminates requirements regarding distance between cell towers; advance notice or provide to our residents the opportunity to appeal. There are no fire setbacks in front of homes, schools, daycare and hospitals allowing little to no time to escape in the event of fires and earthquakes. California is entering another drought year. According to the U.S. Drought Monitor, "Nearly all California and much of the U.S West is in severe to extreme drought." Not allowing for fire setbacks could potentially set us up for a severe or even deadly fire season.
California has suffered devastating fire losses due to telecom equipment, yet no wireless carrier or their agents carry liability insurance for claims of injury or death* In fact since 2007 four major Southern California fires were caused by telecommunication equipment failures including the Woosley fire, which caused $6 billion worth of damages and devastated Los Angeles County. The criminal insvestigation by Attorney General found that "Consistent with the scientific findings contained in the report issued by Cal Fire and the Ventura County Fire Department, investigators determined that electrical and communication equipment owned by Southern California Edison caused the Woolsey Fire"**. This fire claimed many lives, displaced approximately 295,000 people,(** oag.ca.gov)
Fires caused by electrical and communication equipment have cost California billions of dollars (not to mention displacement, suffering and death). However, wireless telecommunication facilities are uninsurable (*ehtrust.org/key-issues/reports-white-papers-insurance-industry/).
These ordinances will not close the "Digital Divide." We have an abundance of cell service in our neighborhood and yet many cannot afford safe, inexpensive and reliable internet access. A viable solution to closing the "digital divide" is fiber optics. This proposed wireless build-out is depriving low income and minority communities of an immediately viable, safe, fast, cyber-secure, energy efficient alternative According to a research from the USC study, "Who gets access to Fast Broadband? Evidence from Los Angeles County," by Dr. Hernan Galperin, "The findings indicate that competition and fiber-based services are less likely in low-income areas and communities of color, with the most severe deficits observed in census block groups that combine poverty and a large percentage of people of color."
Other Concerns:
The Board of Supervisors is overriding federal statutes/protections: Public entities such as counties must comply with the Historic Preservation Act, the Endangered Species Act, the Americans with Disabilities Act, and the Fair Housing Amendments Act. In its search for a balanced solution for cell towers, it will be beneficial for the Board of Supervisors to consider these federal statutes they preempted by the 1996 Telecommunications Act.
No environmental assessments: California Environmental Quality Act (CEQA) and federal National Environmental Policy Act (NEPA). No residential setbacks between homes/towers. Antennas and cell tower will be set in their front yard may also violate FCC guidelines and no Environmental Impact Report will be required.
California Consumer Privacy Act: These ordinances will deny millions of

				constituents and stakeholders in Los Angeles County their right to opt out from the most personal and private information being packaged, sold, and resold without their consent. The California Consumer Privacy Act established in 2018, new amended protections in 2020, in the areas of privacy, technology and consumer rights ensure that consumer's privacy and data rights are safeguarded. We look to your support to oppose these ordinances and encourage the option of municipal fiber-optic, wired broadband. Los Angeles County could follow the example of the city of Chattanoga,TN, their Community Fiber Optic network proved to be energy efficient, reduced power outages, bridged digital divide, decreased environmental damage, enable job creations and retentions. Oppose these ordinances; let's explore more safe, protective practices that reflect heightened vigilance, care, and precaution by our publicly elected Board of Supervisors. We urge the Board of Supervisors to heed the voices of your constituents. Thank you for taking the time to read this letter. Respectfully, Boyle Heights Neighborhood Council CC: Councilmember Kevin De Leon LA City Council President Nury Martinez LA City Councilmembers Assembly member Miguel Santiago Senator Maria E. Durazo Congressmember Jimmy Gomez
			Brenda Trujillo	if you pass these ordinances, you will be stripping constituents and our environment from VITAL rights. You will then be responsible and liable for not closing the digital divide, for consequences of electrical fires, polluting our environment, and bringing health harm, especially to our children. I ran a community garden, then when we opposed to building a cell tower and question the expired CU permits. VERIZON and East LA Community Corporation, they sent ARMED GUARDS, and SIX POLICE OFFICERS, TO REMOVED A GROUP OF CHILDREN,PARENTS AND GRANDPARENTS!!! just to build a cell tower,STAND WITH YOUR PEOPLE, VOTE NO ON ITEM 59!
			Callie Lucas	Hello. Cell towers continuously expose us, our children and the environment to toxic levels of RF radiation - where they are placed within communities should have much careful consideration and public input during the planning process.
			Carol Snyder	Hazardous to the health and safety of the community
			Carolyn Hutchins	I absolutely do not want telecom companies having free reign to place G5 towers and cell towers anywhere.
			Caryn Curran	Absolutely NO. This is an infringement on people's rights of privacy and protection. Enough!

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			Catherine Cooley	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			CATHERINE M MCCORMACK	
			Chandra I Robak	I oppose this item/amendment! Please Safeguard Due Process Rights of California citizens. The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Please adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Please invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in residential neighborhoods. Please protect us from Telecom Wildfires! In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Please help keep California safe!

PUBLIC REQUEST TO ADDRESS THE BOARD OF SUPERVISORS COUNTY OF LOS ANGELES, CALIFORNIA

Correspondence Received

			Charlene Hopey	Honorable Supervisors, Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. . The Staff's recent changes to the proposed Amendments to Titles 16 and 22 are deceptive. They do not meaningfully address the Board's concerns or questions with these Titles that were brought up at the December 6th meeting. If the Planning Department is telling you that these revisions are substantive, they are wrong or being misled. We are deeply concerned that you have not been able to study the long range effects of this very critical issue with regard to the permitting of wireless infrastructure in LA County or the problems and issues we have presented to you over the past many months. We understand the pressure you are under but the newest Amendments proposed do not add any teeth and will not take care of your constituents in LA County. It appears that nobody has taken the time to read the redline changes submitted by Fiber First LA and how they compare to the Planning Department's Amendments to Titles 16 and 22. The Staff's newest revisions do not provide more protections for LA County and its residents who depend on you, they are simply cosmetic. Please Vote no on these recent revisions and the current Amendments to Title 16 and 22 of the LA County Code. This is not a rubber stamp issue - this equates to massive infrastructure that will impact every resident and is considered to be essential infrastructure. The enormous task of approving wireless infrastructure should be futureproof. The revisions to the amendments of Title 16 & 22 are a weak attempt to pacify the BOS into believing that due diligence has been performed. It is apparent that it has not. I have to wonder why the staff is so reluctant to make any meaningful changes to the wireless ordinance.

				The ordinance as written lacks any fact-finding requirements or evidentiary guidance. The feigned attempt by staff to give the appearance of protective language reveals that they know that they can add genuine protective language. After months of staff telling the BOS that they HAVE to pass the code as written, essentially stating that their hands are tied, they are now conceding that the county's hands are not tied! I implore you (BOS's) to ask the staff to get this right! I'd like to say from my observations and comments from telecom, I wish you had welcomed input from your constituents over the past 3 years as much as you have welcomed the input and presence of the telecommunications industry. I have felt mainly ignored or appeased in some way. Your staff was always kind, but the input was never responded to from you. Please vote no - make this Ordinance, Amendments to 16 and 22 more protective for LA County and its'citizens. Charlene Hopey
			Christian Amatulli	I urge the board to vote no because this change would violate the privacy of my family if passed and approved on my property.
			Christina Rizzoni	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Christine Mallin	Safeguard due process rights by voting NO to the proposed changes to Titles 16 and 22 of the L.A. County Code. Private property should remain private not have public installations.
			Cindy Koch	5G is not safe! Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

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			Clara M Solis	Dear Supervisors, Hilda Solis, Janice, Hanh, Kathryn Barger, Holly J. Mitchel, Lindsey Horvath, I oppose the Amendments to Titles 16 & 22 of the LA County Code. Do not take away our rights and protections. Please vote no on agenda item # 56. The Trump administration promoted privatization and the satellite, cable, and telecommunications industry seized that opportunity to engage in a very well funded campaign to push through legislation that served their multinational corporate agendas at the expense of our constitutional rights, our health and well-being, the endangerment of our environment caused by radiation, and a massive waste of public funds. Please, we do not want a cell tower or small cell facility installed right outside our homes or in our neighborhoods without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I urge a reversal of the Categorical Exemptions to California Environmental Quality Act in Titles 16 & 22, so the County Code complies fully with the California Environmental Quality Act. I also encourage the the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. Respect the rights of the disenfranchised segregated unincorporated areas in Los Angeles and other areas of the county. That have yet to receive equal access and protection for build outs, maintenance, upgrades, or adequate remediation for past fires and the current fire risks that remain. In these environmental justice communities people have died and are dying, are facing chronical illnesses and future generations will forever be negatively impacted due to the environmental racism we continue suffering from. Those who are born with congenital issues or suffer from preexisting conditions will only suffer more from this radiation exposure. We worry that life spans will be shortened due to the radiation exposure and due to the current deplorable environmental racism that plagues segregated areas. In addition, we can't discuss the digital devide and attempt to address it without integrating the electrical grid into the equation in order to make informed decisions regarding these serious topics. Cell tower explosions have caused the loss of human lives, as well as other life forms. They have devastated entire communities and have caused unimaginable heart ache and financial hardships to families and our economy. These fire risks will be exasperated by the complications resulting from the reckless changes to Titles 16 & 22. I support fiber first, for it is less harmful to our health and our environment. It is more secure and sustainable which will lessen our carbon footprint. Fiber

				First is essential for businesses and academic institutions and to our government and our republic as a whole. Fiber First will not leave future generations left behind as it's life span goes far beyond 5G. 5G towers are an eye sore and are designed differently with no community input in minority communities or within areas that have a lower S.E.S. Social Economic Status. Fiber First will provide many much needed jobs all across the county. Furthermore, 5G wireless communication poses national security risks. It is easier to hack which is a threat to our privacy. It allows private corporations to mind all our data. We request that you vote no on agenda item # 59. For your review please access the following link that provides the scientific data that documents the rational for biological based exposure standards for harmful low-intensity Electromagnetic Radiation and Radio Frequencies Radiation. The BioInitiative 2012 Report has been prepared by 29 authors from ten countries, ten holding medical degrees (MDs), 21 PhDs, and three MsC, MA or MPHs. Among the authors are three former presidents of the Bioelectromagnetics Society, and five full members of BEMS. bioinitiative.org/ Thank you, Clara Solis claramsolis@earthlink.net
			Courtney Hill	Installing the towers anywhere near people especially children is harmful and a threat to their health. This should not be allowed and more scrutiny to the impact should be considered instead of the big $ being thrown around.
			CW Moss	Stop the continuous killings and injuries to the people of this country with something that is totally unnecessary.
			Dale Conklin	Placement of antennas is a matter of public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is in appropriate. New small cell antennas will not help 911 calls when power is out since they will not be on emergency backup power.
			Dariel E Blackburn	I am very concerned about the proliferation of wireless--especially 5G--technology that is being forced as the only option in cities across our country. Instead, I encourage you to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband

				that requires hundreds of new antennas in our residential neighborhoods. Not only is radiation emitted from cell towers not safe for humans or the environment but the placement of these cell towers close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. In short, the fiber optic option is a far more economic and safe option for L.A. and for all other cities across our country. Please vote NO to the proposed changes to Titles 16 and 22 of the L.A. County Code and YES to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Thank you for considering good reasons to oppose pushing the cellular option.
			David T Harsh	The proposed changes to Titles 16 and 22 of the L.A. County Code are unconstitutional. Potentially dangerous and toxic levels of radiation placed near civilian activity can cause long-term effects. Without due process, civilians' rights are not being honored. Notice must be given, and an appeal must be permitted. Thank you.
			Dawn Campo	We know these cell phone towers are harming people's health. That reason ALONE is enough to prevent them from being installed. They are also an eyesore and should never be installed for that reason without homeowners consenting to them. Thirdly, they will reduce property values. People have the God-given right to be healthy and free from others harming them and their property. There are karmic consequences for those who transgress those rights.
			Deborah Dinsmore	Vote against this and for safety. Cell tower radiation is unsafe. That makes placement of each tower a matter of public concern. No one should lose their voice in standing up for their right to health and safety and to have the protection of CEQA processes and other environmental laws. The county should invest their resources in fiber instead.
			Deborah Rhodes	These cell towers pose serious health and safety risks: e.g., radiation, fire and other environmental concerns. They should not be installed without basic due process, such as notice and opportunity to be heard and the right to appeal an adverse decision. California should be leading the way in health and environmental issues, not the other way around. What happens in LA will affect other parts of the state. Please vote to oppose this amendment. Thank you.
			Debra M Burke	There are too many environmental and health hazards associated with wireless technology (much safer upwards safety limits have been established in other countries. The honey bee hives on our land had to be protected from wireless radiation. I have worse Restless Leg Syndrome and headaches from the technology. For fast, safe, communication, use fiber optic cables.
			Dee Tvedt	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input

				and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Diana Giaccardo	Each of us is put here in this time and place to personally decide the future of humankind. Did you think the Creator would create unnecessary people in a time of such terrible danger? Know that you yourself are essential to this world. Understand both the blessing and the burden of that. You yourself are desperately needed to save the soul of this world. Did you think you were put here for something less? Be courageous. Courage is the ability to go beyond the familiar. Realize the greatness you have within yourself and go ahead. ADOPT THE RED LINE for Title 16 & 22. Take advantage of federal dollars to provide superior fiber optic broadband connections. Wireless is Not the norm. You have all been programmed to accept that 'fast' is better when in fact there is no faster just dangerous electromagnetic rays that are harming the health of the children mostly as well as yourselves. Rise above the bribes from the telecommunication companies and think about the next SEVEN generations to come that are YOUR RELATIONS! Be the Board that defeats the greed and manipulation of evil enterprise. STAND UP FOR THE POWER OF THE PEOPLE not the few diabolic maniacal industrialists. Show the rest of the United States the Warriors of the West who confront the evil that most refuse to acknowledge. I believe you all CAN DO IT!!!
			Diana Jorgensen	It is the sovereign right of every individual to be informed about what will affect their bodies and their homes - and wireless facilities are a major concern for millions and millions of people with excellent evidence backing up their concerns that EMF and RF are a danger to public health. Please safeguard due process rights by voting NO to Title 16 and Title 22 Safeguard Due Process Rights Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted Protect Us From Telecom Wildfires

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				Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Diana Parmeter	The installation of these cell towers pose a significant fire risk and continuously expose us, our children and the environment to toxic levels of RF radiation. If the proposed changes pass, wireless facilities will be installed without any prior notice, public hearing or opportunity to appeal — without fire or safety scrutiny and without regard to critical environmental protections.
			diane olive	The radiation emitted from cell towers is not safe for humans or the environment
			Donna Barry	
			Doug Wood	The recent changes that have been made to the proposed ordinances do not address the fundamental shortcomings and errors which we have brought to your attention. Other municipalities are adopting much better, stronger and more protective codes than this. It appears that the Planning Department and their legal advisors have caved to the demands of the wireless industry. The Planning department complains that they do not have the resources to handle the expected workload of antenna applications. Other municipalities have solved this problem. Why is Los Angeles taking the drastic, unnecessary and politically dangerous step of cutting off public input?? We urge you to use your authority on behalf of the people of Los Angeles County to demand a better code which does not violate the basic rights of your constituents and allows the county to exert the control which Congress intended you to have over the deployment of wireless technology in the County.
			Earis Corman	If you want to see the BAD environmental IMPACT of approving MORE ANTENNAS of all sorts, JUST WAIT UNTIL ONE of them CAUSES ANOTHER BIG FIRE. We ALL NEED a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. Fiber First LA has done so much work to help you MAKE the RIGHT DECISION and adopt the proposed redline changes to Titles 16 & 22. NO on the proposed amendments to Titles 16 and 22 of the LA County Code.
			Elizabeth H Peterson	The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.
			Ellen Manko	Please, safeguard our due process rights. The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is

				unjustified. Board of Supervisors: Please adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Please vote "no" on the proposed amendments and safeguard the health and well being of all those potentially affected by cell towers Ellen Manko, RN
			Ellen Marks	The California Brain Tumor Association implores upon you to vote no to changes on Title 16 and Title 22. Local authority and citizen participation is critical to public health and safety- and are the backbones of democracy.
			Emily Van Horn	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Eva Bortnick	You may not violate disability rights.
			Eva Bortnick	Supervisors, you may not violate these laws: The Fair Housing Act and Fair Housing Amendments Act Title VI of the Civil Rights Act of 1964 Section 109 of the Housing and Community Development Act of 1974 Section 504 of the Rehabilitation Act of 1973 Titles II and III of the Americans with Disabilities Act of 1990

				The Architectural Barriers Act of 1968 The Age Discrimination Act of 1975 Title IX of the Education Amendments Act of 1972 Vote NO on the proposed title 16 and 22 amendments, and reverse the categorical CEQA exemption that relates to them.
			Everett and Barbara Knudson	The health and safety of residents is truly in peril. Illness, environmental changes are not being considered because of 26 year old law that was meant to protect small business but is now used against us the people. I hope you will vote this down. Charging our airways like this is irresponsible. We can choose to have a device away from us, but with this installation our rights to a calmer environment are taken from us. The air will be charged with electrical current that has true health consequences.
			Franchesca Unida	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Frank Garcia	
			Gianna Paletti	You have no authority to take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. You need to vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. Fiber Optic broadband is fast, secure, safe, less expensive and uses significantly less energy than wireless. The Supervisors should be investing resources and taking advantage of federal dollars to provide superior future-proof fiber optic broadband to the premises (home, office) for everyone in Los Angeles County.
			Gracie E Diaz	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity

				to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Gregory S Pajer	I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code and urge you to please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Heather Jenks	Please vote NO to the proposed changes to Titles 16 and 22 of the L.A. County Code. It is important to safeguard Due Process Rights. The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers.
			Heather Jimenez	Please do not allow cell towers, antennas, etc to be placed on residential property without owners consent.
			Heidi King	Public needs to be able to comment to issues that involve safety. Please adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in residential neighborhoods.
			hillary davis	please do NOT let this be put into law. it takes away ALL of our freedoms to

				protect our health
			ILARIA VARRIALE	The placement of antennas is a matter of urgent public interest, because the radiation emitted from cell towers is not safe for humans or the environment, since they impact the human biology and they're also cause of hazard fires. Please adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. This way, you can invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. The claim that hundreds of new small cell antennas are required for 911 calls is false (because such calls rely solely on the macro towers) and should not be used as an argument for the amendments.
			Ina N Allen	I worry about the health problems imposed by cell towers. I have seen time and time again that policies adopted in California quickly spread to other states. Therefore, I oppose this policy change. Thank you.
			Isabel Duran	Please vote NO to the proposed changes to Titles 16 and 22 of the L.A. County Code. 5G towers are dangerous to your health and should NOT be put in residential areas with proper voting.
			J Johnson	Please consider the following: Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Cell towers in close proximity to homes will devalue the homes and make them harder or impossible to sell.

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			J Weil	1. Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. 2. Invest in fiber optic broadband: Fiber optic connections are superior to slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in residential neighborhoods. 3. Protect Against Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. 4. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. And, yes, the issue before you does concern me as a Coloradan as California laws are frequently adopted elsewhere across the country! Please put the rights and welfare of your constituents--and all Americans--front and center in your vote.
			Jack Neff	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Jaivir Baweja	Dear Members of the Board, I request my written comments be part of the public record for Agenda Item #59, County Code, Title 16 – Highways and Title 22 – Planning and Zoning Amendments for the January 10th LA County Board of Supervisors Meeting. Don't take away our rights and protections.

				I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing, or opportunity to appeal, and without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 and 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 and 22 that were submitted by Fiber First LA. The proposed amendments will increase Fire Risk. Four of the last major local fires have been caused by telecommunications equipment. The claim that hundreds of new small cells are required for 911 calls is false. With loss of electricity, all 911 calls will depend solely upon the macro towers that have already been backed up per the California Public Utilities Commission (CPUC) Order. Do not remove our long-standing protections of CEQA – California Environmental Quality Act, NEPA – National Environmental Policy Act, and NHPA – National Historic Preservation Act, that protect us and our neighborhoods. The LA County Planning Department must be required to prepare an Environmental Impact Report (EIR) to consider potential environmental impacts, including increased fire risk and impacts to historical resources, on ALL telecom permit applications as they relate to Titles 16 and 22 of the County Code. It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; that lie is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these? Sincerely, Jaivir Baweja
			James M Smith	I very much oppose passage of proposed changes to Titles 16 & 22 of the L.A. County Code as this would recklessly eliminate the imperative safeguards now in place that allow for debate, public comment input & would ignore existing environmental laws such as CEQA which are in place for good & important reasons! Radiation emitted from cell towers is dangerous for humans & the environment, and pose a known, serious risk of fire hazards critically multiplied by every one of the many, many more cell towers & installations that 5G would require!! Proposed revisions will allow cell towers to be placed too close to schools, homes & daycare centers to be safe! Instead, I urge the Board of Supervisors to adopt the redline for titles 16 & 22

				that Fiber First L.A. has submitted, invest in resources, and take advantage of federal dollars to provide superior, safer fiber optic broadband connections instead of slow, expensive, unreliable, unregulated & hazardous wireless broadband requiring the imposition of hundreds of dangerous new antennas within our residential neighborhoods. Claims that hundreds of new small cell antennas are required for 911 calls are false as macro towers are already designated to receive backup power to handle such needs in case of a loss of electricity per the California Public Utilities Commission Order, so this is NOT a valid argument for these amendments! Voting 'NO" on these proposed amendments is really a "no brainer" from any common sense, public safety, reliability, performance or economic efficiency standpoint. If these proposed amendments were to pass despite these facts, it would signal a very high likelihood of compromised ethics, conflicts of interest, and corruption which would be more than grounds enough for launching an investigation into any such potential violations & prosecution of any found to be involved. I therefore urge that the Los Angeles County Board of Supervisors do the right thing and vote "NO" on these proposed changes to Titles 16 and 22 of the L.A. County Code!!!
			James X Ellingson	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please VOTE NO! I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA IN Titles 16 and 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposal redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			James-Michael Blaga	The people of LA county deserve better! Cell towers and small cells are known to emit Radio Frequency (RF) energy waves. These waves have been documented to cause harm to living creatures including humans, disrupting cellular metabolic pathways/processes. Why do the people of LA and other areas of America have to endure the designs of big business and it's supporters whose motivations are based on the flow of revenue. Alternatively, we need to think carefully about advances in technology. Do they really make the quality of live better? What are the adverse effects? Lifeforms including humans are organic, biologic creatures. They are not robotic. Why not consider this in your decision? RF are indeed already a part of our environment and are a kind of pollution. Let's not degrade the environment without considering the consequences.
			Jamie Lehman	vote NO on amendments to Titles 16 & 22 of the LA County Code that

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				remove basic rights (prior notice, opportunity to be heard, and right to appeal). Reverse the Categorical Exemptions to CEQA in Titles 16 & 22. We want Supervisors to require the LAC Planning Dept. to prepare a comprehensive Environmental Impact Report (EIR) on all proposed telecommunication projects, including historic impacts. We want FiberFirstLA submitted “redline” changes to Titles 16 & 22 of the County Code to be adopted in order to provide critical safety protections.
			JAMIE TRUEBLOOD	Item #59 & public comment. These Wireless Facilities Ordinances are not ready for final approval because they do not comply specifically with requirements of the FCC consent decree issued Dec 19, 2022 in which Verizon was fined $950,000 for noncompliance - see decree EB-SED-22-00033134. On December 19th, the FCC sanctioned Verizon for failing to conduct NEPA review of small cells that could have impacts on historic streetscapes, tribal resources or otherwise affect the environment through significant changes to surface features. The NEPA checklist includes items such as environmental impact on endangered species and wetlands which is significant to LA county. As part of the settlement with the FCC, Verizon committed to designate an environmental compliance officer; formulate a compliance plan; establish written operating procedures for environmental review that will include, among other steps, pre-construction assessments and completion of the NEPA checklist; draft a compliance manual; implement a compliance training program; and report any instances of noncompliance. Based on the FCC order, all applicants, and particularly Verizon, should be required to submit proof of compliance with the FCC environmental review regulations and policies implemented by a qualified personnel. A copy of the consent decree order has been emailed to the Board of Supervisors offices and submitted as a comment to the record. The County should include the specific requirements of the decree that apply to other carriers as well in their ordinances. Please review the requirements of the recent FCC decree. I think you will agree that the current versions of the LA County Wireless Facilities Ordinances do not specifically comply with the requirements of this recent FCC consent decree.
			Janet M Robinson	choose safety of people overagencies
			Jared Startz	I categorically oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Jan. 10 and safeguard our due process rights, maintain local control and adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. It is never okay to install cell towers or small cells outside residents’ homes

				without prior notice, public hearing or opportunity to appeal, without fire or safety scrutiny and without regard to critical environmental protections that keep us all safe. I urge you to implement the following protections regarding the installation of wireless communications infrastructure: ?? Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. ?? Adopt the Redline: I urge you to adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A. Rather, invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. ?? Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions would allow cell towers to be too close to homes, schools and daycare centers. ?? Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. You must prioritize the health and safety of residents and protection of the environment. Please vote no.
			Jean a Coffey	Strongly object to this plan for cell towers installations. Please vote NO on these proposed changes. Keep us SAFE!
			Jeanette M Hammer	Safeguard due process rights by voting NO to the proposed changes to Titles 16 and 22 of the L.A. County Code.
			Jill McManus	I oppose having telecom industry simply put towers wherever they want them without consent or warning. The towers emit electromagnetic fields that put residents' health and safety at risk if they are not already disabled by exposure to the unmeasured aggregated amounts that are already higher than life has evolved to withstand. Wireless will not work in an emergency or disaster. There will be liabilities as insurance does not cover microwave harms. Instead install fiber to the premises, more reliable, more secure, and no huge amounts of radiation. And future-proof for all parts of the population.
			Joanne Munro J Munro	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input

				and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Jodi Nelson	Dear Board of Supervisors: I have just read the anemic changes made by staff for Title 16 & 22. I'm very disappointed. LA County is on the cusp of approving a wireless ordinance for infrastructure that will impact every individual and business in the County. Instead of giving it the analysis it deserves, it's being given less weight than a permit for a shed! It appears that staff want to rubber stamp the permitting process for this infrastructure, that they do not want to take on the challenge of writing a meaningful ordinance, and that they consider the responsibility a burden. It also seems to me that even the weak, anemic additions added to Title 16 & 22 is an admission that your hands are not tied, so why does staff continue to push back? The misinformation that their "hands are tied" seems to be a welcome conclusion for them. I implore the Board to take action and direct staff to do their job! The ordinance as written lacks any fact-finding requirements or evidentiary guidance. Without this, the ordinance is just words on paper and in my opinion a ploy to pacify the Board. I feel we are all being played. You have had the opportunity to work with the Fiber First LA experts and we have even gone so far as to take the time to draft a redline copy of Title 16 & 22 with meaningful language that would be a win-win for the County. Isn't it time to roll up our sleeves and create an ordinance that will give the Board, staff and County residents something substantial, meaningful and something to be proud of? Doing the right thing might be hard, but in the long run, it serves those you purport to want to serve and protect. The unserved and underserved of L.A. County.
			John Cope	On Jan. 10, you're voting on A HORRIBLE agenda item; one that is both

UNSAFE AND UHEALTHY! I urge you to respect L.A. residents RIGHT to DUE PROCESS on such usafe proposals as Titles 16 and 22.

In adopting these changes, you ARE NOT ONLY GIVING A FREE PASS to the telecom corporations, to fast-track their cell tower installations (& small cells) without due consideration to Las Angeles residents (back yards, children's schools, etc), you are 'Breaking Ground' for these telecom giants to do so anywhere in the state! ALL CALIFORNIANS will be more likely to have their Process Rights stripped as well!
Do not surrender local control over this issue!

These installations pose a major fire risk and expose our children and the environment to toxic levels of RF radiation. Approving these two agenda items will allow these wireless facilities to be installed without 'Prior Notice', 'Public Hearings' or any opportunity to appeal (without fire/safety scrutiny & without regard to our environment.

Here's why I strongly urgy you to VOTE NO ont titles 16 & 22!...

1st... These coporate giants are trying to avoid proper portocal and safety/environmental guidelines! The placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws IS NOT JUSTIFIED...

2nd... The option (submitted by "Fiber First") will encourage telecomunications to invest better materials, use resources (& in-source federal dollars) that provide far better fiber optic broadband connections (rather than the slow, unreliable, expensive, unregulated and hazardous wireless broadband they proposing to use), needing far fewer new antennas installations...

3rd... Wildfire Protection: In the last 15 years, four (4) major Southern California wildfires were initiated (wholy or partly) by telecommunications equipment. Fire fighters cannot fight these Cell tower fires until the grid is cut (which may take 60 minutes). Cell tower installations near homes & schools could be disasterous if said Cell tower catches fire! The PROPOSED REVISIONS ALLOW CELL TOWERS TO BE TOO CLOSE TO HOMES, SCHOOLS & DYCARE CENTERS...

4th... The information you were given about emergency 911 calls is FALSE! Should thier be an emergency, 911 calls will depend solely upon the macro towers, receiving backup power as per California's Public Utilities Commission (CPUC). The New antennas ARE NOT REQUIRED FOR 911 CALLS!
I'm both aware and grateful for all the work you and your piers do for the LA residents. Please continue to serve them by voting "NO" ON TITLES 16 & 22!

John Cope, Semi-retired Piano tech.

			John Hodgson	

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	In support of other like-minded citizens of LA County: Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
John Chetcuti Chetcuti	Strongly oppose proposed changes that would take away personal and property due process rights.
Jonathan Nielsen	Imagine waking up one morning to a cell tower being installed in your front yard. You were not notified and are not allowed to appeal the decision. There is nothing you can do. This is EVIL and should NEVER be allowed!
Jonathon E Cadena	I am commenting for the safety of my grandchildren. Vote NO to the proposed changes to Titles 16 and 22 of the L.A. County Code. The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Citizens are pleading you hold their interest in safety first, adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Safety for humans should be priority, cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers.
Judith Gurian	
Julie Levine	January 8, 2023 Los Angeles Board of Supervisors Honorable Janice Hahn, Chair Honorable Board Members: Hilda Solis, Holly J. Mitchell, Lindsey Horvath & Kathryn Barger

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Re: Agenda Item 59- County Code, Title 16 - Highways and Title 22 - Planning and Zoning Amendments

Dear Members of the LA Board of Supervisors:

We appreciate your delaying your vote on Titles 16 and 22 of the LA County Code on December 6th. We urge you not to approve the recently “revised” language of Titles 16. because protective language that the people of LA County need to keep them safe from the explosive expansion of wireless infrastructure has not been incorporated into these revised Titles.

We know that Verizon “has been working proactively with cities across the county to update ordinances and design standards to better align with Federal Communication Commission (FCC) regulations.”

Although the FCC does mandate certain requirements for local governments regarding telecom permit applications, such as shot clocks (where local planning and zoning departments must act within a prescribed time period), and radio frequency (RF) emissions guidelines (assuming that the provider is in compliance with the Commission’s RF rules), there are still a number of actions that local governments can take to ensure maximum safety for their populous.

Fiber First LA has prepared comprehensive “redline” drafts of Titles 16 and 22 to give LA County the maximum amount of control over the siting of telecommunication infrastructure. It appears that the revised versions of 16 and 22 did not take these suggested control measures into consideration. Why is that? It appears Verizon certainly had their say with County staff.

Verizon’s public comment letter specifically states, “By separate letter, Verizon has previously provided technical comments to the proposed ordinance. The Verizon legal team greatly appreciates the ongoing engagement with County staff to develop strategies to accelerate the deployment of broadband infrastructure and delete the digital divide."

Of course, companies such as Verizon would want to accelerate the deployment of their infrastructure because that is their business model and they have stockholders to satisfy. Verizon, AT&T, T-Mobile and others are all competing for market share. Can’t blame them for trying to make a buck, or a few billion bucks. They want you to think that their product is the only way to eliminate the digital divide.

What does this mean? Who has actually written these amendments to the County code titles? Is it Verizon? Why hasn’t Fiber First LA been consulted? Their redline drafts of Titles 16 and 22 have been prepared by a top notch legal team NOT connected to Telecom, so there is no conflict of interest. Their only motivation is to give the County maximum control and the people maximum protection of rights. Can’t argue with that!

There is something very wrong with this picture.

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				No one is saying that the County must prohibit wireless service or not take important steps to "bridge the digital divide." We are simply advocating for the County to employ a balanced approach. (1) Maximize protective measures in the permitting of wireless infrastructure, (2) Take proactive steps to develop comprehensive fiber networks to give people more choice in connectivity (taking advantage of billions of federal dollars for developing low cost wired networks) and (3) Work with local city governments and county residents to ensure that ALL have the right to fair hearings in the placement of telecom infrastructure with maximum protection so they can be safe in their communities. Please don't allow Verizon, or any other wireless company to cloud your judgment. The future of LA County is at stake here. This is not an exaggeration. The decision you make on Tuesday could be the biggest one that you will ever make as Supervisor. Thank you for your consideration. Sincerely,Julie Levine, Executive Director5G Free California
			Julie Levine	We urge you to safeguard due process rights by voting NO to the proposed changes to Titles 16 and 22 of the L.A. County Code. We demand the following protections: Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Please vote no!

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			Julie Votaw	The Cell phone towers are dangerous and more research needs to be done. People can be hurt by the Electro- magnetic waves and they have a right to protest the construction of towers near their dwelling and communities. Please vote NO!
			Karen Fentress	The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Also - please adopt the redline that Fiber First L.A. submitted.
			Karoline Muniz	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home without any fire or safety provisions and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input, and ignoring environmental laws (including CEQA) is unjustified. The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.
			kate mcmahon	We trust you to safeguard our community, families, children & wellbeing of all citizens. I urge you to adopt the redline on title 16 & 22 submitted by Fiber

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	First LA. Please do the right thing and protect our lives and environment.
Kathleen Egbert	After listening to your meeting last month, I got the impression you want to do the right thing and vote NO on Categorical Exemptions to CEQA in Titles 16 & 22. But it seems some are trying to convince you this is not an option. The County Code MUST COMPLY fully with CEQA, so instead adopt the redline changes to Titles 16 & 22 provided by Fiber First LA. FIBER OPTIC is SAFER, FASTER, and MORE RELIABLE than MORE WIRELESS ANTENNAS. Consumer fees have already paid for fiber, but Big Telecom wants to cheat us and force us into more second rate wireless. Say NO to the Categorical Exemptions to CEQA in Titles 16 & 22.
Kathleen Gildred	I urge you to vote NO on Titles 16 and 22. In the posted revisions, it appears you are attempting to address the problems that I and many of your other constituents have pointed out to you over the past several months. But the changes you've made do not have any enforcement mechanism or specifications. So the issues we’ve raised are still valid.
Kathleen M Sundmark	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
Katia Kraus	
Katie Smith	I want a reversal of the Categorical Exemptions to CEQA (California Environmental Quality Act) in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. LA County plans to wipe out decades of CEQA protections! Do not remove our long standing protections of CEQA - California Environmental Quality Act, NEPA - National Environmental Policy Act, and NHPA - National Historic Preservation Act, that protect us and our neighborhoods.
Kelly Brinn	Don’t take away our rights and protections. I oppose LA County’s proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing, or opportunity to appeal, and without any fire or safety provisions, and without regard to critical environmental protections.

				I want a reversal of the Categorical Exemptions to CEQA in Titles 16 and 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 and 22 that were submitted by Fiber First LA.
			Kelly McKinney	NO… bad government.
			Kim D Hahn	Microwave radiation is a known carcinogen. Every person, especially those of us who live in a democratic society where we are entitled to life, liberty, and the pursuit of happiness, should have the right to ensure that his or her living environment is safe. Microwave antennas near homes generate unhealthy living conditions. Their location, strength, type, means of transport of the signal (i.e. via fiber optic cable or via antennae) should be determined not just by the companies installing them or the governmental body responsible for approving the installation, but by the residents who shall be directly affected by the radiation. Already far too many people have been injured and/or killed by the antennae installations near their homes, in their workplaces, or in their classrooms. This issue MUST be addressed before more are harmed.
			Kristina Stone	Please Vote no on these recent revisions and the current Amendments to Title 16 and 22 of the LA County Code. This is not a rubber stamp issue - this is going to affect La County forever. These revisions to the amendments of Title 16 & 22 are a weak attempt to pacify the BOS into believing that due diligence has been performed. It has not. I have to wonder why the staff is so reluctant to make meaningful changes.
			Kymberly Ponegalek	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Larry Brownstein	I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

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				I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Larry Nelson	Don't take away our rights and protections. The current changes in Title 16 & 22 do not provide real assurances that all residents will be given public notification. I want to know in advance if a wireless antenna is going to be installed in front of my home or apartment, and I deserve the opportunity to have my voice heard. Don't take this right away from me! I believe everyone in Los Angeles County is entitled to reliable, affordable, safe, future-proof high-speed fiber optic internet access. People in underserved communities deserve the same quality internet as people in the rest of the developed world. Giving Big Telecom carte blanche to place wireless infrastructure in our communities isn't the answer. Wireless is a temporary solution and a broadband band-aid to triage the digital divide and will only saddle underserved communities with inferior service and extend the digital divide into the next decade.
			Laura Love	The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input, and ignoring environmental laws (including CEQA) is unjustified. I urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted, to invest in resources, and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated, and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.

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Laura M Dini	
Laura Slaven	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
Laura Sturino	Please prioritize the health and safety of residents and the environment and to vote NO on Jan. 10.
Leslie Diller Zollo	
Leta Bell	Please safeguard due process rights by voting NO to the proposed changes to Titles 16 and 22 of the L.A. County Code.
Leyla K Schimmel	Fire hazard. Radiation will hurt children and should not be allowed near schools and parks.
Linda Neault	
Lonnie Gordon	
Lonnie Gordon	The vote on Titles 16 and 22 will be coming up next week and there is information you really need to consider. We have gone through the amendments, both the previous and this current one. Our attorney's and group members have vast experience with codes, zoning, and ordinances. My concerns are: It appears that nobody has taken the time to read the redline changes submitted by Fiber First LA and how they compare to the Planning Department's Amendments to Titles 16 and 22. The Staff's newest revisions do not provide more protections for LA County and its residents who depend on you, they are simply cosmetic. These revisions to the amendments are a weak attempt to pacify the BOS into believing that due diligence has been performed. It has not. I have to wonder why the staff is so reluctant to make meaningful changes. The staff is using subterfuge, as no substantive changes have been made. This is one of the most important decisions the BOS will be making, that will be in place for decades. It is unconscionable to vote for this unless it it changed to actually protect the rights of the citizens of LA CO. As it is currently presented by Planning, it is not adoptable.

				Sincerely, Ms. Lonnie Gordon Exec.Director MalibuForSafeTech.org malibuforsafetech.org
			Lonnie Gordon	
			Lori Tooker	NO to the proposed changes to Titles 16 and 22 of the L.A. County Code.
			Louise Lintz	Stop trying to make us sick with all these towers. Medical expenses are through the rood as it is. Stop spreading more poison in our air. You already are putting plenty there now. GET IT? NO on these 2-codes.
			Marcus Nousala	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. he redline changes from Fiber First LA provide better protection for LA County. The LA County Planning Department must be required to prepare an Environmental Impact Report (“EIR”) to consider potential environmental impacts, including increased fire risk and impacts to historical resources on ALL telecom permit applications as they relate to Titles 16 and 22 of the County Code. These Amendments will increase Fire Risk. Four of the last major local fires have been initiated, in whole or in part, by telecommunications equipment. These proposed revisions/amendments by L.A. County contain nothing about fire safety. Do not remove our long standing protections of CEQA - California Environmental Quality Act, NEPA - National Environmental Policy Act, and NHPA - National Historic Preservation Act, that protect us and our neighborhoods.

				The claim that hundreds of new (un-backed-up) small cell antennas are required for 911 calls is false. With loss of electricity, all 911 calls will depend solely upon the macro towers that have already been backed up per the California Public Utilities Commission (CPUC) order. Wireless broadband uses ten times as much energy as fiber optic broadband, therefore significantly increasing our carbon footprint. Wireless is slow, easily hacked, unreliable, expensive, unregulated and hazardous for our neighborhoods and open spaces. Fiber Optic broadband is fast, secure, safe, less expensive and uses significantly less energy than wireless. The Supervisors should be investing resources and taking advantage of federal dollars to provide superior future-proof fiber optic broadband to the premises (home, office) for everyone in Los Angeles County. The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; this misinformation is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these? These Amendments would give away the County’s ability to decide whether a proposed facility is necessary and in a proper location. The LA County Board of Supervisors are citizens' first and only line of defense against any irresponsible placement and construction of telecommunications equipment; it is not true that your hands are tied. This is supported by Congress, the FCC and the Courts.
			Margaret Murphy	PLEASE Safeguard Due Process Rights-cutting off public input isn't good for citizens of LA County PLEASE Adopt the Redline submitted by Fiber First L.A. PLEASE Protect Us from Telecom Wildfires PLEASE Stick to Facts and do not claim the false notion that hundreds of new small cell antennas are required for 911 calls THANK YOU!
			Maria Howard	Agenda #59 on the Jan 10th LA BOS agenda. - 1- Please vote NO on their amendments to Titles 16 & 22 of the LA County Code that remove basic rights (prior notice, opportunity to be heard, and right to appeal).2- We ask for a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22. We want the Supervisors to require the LAC Planning Dept. to prepare a comprehensive Environmental Impact Report (EIR) on all proposed telecommunication projects, including historic impacts. 3- We ask that the

				FiberFirstLA submitted “redline” changes to Titles 16 & 22 of the County Code be adopted that will provide critical safety protections.
			Mark Edwards	Please oppose this change. Instead, please act upon the following: Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Thank you for your consideration and time.
			Mary Boyle	I'm asking you to vote NO to the proposed changes to Titles 16 and 22 of the L.A. County Code which would allow 5G Towers to be built without public approval. There is plenty of evidence that these towers are dangerous to human health; it doesn't make sense to invest in this risky technology when fiber optic is safe, faster, and less expensive. Your actions here will very well affect the rest of the country. Now is the time to make a stand and do your job to protect the people of your community and your budget. You can achieve both by voting NO.
			Mary Rudie	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Adopt the Redline: for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that

				hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Melanie Lanham	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. VOTE NO
			Melinda DeGier	Please oppose changes to Title 16 and 22. For the health and safety of all.
			Melinda Hewitt	Dear L.A. County Board of Supervisors, Please safeguard due process of rights and vote no to the proposed changes. Please do not eliminate public input and ignore environmental laws (CEQA). Instead adopt redline for Titles 16 and 22 like Fiber First L.A. submitted. Optic broadband connections can use federal dollars for citizens needs rather than slow, unreliable, expensive, unregulated, and hazardous wireless broadband. By opposing the changes board members are protecting citizens from telecommunications equipment that may cause fires, which firefighters cannot fight until the grid is cut causing the fire to spread for up to 60 minutes without respite. Cell power placement close to homes and schools poses a fire threat people may not have enough time to escape. Finally, the claim new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission Order. Please prioritize the health and safety of residents and the environment and vote NO on Jan. 10th. Thank you for your time. Sincerely, Melinda Hewitt
			Melissa Cooper	The radiation emitted from cell towers is not safe for humans or the

				environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.
			Michael Shepherd	Not right. What would you do if a tower was installed outside your bedroom window?
			Michelle Mohawk	I’m a homeowner in Sherman Oaks as well as a physician. I ask that you please do NOT take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Mirwais Zafari	I don’t want small cell antennas/ towers in our neighborhood for they catch fire and so far we had this happen 4 times. Wired fiberoptic is much better fit it is much safer and uses much lesser energy, thus, leaving much less carbon footprint.
			Molly Stanton	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.
			Neil Nesti	Message: I categorically oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Jan. 10 and safeguard our due process rights, maintain local control and adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. It is never okay to install cell towers or small cells outside residents’ homes without prior notice, public hearing or opportunity to appeal, without fire or safety scrutiny and without regard to critical environmental protections that keep us all safe. I urge you to implement the following protections regarding the installation of wireless communications infrastructure: ?? Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. ?? Adopt the Redline: I urge you to adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A. Rather, invest in resources and take advantage of federal dollars to provide superior fiber optic broadband

				connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. ?? Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions would allow cell towers to be too close to homes, schools and daycare centers. ?? Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. You must prioritize the health and safety of residents and the protection of the environment. Please vote NO.
			NICOLE PAJER	The World Health Organization has FINALLY agreed to study the health effects of 5G radiation — but not until 2025. You don't study something if you don't think there is a reason to— i.e. a health risk. Why would we fast track 5G towers outside of people's homes and children's bedrooms windows just to have it found to be unsafe years later when irreversible damage has been done? I pay a lot to live in LA County and don't want my property value devalued or the health of myself and my family threatened. I trust the supervisors to vote with the public's best interest, health, and safety in mind. Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code and urge you to please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. Thank you for listening to the concerns of your constituents and please make the right decision here!

PUBLIC REQUEST TO ADDRESS
THE BOARD OF SUPERVISORS
COUNTY OF LOS ANGELES, CALIFORNIA

Correspondence Received

			Nicole Smith	Vote NO on the proposed changes to Titles 16 and 22 of the L.A. County Code. Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. Thank you.
			Nicole Zwiren	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Nora Wohlfeld	Vote NO to proposed changes to Titles 16 and 22 of LA County Code, for the following reasons Our due process right are violated by these proposed changes. The adoption of optic broadband connections is a far superior solution.

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					We need to be protected from telecom wildfires, which pose a serious threat from cell tower installations. Do not believe the false assertion that 911 calls require new small cell antennas. 911 calls will not be compromised by opposing the installation of small cell antennas.
				Odette J Wilkens	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside the home or in the neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
				olga B gonzalez	cell antennas are not safe, they are hazardous to children and adults. there should be the due process of law. not allowing the citizens to have a say in such an important matter affecting their health is WRONG! Do not allow this amendment to be passed that could have nefarious effects for the citizens of LA and repercusions to all americans.
				Olga M Hernandez	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. Thank you, Olga Hernandez
				Paige Weber	The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Please adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. The most forward thinking choice is to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods.

				Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. In case of emergency or should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Paula Van Blarcom	I am demanding these protections: • Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. • Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. • Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. • Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Penelope Ward	I was informed my name was on a Verizon petition. I did not sign a Verizon petition.
			Pilar Reynaldo	
			Prof Dr Tony Pereira PhD Fulbright Scholar	We oppose LA County's amendments to Titles 16 and 22 of the LA County Code. Please vote NO! We do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or

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					opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. We want fiber instead of G5 or wifi. Fiber is safer, lasts longer, it is more economical in the long run, can use existing infrastructure by just updating it, and it is much faster. Soft tissue development in humans, ie brains, nervous system, reproductive organs, starts with birth until the age of 22 yrs of age. Children up to that age are most vulnerable to ionizing radiation damage to the soft tissues in their bodies during that period. We oppose the increase of ionizing radiation in our neighborhoods due to the widespread use of G2-G5 cellphones, wifi and communication towers. Los Angeles should follow the example of several European Countries that have already started limiting/banning the use of wifi in schools, in favor of fiber. We want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. We also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. We are requesting you respect the rights of the disenfranchised segregated unincorporated areas in Los Angeles. They have yet to receive equal access and protection for build outs, maintenance, upgrades, or adequate remediation for past fires and the current fire risks that remain. These fire risks will be exacerbated by the complications resulting from the reckless changes to Titles 16 & 22. We support fiber first, for it is less harmful to our health and environment. It is more secure and sustainable which will lessen our carbon foot print. Fiber First will not leave future generations left behind as it's life span goes far beyond 5G. Fiber First will provide many jobs. 5G wireless communication poses national security risks. It is easier to hack which is a threat to our privacy. It allows private corporations to mind all our data. Prof. Dr. Tony Pereira, UCLA PhD, Fulbright Scholar 1501 E Carsons St 15 Carson, CA 90745 (310) 549-3077 apereira@ucla.edu
				Raymond Pierini	I categorically oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Jan. 10 and safeguard our due process rights, maintain local control and adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. It is never okay to install cell towers or small cells outside residents' homes without prior notice, public hearing or opportunity to appeal, without fire or safety scrutiny and without regard to critical environmental protections that keep us all safe. I urge you to implement the following protections regarding the installation of wireless communications infrastructure:

				?? Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. ?? Adopt the Redline: I urge you to adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A. Rather, invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. ?? Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions would allow cell towers to be too close to homes, schools and daycare centers. ?? Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. You must prioritize the health and safety of residents and the protection of the environment. Please vote NO.
			Raymond E Korns	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Rob Duvall	Please keep due process rights in place by voting NO to the proposed changes to these two titles. The radiation emitted from cell towers poses safety concerns for humans and the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Please also adopt the redline for these two titles that Fiber First L.A. submitted and take advantage of federal dollars to provide superior

					fiberoptic broadband connections rather than slower, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in residential neighborhoods. Thank you :)
				Robert Gaylord	(See attached PDF)
				Robert Robinson	In re: “Health effects” Mid band: 1 to 6 GHz. And High band: 24 to 95 GHz. I categorically oppose the proposed changes and urging the Board to vote NO on the proposed changes to Titles 16 and 22 of the L.A. County Code to safeguard public health and due process and local control rights. The analysis presented to the board by acting county counsel grossly miss understands and understates the public health risks triggered by the proposed changes in standards, while failing to protect the public health, safety, and welfare of County residents, requiring conditional use permits A petition with a thousand signatures is not scientific proof of safety. What is needed is an independent review of a committee: healthcare and public health professionals, a grand jury investigation and perhaps, a courtroom trial to parse, weigh, and balance the evidence. Rashly moving forward today would be bad government and a massive step backward. Telecom giants want to get a free pass for installing cell towers and small cells, wherein fiber cable is the proven safer technical path (provides superior fiber optic broadband) as it avoids toxic levels of RF radiation. Proposed wireless installation should be located away from National Forests & watershed zones. Bill Robinson of West Covina. I came to discuss 5G EMF related to tumors of the central nervous system Dear members of the BOARD of Supervisors: The D.C. Court of Appeals found in 2021, that the Federal Communication commission (FCC) failed to consider the non-cancer evidence regarding adverse health effects of wireless technology. (FCC) sets regulatory guidelines, not safety limits are miss-perceived as such, for radiofrequency (RF) emissions. The LA’s Board of Supervisors regulates public health (ph) effects, FCC without (ph) jurisdiction; doesn’t care!. The relevant public health jurisdiction definitely rest with the County. Please do not prostitute LA County to the FCC agency. The Science and policy non-profit ECOLOG Institute raises the following public health concerns: Bill Robinson of West Covina. I came to discuss 5G EMF related to tumors of the central nervous system, for Leukemia: “Higher risks were also demonstrated for several forms of leukemia.” And cancer development from the damage of the genetic material via the uninhibited proliferation of cells

and debilitation of the immune system Central Nervous System: notable for Testicular Cancer: “The epidemiological findings for testicular cancer also need to be interpreted in conjunction with the results of the studies of fertility problems occurring in

“Damaging effects on the immune system which can aid the development of illnesses were demonstrated in animal experiments. Electromagnetic Sensitivity: “manifests in a variety of symptoms including: nervous symptoms such as sleep disturbances, headaches, exhaustion, lack of concentration, irritability, anxiety, stress, cardiovascular complaints, disruptions of hormones and metabolism, skin complaints.

Summary:

I here to talk about LA County Supervisors as the driver of Public Health protection. The FCC is serving the Telecomm industry profits, doesn't care about public health.

Fiber cable is the health alternative, so you needn't turn yourselves into prostitutes of the FCC and the Telecomm industry. Stay focused on public health

and allow the Zoning of needed towers stay at the municipal level. Don't allow county residents to be "microwave-cooked" with 3, 4, 5, 7, G people are being cooked by increasingly higher intensity microwaves and take a stand for public health.

The analysis presented to the board by acting county counsel grossly miss understands and understates the public health risks triggered by the proposed changes in standards, while failing to protect the public health, safety, and welfare of County residents; requiring conditional use permits

Problematic sections of the County council letter include these two quotations:
“adopt a design standards checklist and permit conditions that implement the requirements”

“establish standards to regulate the placement, design, and aesthetics of wireless facilities to minimize visual and physical impacts to surrounding properties; create streamlined permitting procedures for the installation, operation, and modification of wireless HOA.103855987.9 2 facilities while protecting the public health, safety, and welfare of County residents; require conditional use permits”

The Evidentiary burden Is upon Telecom Giants; I Back evidence Burden is on the industry. the industry that cannot prove that 5 G is safe, because it is NOT SAFE or as effective as Fiber Cable. A massive number of

				precautionary signals already exists to defeat this proposal. County Staff only needs to do a bit of research and supervisors must resist the industry lobby pressure. You must prioritize the health and safety of residents and the protection of the environment. Please vote NO. 1.) Vote NO on the proposed amendments to Titles 16 and 22 of the LA County Code. 2.) Reverse the Categorical Exemptions to CEQA in Titles 16 & 22. 3.) Adopt the Fiber First LA submitted “redline” changes to the Code.
			Robert A Miramar	Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Adopt the Redline: Urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Encourage them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
			Robert C Krieckhaus	adopt the redline for Titles 16 and 22 from Fiber First LA. 911 calls more reliable this way in case of power outages. I care in AZ because what CA does comes here next! bob Krieckhaus
			Roberta Godbe-Tipp	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

Correspondence Received

Rod Hans	In less you OK with a 5G antenna in your back yard I humbly urge you to vote NO.
Ronald Frank	I have missed one day of work due to illness in the past 30 years. On that day I had a severe migraine due to over exposure to 5G. I was rolling on the floor in pain and nausea caused by the pain. I couldn't work. I got rid of the 5G exposure in my home and at work, and have not had the pain since. Before it was recurring at less intensity than that day but on a roughly twice a month basis. Giving blanket rights to industry has got to stop. If I can't control my exposure then I can't live or work here. Environmentally if this can hurt me, how does it not hurt Nature? This is common sense. I need my rights to be able to manage my health the way I inherently need to.
Ronald J Diaz	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
Ronald M Diaz	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
Sharina Latch	June 9th 2023 Dear Board of Supervisors, I am writing you to let you know why I am opposing Title 16 and Title 22, unless amended, in regards to the the radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. I would urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Please invest in resources that are offered through federal dollars to provide superior fiber optic broadband connections

				rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Please Protect Us From Telecom Wildfires. In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that has been made about hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments. The telecommunications industry has almost complete control of the FCC, according to Captured Agency, a monograph written by journalist Norm Alster during his 2014-15 fellowship at Harvard University's Center for Ethics. There's a revolving door between the membership of the FCC and high-level people within the telecom industry that's been going on for a couple of decades now. This industry spends about $100 million a year lobbying Congress. The CTIA, which is the major telecom lobbying group, spends $12.5 million per year on 70 lobbyists. According to one of their spokespersons, lobbyists meet roughly 500 times a year with the FCC to lobby on various issues. The industry as a whole spends $132 million a year on lobbying and provides $18 million in political contributions to members of Congress and others at the federal level. Please send a clear message to the Telecommunications Industry and the Special Interest Lobbyists, that you will not allow LA residents or the rest of Californians be exposed to harmful radiation from these towers. OUR HEALTH MATTERS!!! Sincerely, Sharina Latch
			Sheila Reavill	Radiation from cell towers has been shown to have serious biological effects. No one should have cart blanche to install one of these dangerous pieces of infrastructure (cell tower) anywhere near humans or animals alike. See FCC vs Children's Health Defense Federal Court Summary 2020 recognizing the health affects of wireless radiation.
			SHEILA A DI	Please vote, "No," on the proposed changes to Titles,"16 and 22" of the LA

PUBLIC REQUEST TO ADDRESS THE BOARD OF SUPERVISORS COUNTY OF LOS ANGELES, CALIFORNIA

Correspondence Received

			BARTOLOMEO	County Code. Please consider the safety of our children, the future of our country and civilization.
			Sidnee Cox	Re: Agenda Item 59- County Code, Title 16 - Highways and Title 22 - Planning and Zoning Amendments Dear Members of the LA Board of Supervisors: Thank you for your careful foresight in postponing your vote on Titles 16 and 22 of the LA County Code on December 6th. However, on Tuesday, January10th, please DO NOT APPROVE the “revised” language of Titles 16 and 22 that was added in the last few weeks. Here’s why: Protective language that the people of LA County need to keep them safe from the explosive expansion of wireless infrastructure has not been incorporated into these revised Titles. We know that Verizon “has been working proactively with cities across the county to update ordinances and design standards to better align with Federal Communication Commission (FCC) regulations.” Although the FCC does mandate certain requirements for local governments regarding telecom permit applications, such as shot clocks (where local planning and zoning departments must act within a prescribed time period), and radio frequency (RF) emissions guidelines (assuming that the provider is in compliance with the Commission’s RF rules), there are still a number of actions that local governments can take to ensure maximum safety for their populous. Fiber First LA has prepared comprehensive “redline” drafts of Titles 16 and 22 to give LA County the maximum amount of control over the siting of telecommunication infrastructure. It appears that the re-vised versions of 16 and 22 did not take these suggested control measures into consideration. Why is that? It appears Verizon certainly had their say with County staff. Verizon’s public comment letter specifically states, “By separate letter, Verizon has previously provided technical comments to the proposed ordinance. The Verizon legal team greatly appreciates the ongoing engagement with County staff to develop strategies to accelerate the deployment of broadband infra-structure and delete the digital divide." Of course, companies such as Verizon would want to accelerate the deployment of their infrastructure because that is their business model and they have stockholders to satisfy. Verizon, AT&T, T-Mobile and others are all competing for market share. Can’t blame them for trying to make a buck, or a few billion bucks. They want you to think that their product is the only way to eliminate the digital divide. What does this all this mean? Who has actually written these amendments to the County code titles? Is it Verizon? Why hasn’t Fiber First

				LA been consulted? Their redline drafts of Titles 16 and 22 have been prepared by a top notch legal team NOT connected to Telecom, so there is no conflict of interest. Their only motivation is to give the County maximum control and the people maximum protection of rights. Can't argue with that! There is something very wrong with this picture. No one is saying that the County must prohibit wireless service or not take important steps to "bridge the digital divide." We are simply advocating for the County to employ a balanced approach. (1) Maximize protective measures in the permitting of wireless infrastructure, (2) Take proactive steps to develop comprehensive fiber networks to give people more choice in connectivity (taking advantage of billions of federal dollars for developing low cost wired networks) and (3) Work with local city governments and county residents to ensure that ALL have the right to fair hearings in the placement of telecom infra-structure with maximum protection so they can be safe in their communities. Please don't allow Verizon, or any other wireless company to cloud your judgment. The future of LA County is at stake here. This is not an exaggeration. The decision you make on Tuesday could be the biggest one that you will ever make as Supervisor. Thank you for your consideration. Sincerely, Sidnee Cox Director, EMF Safety Network Consultant, Safetech4SantaRosa
			Sofia Quinones	Supervisors, Hilda Solis, Janice, Hah, Kathryn Barger, Holly J. Mitchel, Lindsey Horvath, The digital divide has been caused by a partisan divide that in recent years has perpetuated an agenda that has exposed the bigotry and a financial theocracy practiced by both both the extreme right and fascist neo liberals. This partisan divide has blocked and stalled President Joseph Biden's appointment of Gigi Sohn's to the Federal Communications Commission. The previous administration promoted privatization and the satellite, cable, and telecommunications industry seized that opportunity to engage in a very well funded campaign to push through legislation that served their multinational corporate agendas at the expense of our constitutional rights, our health and well being, the ecocide of our environment caused by radiation, and the

massive hyste of public funds.

Therefore, we oppose the Amendments to Titles 16 & 22 of the LA County Code. Do not take away our rights and protections. Please vote no on agenda item # 56.

We do not want a cell tower or small cell facility installed right outside our homes or in our neighborhoods without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

We want a reversal of the Categorical Exemptions to California Environmental Quality Act in Titles 16 & 22, so the County Code complies fully with the California Environmental Quality Act.

We also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

We are also requesting that you respect the rights of the disenfranchised segregated unincorporated areas in Los Angeles and other areas of the county. That have yet to receive equal access and protection for build outs, maintenance, upgrades, or adequate remediation for past fires and the current fire risks that remain. In our areas we have died, we are chronically sick and our future generations will forever be negatively impacted due to the environmental racism we continue suffering from. Those who are born with congenital issues or suffer from preexisting conditions will only suffer more from this radiation exposure and know our life spans will be shortened due to the radiation exposure and due to the current deplorable environmental situation that plagues our segregated areas.

In addition, we can't discuss the digital divide and attempt to address it without integrating the electrical grid into the equation in order to make informed decisions regarding these serious topics.

Cell tower explosions have caused the loss of human lives, as well as other life forms. They have devastated entire communities and have caused unimaginable heart ache and financial hardships to families and our economy. These fire risks will be exasperated by the complications resulting from the reckless changes to Titles 16 & 22.

We support fiber first, for it is less harmful to our health and our environment. It is more secure and sustainable which will lessen our carbon footprint. Fiber First is essential for businesses and academic institutions and to our government and our republic as a whole.

Fiber First will not leave future generations left behind as it's life span goes far beyond 5G.

				5G towers are an eye sore and are designed differently with no community input in minority communities or within areas that have a lower S.E.S. Social Economic Status. Fiber First will provide many much needed jobs all across the county. Furthermore, 5G wireless communication poses national security risks. It is easier to hack which is a threat to our privacy. It allows private corporations to mind all our data. We request that you vote no on agenda item # 59. For your review please access the following link that provides the scientific data that documents the rational for biological based exposure standards for harmful low-intensity Electromagnetic Radiation and Radio Frequencies Radiation. The BioInitiative 2012 Report has been prepared by 29 authors from ten countries, ten holding medical degrees (MDs), 21 PhDs, and three MsC, MA or MPHs. Among the authors are three former presidents of the Bioelectromagnetics Society, and five full members of BEMS. bioinitiative.org/ Por Mi Raza Habla Mi Espíritu! Sofía G. Quinones East Los Angeles Boyle Heights Coalition (323)494-6005
			Stacy Sebasty	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

PUBLIC REQUEST TO ADDRESS
THE BOARD OF SUPERVISORS
COUNTY OF LOS ANGELES, CALIFORNIA

Correspondence Received

			Stephen J Walker	Allowing the installation of wireless towers and equipment absent vigorous public debate eliminates due process and should not be considered. Increased wireless communication and the radiation produced at higher and higher frequency has serious hazardous implications for the health of people and animals as well as the environment in general. The potential danger in short and long term has implications that require debate based upon study and review done with objectivity by individuals and/or entities that have NO financial interest in the outcome. Vote NO to the proposed changes to Tile 16 and 22 of the LA County Code.
			Steven Lazur	We are not ready for this change. No proof 5G is harmless.
			Steven T Diaz	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			susan andaloro	Don't take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Susan Smith	Please vote NO to the proposed changes to Titles 16 and 22 of the L.A. County Code.
			Susan Stranak	
			Suzanne Piazza	Cell phone towers make local residents sick!! You should care about your citizens over profits--history is watching you.
			Tani Kaye	
			Ted strauss	
			Teresa Griffin	I urge the Board of Supervisors to vote NO on the ordinance as written. I urge the Board of Supervisors to adopt the redline copy of Title 16 & 22 submitted

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Correspondence Received

				by Fiber First L.A.
			Terry G Halberg	Safeguard due process rights by voting NO to the proposed changes to Titles 16 and 22 of the L.A. County Code.The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. Thank you for your consideration.
			The United Keetoowah Band of Cherokee Indian	The United Keetoowah Band of Cherokee Indians in Oklahoma are writing in opposition to Agenda Item 59, Titles 16 and 22, which will fast-track cell towers throughout Los Angeles County.The Los Angeles County Board of Supervisors has already passed a categorical exemption to the California state environmental law, CEQA. We are opposed to any exemption of environmental review when it comes to the placement of cell towers. The United Band of Keetoowah Cherokee Indians sued the FCC, asking the federal courts to halt the FCC's Wireless Infrastructure Streamlining Order which was passed in September 2018. The United Band of Keetoowah Cherokee Indians was victorious in the lawsuit against the FCC. The UBK therefore stands in opposition to the passage of titles 16 & 22 and urges the Los Angeles County Board of Supervisors to reverse their categorical exemption of California's environmental law.
			Theresa Lafferty-Steen	
			Theresa L Banks	Safeguard due process rights by voting NO to Title 16 and 22 of the L.A.County Code
			Vicki Goldbach	!!! NO to the proposed changes to Titles 16 and 22 PLEASE invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods.
			Victoria I Knox	we must have the right to refuse to have these radiation producers installed in our front yards. the evidence of the harm they cause is too easy for wealthy corporations to obscure. this is outrageous in a country which was founded on the idea of our natural rights to life, liberty and the pursuit of happiness. note we did not say "the unlimited rights of the wealthy to make more wealth by ignoring the harm to human beings."
			Virginia Norris	Very dangerous for people and totally unconstitutional and unethical to infringe on private rights and health. PLEASE vote NO.
			Vivian J Edmondson	Don’t take away our rights and protections. I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.

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				I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.
			Vivian M Escalante	I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA. Fiber Optic broadband is fast, secure, safe, less expensive and uses significantly less energy than wireless. The Supervisors should be investing resources and taking advantage of federal dollars to provide superior future-proof fiber optic broadband to the premises (home, office) for everyone in Los Angeles County. It is not true that the FCC requires these amendments to be made to our existing L.A. County Code; this misinformation is being perpetrated by the telecoms and echoed by our own uninformed Planning Department. Why are other cities and counties adopting much better and more protective codes than these? The LA County Board of Supervisors are citizens' first and only line of defense against any irresponsible placement and construction of telecommunications equipment; it is not true that your hands are tied. This is supported by Congress, the FCC and the Courts.
			Warren Woodward	1.) Vote NO on the proposed amendments to Titles 16 and 22 of the LA County Code. 2.) Reverse the Categorical Exemptions to CEQA in Titles 16 & 22. 3.) Adopt the FiberFirstLA submitted “redline” changes to the Code.
			William C Brown	Adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods. In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers. The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.

			Zachariah Nash	Please, vote NO on changes to title 16 and 22. It limits the due process of individuals to have a say what is installed near their homes and communities.
		Other	Lisa Henschel	No cell towers without resident approval
			Renee Moser	Please uphold and do not change titles 16 and 22 that would prohibit 5G cell towers from being placed next to schools, homes, churches or any public space. You must adhere to laws that dictate public discussion and transparency and acknowledge the devastating effects of wireless radiation to human DNA!
		Item Total	**198**	
Grand Total			**198**	

verizon✓

December 5, 2023

Honorable Janice Hahn, Chair and
Honorable Board Members Hilda Solis, Holly Mitchell,
Lindsey Horvath & Kathryn Barger
Los Angeles County Board of Supervisors

RE: January 10, 2023 Board of Supervisors Meeting – AGENDA ITEM 59
SUPPORT - REVISED WIRELESS FACILITIES ORDINANCE TO ACCELERATE THE DEPLOYMENT OF WIRELESS BROADBAND INFRASTRUCTURE

Dear Chair Hahn and Board Members,

On behalf of Verizon, we are generally supportive of the proposed revisions to the County's Wireless Facilities Ordinance. Verizon agrees with the Regional Planning Department staff report that *"The proposed Ordinance will satisfy a key component of the…Digital Divide Regional strategy for improving access to broadband services and digital resources."* We applaud the Board's initial approval of the ordinance at your meeting of November 15, 2022 and urge final adoption.

Verizon applauds the many motions by the Board of Supervisors to accelerate the deployment of broadband and efforts by the County's Internal Services Department (ISD) to "Delete the Divide." In alignment with the County's vision, Verizon has continued to expand its wireless broadband networks to meet the growing demands from the rapid increase in mobile devices and exponential use of data to power video conferencing, telemedicine, remote learning, hybrid work and to advance our economic recovery. Verizon has also launched "fixed wireless broadband access" for home and small business internet to expand options for consumers.

To accelerate broadband infrastructure deployment, Verizon has been working proactively with cities across the county to update ordinances and design standards to better align with Federal Communication Commission (FCC) regulations. These efforts are advancing the deployment of hundreds of wireless facilities (small cells) on street lights and traffic signal poles. Additionally, we are retrofitting "macro" wireless facilities to quickly extend coverage and increase capacity. These wireless facilities are powered by thousands of miles of fiber that is currently in ground or is being newly deployed throughout the county. In addition to cities, Verizon is regularly engaged with the County's Department of Public Works (including the County Flood Control District) and Regional Planning in the deployment of fiber and wireless facilities.

We know that reducing the overall cost of internet is also a priority for the Board. ***Verizon announced in 2022 select 5G Home and LTE Home Internet services are available for free to qualifying households*** through the new Verizon Forward Program. The Verizon Forward Program is part of Verizon's concerted efforts to address affordability for the value segment of the market, which includes providing free wireless voice services through our TracFone subsidiary; participation in Lifeline and our entire company's participation in the FCC's Affordable Connectivity Program (ACP).

The ACP helps low-income households pay for fixed and mobile Internet and voice services. To qualify for free Verizon Home Internet, customers must be enrolled in ACP. We have also been working closely with County ISD on the Delete the Divide initiative and **the Verizon team participated in last month's ISD's "ACP Day" where residents were able to sign-up for ACP at select libraries across the county.**

Verizon respectfully requests the Board of Supervisors APPROVE the proposed "Wireless Facilities Ordinance" which is also supported by over 1,000 residents throughout the county (see attached). By separate letter, Verizon has previously provided technical comments to the proposed ordinance. The Verizon team greatly appreciates the ongoing engagement with County staff to develop strategies to accelerate the deployment of broadband infrastructure and delete the digital divide.

Sincerely,

Randal Hernandez
Executive Director
External Affairs – Southern California
randal.hernandez@verizon.com

Attachment: **Los Angeles County residents who have signed petition calling for support of expanded wireless networks through the Wireless Facilities Ordinance**

Board of Supervisors: Lend Your Support for Innovative Connectivity in Los Angeles County

The following **1,077** constituents from Los Angeles County have signed this letter calling for your support of expanded wireless networks through the Wireless Facilities Ordinance.

Dear Supervisors,

As a local community member, I'm writing to express my support for the Los Angeles County Wireless Facilities Ordinance (WFO). This updated ordinance will help facilitate the deployment of wireless broadband infrastructure throughout the region. Expanding wireless broadband networks are needed now more than ever to meet the growing demands resulting from the explosion in mobile devices and exponential use of data to power video conferencing, telemedicine, remote learning, hybrid work and for our economic recovery. This wireless infrastructure can also facilitate an entirely new type of home broadband service, giving Los Angeles County residents and small businesses a new option for reliable high-speed internet access.

Communities across the country, including Los Angeles County, are recognizing the critical importance of wireless infrastructure to connect kids to the classroom, power the local economy, and provide government and healthcare services. All of this is only possible in areas that have a robust and reliable communications network.

Ultimately, I believe that the modernization of these guidelines will help advance the Board of Supervisors' goals to expand broadband infrastructure, increase affordability, and enhance broadband connectivity across the county. The benefits to people who live and *work in Los Angeles County, to local businesses and to the entire population are immense:*

- *More wireless infrastructure = A powerful tool to help close the digital divide — Robust broadband infrastructure is essential to making progress toward serving all residents with high-speed internet, helping ensure children and adults are not left behind in our rapidly transforming digital economy.*

- *More wireless infrastructure = Improved city services, transportation and public safety— First responders, police officers, and firefighters will be able to coordinate faster, sharing vital emergency information in real-time to help protect our community.*

- *More wireless infrastructure = Lower health care costs and elevated care — Virtual healthcare will be raised to new levels, and remote care will be made even more effective and accessible to those who need it most.*

- *More wireless infrastructure = More competition and lower costs — A new entrant into Los Angeles County's home broadband market will increase competition and should lower consumer costs, while also improving speed and reliability.*

This is your chance not only to deliver for your constituents, but to demonstrate thought leadership and be part of transforming our region into a national connectivity leader. I ask you to support the passage of the Los Angeles County Wireless Facilities Ordinance.

Name	City	Zip Code
Kulala Shimizu	Rancho Palos Verdes	90275
Rachel Russell	Agoura Hills	91301
Doriley Juarez	Agoura Hills	91301
Amy Morse	Agoura Hills	91301
Cruz Castillo	Alhambra	91801

Leonard Versoza	Alhambra	91801
Lorraine Versoza	Alhambra	91801
Kimberly Contreras	Alhambra	91801
Loretta Carranza	Alhambra	91801
Anjanette Caron	Alhambra	91803
Lorretta Placido	Alhambra	91803
Richard Wightman	Arcadia	91006
Iris King	Arcadia	91006
Shannon Folsom	Arcadia	91006
Erin Schmidt	Arcadia	91006
Lourie Aldana	Arleta	91331
Angelica Nuñez	Arleta	91331
Arianna Vargas	Arleta	91331
Amy Cruz	Arleta	91331
Donald Mattox	Artesia	90701
Destiny Flores	Artesia	90701
Adriana Saldivar	Artesia	90701
Marie Vega	Artesia	90701
Kaylah Bell	Azusa	91702
Leonida Callihan	Azusa	91702
Aney Gama	Azusa	91702
Leanne Richardson	Azusa	90272
Eva Gallardo	Baldwin Park	91706
Dixianah Cervantes	Baldwin Park	91706
Ana Mercado	Baldwin Park	91706
Vincent Santos	Baldwin Park	91706
Mary Saverio	Baldwin Park	90807
Grace Isah	Bellflower	90706
Liz Rodriguez	Bell	90201

Socorro Munguia	Bell	90201
Alexa Calleros	Bell Gardens	90201
Alexa Romero	Bell Gardens	90201
Kristy Streicker	Bell Gardens	90813
Rocio Pulido	Bell Gardens	90201
Victor Cajas	Bell Gardens	90201
Yolanda Roldan	Bellflower	90706
Elyse Villanueva	Bellflower	90706
Karen Reconco	Bellflower	90706
Juan Barron	Bellflower	90706
Nicole Pollina	Bellflower	90706
Diana Linares	Bellflower	90706
Peggy Vanderlip	Bellflower	90706
Darryl Bellfield	Bellflower	90706
Evelyn Ellis	Bellflower	90706
Debra Alvarez	Bellflower	90712
Gerardo Guerrero	Bellflower	90005
Karla Ortiz	Bellflower	90706
Deborah Wilhite	Bellflower	90064
James Wolff	Beverly Hills	90210
Lola Stenner	Beverly Hills	90210
Ruth Rosenfeld	Beverly Hills	90210
Christine Archambault	Beverly Hills	90212
Zac Luciano	Beverly Hills	90212
Shanna Mehrdad	Beverly Hills	90212
Eleanor Lambert	Beverly Hills	90212
Nan Norris	Beverly Hills	90212
Marissa Flores	Beverly Hills	90706
Sherry Williams	Beverly Hills	90210

Craig Hamann	Burbank	91505
Marukah Peters	Burbank	91505
Laura Herndon	Burbank	91505
Monica Moskatow	Burbank	91505
Lacey Wozny	Burbank	90042
Nicole Hansen	Burbank	90650
Mike Graceffo	Burbank	91505
Sandra Cordero	Calabasas	91302
Janice Celeste	Calabasas	91302
Deborah Berman	Calabasas	91016
Elinor Bernstein	Calabasas	90265
Jamal Ringstone	California	90255
Cindy Swalley	Can Nuys	91405
Kaithlynn Rosado	Canoga Park	91303
Steve Wang	Canoga Park	91304
Genesis De Paz	Canoga Park	91304
Keith Nelson	Canoga Park	91304
Vivian Thai	Canoga Park	91304
Robert Graham	Canoga Park	91304
Linda Parker	Canoga Park	91304
Alex Lopez-Diaz	Canoga Park	91304
Paola Gonzalez	Canoga Park	91304
Emma Castro	Canoga Park	90012
Luke Guevara	Canoga Park	91406
Lennon Corona	Canoga Park	90032
Neal Zoromski	Canoga Park	90004
Rebecca Martinez	Canoga Park	91352
Antoinette Reynolds	Canoga Park	91306
Liz Escobedo	Canoga Park	91303

Juana Sanchez	Carson	90745
Natalie Stolp	Carson	90745
Gloria Sanchez	Carson	90745
Carol Starr	Carson	90745
Paulette Villanueva	Carson	91505
Donna Rosenquist	Carson	91406
Yvonne Lovato	Cerritos	90703
James Lindgren	Cerritos	90703
George Medina	Cerritos	90703
Mio Watanabe	Cerritos	90703
Andrew Gomez	Cerritos	90703
Michael Wauschek	Cerritos	90703
Jaz Robledo	Cerritos	90703
Rosita Ocampo	Cerritos	90703
Annette Avinger	Cerritos	90703
Barbara Shryack	Cerritos	90703
Christopher De Goeas	Cerritos	90703
Binh Tang	Chatsworth	91311
Heidi Hamuel	Chatsworth	91311
Selene Alba	Chatsworth	91311
Pritam Singh	Chatsworth	91311
Vanessa Hing	Chatsworth	90275
Julia Nila	Chino	91710
Roger Stofferahn	Chino	91710
Hailey Castro	Chino	91710
Cathleen Earle	Chino	91710
Melanie Soares	Chino	91710
Luis Ramirez	Chino	91710
Steven Doyle	Chino	91710

Alexis Chapman	Chino	91710
Dymond Caviness	Chino	91766
Beyoncè Becerril	Chino	91710
Desiree Love-Barrett	Chino Hills	91709
Michael Israel	Chino Hills	91709
Vivian Meraz	Chino Hills	91709
Laurie Ortiz	Chino Hills	91709
Vania Lo	City Of Industry	91748
Jill Boyle	Claremont	91711
Neena Diaz	Claremont	91711
Cozy Enrique	Claremont	91711
Gertrude Monsour	Claremont	91711
Deanne Dulyea	Claremont	91711
Ruth Lugo	Claremont	91711
C.J. Magana	Commerce	90222
Rocio Sanchez	Compton	90221
Katherine Acosta	Compton	90221
Wesley Berryhill	Compton	90221
Maria Quevedo	Compton	90222
Kenya Villarreal	Compton	90222
Ena Mairena	Compton	90222
Janet Girard	Covina	91710
Stephanie Leon	Covina	91722
Mazacuauhtli Burrola	Covina	91722
Elizabeth Flores	Covina	91723
Martha Gartsman	Covina	91724
Cruzita Harris	Covina	91724
Karin Yehling	Covina	91342
Kalanie Coronado	Covina	91723

Tarneem Tanas	Covina	91722
Dina Devine	Covina	91724
Ana Esquivel	Cudahy	90201
Sarah Grossman	Cudahy	91324
Heidi Lepe	Culver City	90232
Ivy Strohmaier	Culver City	90232
Sabrina Tinoco	Cypress	90630
Brianna Molden	Cypress	90630
Anthony Lepage	Cypress	90630
Ken Davis	Diamond Bar	91765
Corinne Navarrete	Diamond Bar	91765
Mariah Warren	Diamond Bar	91765
Anoushka Sahgal	Diamond Bar	91765
Lucy Mojica	Downey	90240
Cristina Márquez	Downey	90240
Graciela Sotomayor	Downey	90240
Darian Babe	Downey	90240
Yolanda Tenorio	Downey	90241
Kayla Angon	Downey	90241
Jesse Swoboda	Downey	90241
Mi Hlaing	Downey	90242
Ashkall Madril	Downey	90242
Lizbeth Delgado	Downey	90240
Lezlie B Lopez	Duarte	91010
Elizabeth Villarreal	El Monte	91731
Iseilia Fisk	El Monte	91731
Valerie Reyes	El Monte	91731
Mary Pasos	El Monte	91731
Janaye Adams	El Monte	91732

Joseph Greenwood	El Monte	91732
Megan Luong	El Monte	91732
Natashia Parker	El Monte	91732
Denise Ballesteros	El Monte	91733
Ilse Fabela	El Monte	91733
Bryan Calix	El Monte	91733
Eric Hinwood	El Monte	90023
Maryah Reyes	El Monte	91731
Sergio Alvarez	El Monte	91731
Manuel Arreola	El Monte	91732
Jesse Ochoa	El Monte	91732
Celia Perez	El Monte	91732
Janet Kleinbart	Encino	91316
Zahra Farjami	Encino	91316
Patricia McCook	Encino	91316
Erica Marino	Encino	91316
Leah Herzberg	Encino	91436
Edward Kanemoto	Gardena	90247
Stevie Silva	Gardena	90247
Crystal Caceres	Gardena	90247
Dianna Guyumdzhyan	Gardena	91406
Tyler Denering	Glendale	91204
Seda Kazaryan	Glendale	91204
Justine Woodford	Glendale	91205
Jasmine Gee	Glendale	91206
Ricky Garcia	Glendale	90073
Claudia Rodriguez	Glendale	91768
Stacie Turk	Glendale	90403
Mike Martinez	Glendale	91745

Carlos Vasquez	Glendale	91206
Julie Sevelov	Glendora	91740
Larissa Shen	Glendora	91740
Gabriela Aguayo	Glendora	91740
Hyde Paul	Glendora	91740
Shirley Harris	Granada Hills	91344
Victoria Munoz	Granada Hills	91344
Micaela Wheeless	Granada Hills	91344
Michelle Lucero	Hacienda Heights	91745
Frances Chee	Hacienda Heights	91745
Alexandra Gutierrez	Hacienda Heights	91745
Angelina Rodriguez	Hacienda Heights	91745
Stephanie Rodriguez	Hacienda Heights	91745
Rosalie Sedillo	Hacienda Heights	90744
Sheila Willens	Hacienda Heights	90046
Angelina Tan	Hacienda Heights	91745
Erica Guaydacan	Hacienda Heights	91745
Pamela Young	Hacienda Heights	90623
Kenmora Knotts	Harbor City	90710
Maria Garrido	Harbor City	90710
Barbara Romero	Harbor City	90631
Paco Gomez	Harbor City	90710
Jesse Wilson	Hollywood	90028
Diane Edington	Hollywood	90028
Roxanna Rodriguez	Huntington Park	90255
Lucero Osuna	Huntington Park	90255
Ivette Castillo	Huntington Park	90255
Jazmin Perez	Huntington Park	90255
Keenan Sheedy	Huntington Park	90065

Vanessa Collard	Huntington Park	90723
Karen Gunn	Huntington Park	90602
Marybeth Mendoza	Huntington Park	90255
Brenda Reyes	Huntington Park	90262
Joey Gonzalez	City of Industry	91016
Janice Tarr	Los Angeles	90049
Beverly Kleiner	Los Angeles	90402
Greg Barris	Los Angeles	90026
Attilio Pandolfo	Los Angeles	90028
Monique De Warren	Los Angeles	90046
Robert Trebor	Los Angeles	90046
Eva Valdez	Los Angeles	90001
Susan Olar	Los Angeles	91604
Eileen Fuentes	La Mirada	90638
Destiny Lee	La Palma	91402
Sofia Miramontes	La Palma	90623
Janie Gutierrez	La Puente	91744
Finch Arteafa	La Puente	91746
Flory Huang	La Puente	91748
Natasha Harrell	La Puente	90011
Deitra Mazurak	La Verne	91750
Brooke Diebold	La Verne	91750
Ashley Odriozola	La Verne	91750
Liliana Haro-Fausto	Lake Balboa	91406
Audrey Broughton	Lakewood	90713
Nancy Mccardell	Lakewood	90715
Mario Zambrano	Lakewood	90715
Daniel Berzoza	Lakewood	90022
Kristie Kanner	Lakewood	91723

Gloria Garcia	Lakewood	90804
Heather Rios	Lakewood	91311
Shayna Anayap	Lakewood	90715
Usi Koe	Lakewood	90715
Danny Ray	Lakewood	90046
Jean Howe	La Puente	91745
Ariel Medina	Laverne	91750
Lucia Miller	Lomita	90710
Joyce Thomas	Long Beach	90802
Steven Turner	Long Beach	90803
Geof Garth	Long Beach	90803
Chaz Ocasio	Long Beach	90803
Nadine Zamiski	Long Beach	90803
Lara Schilling	Long Beach	90803
Leslie Jones	Long Beach	90803
Alison Cameron	Long Beach	90804
Jenelle Herman	Long Beach	90804
Carinne Kee	Long Beach	90804
Rachael Hamm	Long Beach	90804
Alba Villa	Long Beach	90804
Diana Kliche	Long Beach	90804
Alexander Salinas	Long Beach	90804
Sherry Thomas	Long Beach	90804
Danalie Daniels	Long Beach	90805
Mer Young	Long Beach	90805
Brianna Cervantes	Long Beach	90805
Rosalinda Alvarez	Long Beach	90805
Linda Tapia	Long Beach	90805
Monthon Promphao	Long Beach	90805

Destiny Destiny	Long Beach	90805
Elizabeth Espinoza	Long Beach	90805
Raven Maxwell	Long Beach	90805
Lisa Arndt	Long Beach	90806
James Baylie	Long Beach	90806
Graciela Macedo	Long Beach	90806
Ricardo Galvan-Campos	Long Beach	90806
Greta Hunold	Long Beach	90806
Kristine Casillas	Long Beach	90806
Courtney Childress	Long Beach	90806
Irene Brodie	Long Beach	90807
Joy Zadaca	Long Beach	90807
Elise Watt	Long Beach	90807
Vanessa Harmon	Long Beach	90807
Bella Pelayo	Long Beach	90808
Khara Yeazus	Long Beach	90808
Daniel Curry	Long Beach	90810
Vivian Serrano	Long Beach	90810
Brian Prosser	Long Beach	90810
Lisa Lawton	Long Beach	90813
Mildred Hill	Long Beach	90813
Carmen Aguirre	Long Beach	90813
Cristal Brown	Long Beach	90813
Jeremy Meracle	Long Beach	90813
Kalien Nichols	Long Beach	90813
Sara Hayes	Long Beach	90814
Denise Hinckley	Long Beach	90814
Allard Kuijken	Long Beach	90814
Emilu Warner	Long Beach	90814

Ian Bixby	Long Beach	90814
Samuel Rosado	Long Beach	90814
Jeannette Canseco	Long Beach	90814
Antoinette Gust	Long Beach	90814
April Luna	Long Beach	90814
Susie Amster	Long Beach	90815
Karla Arce	Long Beach	90815
Alex James	Long Beach	90815
Kathleen Gause	Long Beach	90815
Tim Hainley	Long Beach	90815
Barry Jackson	Long Beach	91791
Elena Paquot	Long Beach	90505
Kelly Sutherland	Long Beach	91423
Sherry Price	Long Beach	90028
Sarah Shradish	Long Beach	90049
Gwynne Garfinkle	Long Beach	90039
Dominguez Yazmin	Long Beach	90039
Michelle Arc	Long Beach	90210
Evelyn Bermudes	Long Beach	91352
Taylor Stein	Long Beach	90732
Joseph Garnica	Long Beach	90640
Stacy Thompson	Long Beach	90706
Jeannette Lopez	Long Beach	90031
Colleen Garcia-Butler	Long Beach	90803
Wanda Rice	Long Beach	90805
Vanessa Acosta	Long Beach	90806
Melody Taylor	Long Beach	90806
Ross Tanner	Long Beach	90814
Anna Cardenas	Long Beach	90805

Asha Norman-Hunt	Los Angeles	90004
Danielle Nau	Los Angeles	90004
Elizabeth Adams	Los Angeles	90004
Zoe Nelson	Los Angeles	90004
Marquita Martin	Los Angeles	90004
Emma Smith	Los Angeles	90004
Stacie Tabarez	Los Angeles	90005
Dominick Falzone	Los Angeles	90005
Eunjoo Yang	Los Angeles	90005
Nancy Antunez	Los Angeles	90005
Dominick Falzone	Los Angeles	90005
Stephanie Contreras	Los Angeles	90006
Tania Flores	Los Angeles	90006
Audra Milos	Los Angeles	90006
Angel Santiago	Los Angeles	90006
Heally Ceballos	Los Angeles	90007
Sally Rentschler	Los Angeles	90007
Celia Durea	Los Angeles	90007
Raymundo Ramirez	Los Angeles	90011
David Michel	Los Angeles	90011
Rivka Villanueva	Los Angeles	90011
Kenny Ramirez	Los Angeles	90011
Michelle Montes	Los Angeles	90011
Lishawn Camacho	Los Angeles	90011
Rossy Martinez	Los Angeles	90011
Lana Simon	Los Angeles	90012
Brenda Hernandez	Los Angeles	90012
Titus Telge	Los Angeles	90012
Grace Guerra	Los Angeles	90012

Rene Cervino	Los Angeles	90012
Lili Ipp	Los Angeles	90012
Karen Rico	Los Angeles	90012
Kayla Bell	Los Angeles	90013
Timothy Pierce	Los Angeles	90014
Eric Shy	Los Angeles	90014
Alona Korzun	Los Angeles	90014
Madison Long	Los Angeles	90014
Ron Deutsch	Los Angeles	90014
Jeff Armfield	Los Angeles	90014
Dalia Salgado	Los Angeles	90017
Sonny Sanchez	Los Angeles	90017
Jacqueline Iovino	Los Angeles	90017
Michelle Hochstein	Los Angeles	90020
Maria Raders	Los Angeles	90020
Sasha McCullom	Los Angeles	90020
Astrid Juarez	Los Angeles	90020
Schuyler Kent	Los Angeles	90020
Noemi Duran	Los Angeles	90022
Jimenez Karla	Los Angeles	90022
Yenifer Perez	Los Angeles	90022
David Lopez	Los Angeles	90022
Roxane Cabeza	Los Angeles	90022
Kristine Slaight	Los Angeles	90022
Eddy Gonzalez	Los Angeles	90022
Gilbert Barragan	Los Angeles	90022
Navarro Anthony	Los Angeles	90022
Marlene Perez	Los Angeles	90023
Danna Moran	Los Angeles	90023

Michelle Romero	Los Angeles	90023
Isabella D'Agnenica	Los Angeles	90031
Erin Holt	Los Angeles	90031
Shaina Renobato	Los Angeles	90031
Santiago Topete	Los Angeles	90031
Candace Rocha	Los Angeles	90032
Brigitte Benchimol	Los Angeles	90032
Linda Martinez	Los Angeles	90032
Rosie Zaldivar	Los Angeles	90032
Julie Macias	Los Angeles	90032
Andrea Groll	Los Angeles	90032
Gus Castaneda	Los Angeles	90032
Livier Gonzalez	Los Angeles	90032
Raymond Dangelo	Los Angeles	90032
Andrew Calean	Los Angeles	90032
Vicente Rosas	Los Angeles	90033
Susana Celis	Los Angeles	90033
Abraham Villa	Los Angeles	90033
Martin Barrera	Los Angeles	90033
Jeanette Martinez	Los Angeles	90033
Silver Angely	Los Angeles	90033
Lilith Ferreira	Los Angeles	90033
Molly Kascel	Los Angeles	90039
Lenore Dowling	Los Angeles	90039
Marilyn Taylor-Kremen	Los Angeles	90039
Dan Schwartz	Los Angeles	90039
Adrian Ramirez	Los Angeles	90040
Mark Jovanelly	Los Angeles	90041
Mark Wenzel	Los Angeles	90041

Shellaine Angeles	Los Angeles	90041
Norma Santos	Los Angeles	90041
Susan Von Manske	Los Angeles	90042
Mona Rivers	Los Angeles	90042
Meadow Carder-Vindel	Los Angeles	90042
Megan Gilbert	Los Angeles	90042
Paul Apelgren	Los Angeles	90042
Lori Knox	Los Angeles	90042
Elana Farley	Los Angeles	90042
Albert Ruiz	Los Angeles	90042
Vicente Ochoa	Los Angeles	90042
Mary Santiago	Los Angeles	90057
Montee Simpson	Los Angeles	90057
Javier Mejia	Los Angeles	90057
Gabriela Jeronimo	Los Angeles	90057
Mark Vieira	Los Angeles	90057
Darwin Gonzalez	Los Angeles	90058
Eveny Mendez	Los Angeles	90063
Marlene Aguilar	Los Angeles	90063
A.L. Steiner	Los Angeles	90063
Nadege Baer	Los Angeles	90065
Noland Carter	Los Angeles	90065
Yael Pardess	Los Angeles	90065
Maria Basaldu	Los Angeles	90065
J.D. Davis	Los Angeles	90065
Emily Miles	Los Angeles	90065
Brenda Holly	Los Angeles	90065
Christopher Molina	Los Angeles	90065
Kaman Chow	Los Angeles	90071

Caroline Fraissinet	Los Angeles	91206
Anita Youabian	Los Angeles	90024
Margaret Jacob	Los Angeles	90024
Gia Sun	Los Angeles	90024
Nisha Andrews	Los Angeles	90024
Miztla Aguilera	Los Angeles	90024
Margaret Phelps	Los Angeles	90024
Andy Cracchiolo	Los Angeles	90025
Samantha Neel	Los Angeles	90025
Sheila Sperber	Los Angeles	90025
Megan Van Prooyen	Los Angeles	90025
Patricia Margulies	Los Angeles	90025
Ron Mcgill	Los Angeles	90026
Jon Benneian	Los Angeles	90026
Patricia Byrdsell	Los Angeles	90026
Grace Gibbs	Los Angeles	90026
Torrie Gregor	Los Angeles	90026
Mariana Moren	Los Angeles	90026
Charlotte Hourston	Los Angeles	90026
Xica Cano	Los Angeles	90026
Mary Loibl	Los Angeles	90026
Allezey Gomez	Los Angeles	90026
Breanna Aguilar	Los Angeles	90026
Josephine Hyde	Los Angeles	90026
David Kilpatrick	Los Angeles	90026
Hanna Wallis	Los Angeles	90026
Lee Fitzgerald	Los Angeles	90026
Jeffrey Lawson	Los Angeles	90027
Racquel Madrid	Los Angeles	90027

Crystal Smith-Connelly	Los Angeles	90027
Shannon M Bullock	Los Angeles	90027
John-Allan Macunovich	Los Angeles	90027
Kaitlynn Nolan	Los Angeles	90027
Akemi Rico	Los Angeles	90027
Anna Cesar	Los Angeles	90027
Bellz Lombard	Los Angeles	90027
Cali Favell	Los Angeles	90027
Brandon Koch	Los Angeles	90027
Elizabeth Riggins	Los Angeles	90027
Mary Mcauliffe	Los Angeles	90028
Megan Milito	Los Angeles	90028
Alexandra Peters	Los Angeles	90028
Daniela Zendejas	Los Angeles	90028
Mathew Quitney	Los Angeles	90029
Rebekkah Drake	Los Angeles	90029
Desiree Whitney	Los Angeles	90029
Kristina Kechkarian	Los Angeles	90029
James Brown	Los Angeles	90034
Patricia Carlson	Los Angeles	90034
Antoinette Samardzic	Los Angeles	90034
Karla Gonzalez	Los Angeles	90034
Erin Moore	Los Angeles	90034
Yue Begay	Los Angeles	90034
Maggie Robins	Los Angeles	90034
Rachel Martinez	Los Angeles	90034
Amanda Mello	Los Angeles	90034
William Perkins	Los Angeles	90034
Rebecca Dienno	Los Angeles	90034

Stephanie Fitt	Los Angeles	90035
Samantha Alderete	Los Angeles	90035
Iris Sangiovanni	Los Angeles	90035
Ximena Quezada	Los Angeles	90035
A.F. Shayne	Los Angeles	90036
Murat Kilic	Los Angeles	90036
Valerie Romero	Los Angeles	90038
Iuliia Pozdina	Los Angeles	90038
Ibbi Schwartz	Los Angeles	90038
L.L. Dored	Los Angeles	90046
Mark Rasbach	Los Angeles	90046
Bonnie Karrin	Los Angeles	90046
Jenny Engel	Los Angeles	90046
Susan Ray	Los Angeles	90046
Joe Lorenzo	Los Angeles	90046
Aspen Moore	Los Angeles	90046
Amber Wagstaff	Los Angeles	90046
Caleb Ellis	Los Angeles	90046
Lynne Weiske	Los Angeles	90048
Kayla Nicholson	Los Angeles	90048
Francine Kubrin	Los Angeles	90049
Amirali Siassi	Los Angeles	90049
Jennifer Bonner	Los Angeles	90064
Julie Sharron	Los Angeles	90064
Diana Davidson	Los Angeles	90064
Ivonne Buitron	Los Angeles	90064
Valerie Libhart	Los Angeles	90066
Scott Shrider	Los Angeles	90066
Tia Triplett	Los Angeles	90066

Alisa Reich	Los Angeles	90066
Andrea Lieberman	Los Angeles	90066
Nancy Goldberg	Los Angeles	90066
Dan Savage	Los Angeles	90066
Sussie Sims	Los Angeles	90066
Amber Spence	Los Angeles	90066
Samantha Santibanez	Los Angeles	90066
Patricia Marlatt	Los Angeles	90068
Ricky Bole	Los Angeles	90068
Jasmine Mayuku	Los Angeles	90068
Paul Munkholm	Los Angeles	90069
Allison Rensch	Los Angeles	90210
David Stobie	Los Angeles	90210
Cristel Cruz	Los Angeles	91311
Ann Dorsey	Los Angeles	91325
Stephanie Mora	Los Angeles	91335
Chad Monk	Los Angeles	91335
Christopher Schram	Los Angeles	91403
Eddie Deatropa-Gonzalez	Los Angeles	91411
Rueben Fuller	Los Angeles	91605
Joe Holmes	Los Angeles	90001
Natalie Serrano	Los Angeles	90001
Heidy Casillas	Los Angeles	90001
Edgar Cardenas	Los Angeles	90001
Martha Gamez	Los Angeles	90001
Satasha Naptarias	Los Angeles	90275
James Kingman	Los Angeles	91745
Scott Ford	Los Angeles	90803
Tara Taylor	Los Angeles	91006

Deborah Warren	Los Angeles	90402
Chandler Bruyn	Los Angeles	90032
Judith Lacher	Los Angeles	90049
Roberta Johnson	Los Angeles	91790
Linda Amason	Los Angeles	91710
Charisse Jones	Los Angeles	90802
Sheila Winston	Los Angeles	91304
Linda Perez	Los Angeles	90027
Maxwell Trueblood	Los Angeles	90005
Jesus Medina	Los Angeles	91342
Michael Bolduc	Los Angeles	90755
Aracely Lua	Los Angeles	91402
Belinda Bautista	Los Angeles	90031
Victoria Vega	Los Angeles	91790
Nick Alexopoulos	Los Angeles	90660
Yeniffer Quijano	Los Angeles	90731
Suzanne Camejo	Los Angeles	90404
Almetrez Thomas	Los Angeles	90015
Charlton Whittington	Los Angeles	90068
Daniel Osborne	Los Angeles	90712
Dempsey Gibson	Los Angeles	90277
Phoebe Michaels	Los Angeles	91304
Leslie Heiss	Los Angeles	90017
Katie Miller	Los Angeles	91303
Joyce Perry	Los Angeles	90068
Judith Webber	Los Angeles	90277
Samantha Avila	Los Angeles	90201
Jodie Myrtue	Los Angeles	90713
Denisse Rivera	Los Angeles	91706

Eleanor Triche	Los Angeles	90247
Steven Adler	Los Angeles	91367
Sheila Bouchard	Los Angeles	91303
Christine Terterian	Los Angeles	91505
Ra'Chel King	Los Angeles	91607
Sandra Mendez	Los Angeles	90255
Joana Zuaiter	Los Angeles	91324
Michael Rubin	Los Angeles	91733
Kay Orias	Los Angeles	90024
Jose Sanchez	Los Angeles	91745
Lidia Estrada	Los Angeles	91352
Malissa Beeson	Los Angeles	90005
Chavez Benally	Los Angeles	90069
Charles Elliott	Los Angeles	91745
Mary Russell	Los Angeles	90745
Diaz Tracey	Los Angeles	90504
Cristina Alvarez	Los Angeles	90031
Michael Vitiello	Los Angeles	90744
Sydney Silverman	Los Angeles	90024
Baza Baqer	Los Angeles	90024
Simone Wagner	Los Angeles	90034
Jacinto Castillo	Los Angeles	90035
Marissa Aguilar	Los Angeles	90036
Marina Phillips	Los Angeles	90036
Jessica Choi	Los Angeles	90036
Joshua Montoya	Los Angeles	90046
Jacob Behymer-Smith	Los Angeles	90046
Alana Silvani	Los Angeles	90046
Taylor Lundeen	Los Angeles	90064

Carolyn Sharp	Los Angeles	90064
Aulden Dion	Los Angeles	90066
Margaret Lauer	Los Angeles	90068
Justin Ketrinchek	Los Angeles	90068
Katie Avery	Los Angeles	90068
Claire De Los Rios	Los Angeles	90210
Jesse Devine	Los Angeles	91342
Say Cruz	Los Angeles	90001
Lexi Heather	Los Angeles	90001
Luis Barraza	Los Angeles	90001
Adrienne Tripp	Los Angeles	90068
Marce Gomez	Los Angeles	90640
Daniel Hammatt	Los Angeles	91706
Kimberly Jackson	Los Angeles	90201
Valeria Garcia	Los Ángeles	90024
Maria Zendejas	Los Ángeles	90028
Kate Womack	Los Ángeles	90001
Beatrice Valenzuela	Los Angeles	90026
Arthur Mann	Los Angeles	91306
Tanya Barsoumian	Los Angeles	90046
Tamra Schnitman	Los Angeles	91302
Sophia Hall	Malibu	90265
Heather Mendez	Malibu	90007
Aaron Webster	Marina Del Rey	90292
Mariko Kahn	Marina Del Rey	90292
Kaila Griffin	Marina Del Rey	90292
Kellie Mena	Maywood	90270
Cristian Gordo	Maywood	90270
Valerie Farlow-Johnson	Mission Hills	91345

Jessica Rodriguez	Mission Hills	91345
Patricia Orduno	Mission Hills	91345
Annette Cortes	Mission Hills	91345
Robert Ricewasser	Monrovia	91016
Christine Neil	Monrovia	91016
Suzanne Conant	Monrovia	91016
Alexandra Johnson	Monrovia	90731
Shannon Moore	Monrovia	91364
Jackie Parker	Monrovia	91016
Barbara Diaz	Montebello	90640
Jacklyn Waight	Montebello	90640
Jamie Montano	Montebello	90640
Destiny Mendoza	Montebello	90640
Javier Del Valle	Montebello	90640
Pamela Vasquez	Montebello	90640
Linda Goldman	Montebello	90064
Jessica Lam	Montebello	90046
Sylvia Martinez	Monterey Park	91754
David Almada	Monterey Park	91754
Almada David	Monterey Park	91754
Deanna Rodriguez	Monterey Park	91754
Mandy Adler	North Hollywood	91607
Tiff Lii	North Hills	91343
Teresita Santos	North Hills	91343
Mandy Thomas	North Hills	91343
Oyuki Parra	North Hills	91343
Natalie Rosen	North Hollywood	91606
Bre Tiesi	North Hollywood	91302
Christopher Renteria	Northridge	91324

Barbara Perle	Northridge	91324
Maryruth Summers	Northridge	91324
Kim Ferlazzo	Northridge	91325
Julie Jacobson	Northridge	91325
Amber Ibanez	Northridge	91325
Lee'Ah-Marie Sofia Sanchez	Northridge	91325
Joseph Vanek	Northridge	91325
Joseph Song	Norwalk	90650
Rebecca Garfias	Norwalk	90650
Verletta Moeller	Norwalk	90650
Destiney Bautista	Norwalk	90650
Suzette Morris	Norwalk	90650
Deborah Desnoo	Norwalk	90027
Debbie Cagle	Norwalk	90650
Judi Mcmahon	Norwalk	90706
Ellen Rudolph	Pacific Palisades	90272
Maureen Mcgee	Pacific Palisades	90272
Kathleen Glander	Pacific Palisades	90272
Susan Lynch	Pacific Palisades	90272
Bonnie Abel	Pacific Palisades	91040
Clarisa Pena	Pacoima	91331
Cytlalli Barrientos	Pacoima	91331
Elevenia Gutierrez	Pacoima	91331
Rosa Bretado-Soriano	Pacoima	91331
Ashley Daniels Mcclellan	Pacoima	91331
Alison Thalhammer	Pacoima	90065
Sandra Guzman	Pacoima	90802
Brigitte Piller	Long Beach	90274
Jada Nakagawa	Long Beach	90274

Chantal Munguia	Panorama City	91402
Mari Hovsepyan	Panorama City	91402
Nathan Fox	Panorama City	91405
Brenda Rogers	Panorama City	91040
Blake Stallions	Panorama City	90401
Anny Lara	Panorama City	91402
Larissa Ortiz	Paramount	90723
Ramon Guerrero	Paramount	90723
Toney Byrd	Paramount	90011
Andrew Flores	Paramount	90004
Maria Miller	Paramount	91770
Mishka Michon	Pasadena	91105
George Navarro	Pasadena	90280
Nina Anakar	Petaluma	90026
Antoinette Lopez	Pico Rivera	90660
Rosemary Hernandez	Pico Rivera	90660
Jasmine Castillo	Pico Rivera	90660
Melissa De La Cruz	Pico Rivera	90660
Gloria Mejia	Pico Rivera	90660
Stanley Brent	Pico Rivera	90048
Savannah Molina	Pico Rivera	90660
Ivette Rubio	Pico Riviera	90660
Melinda Loza	Pomona	91733
Ashley Martinez	Pomona	91766
Suenssy Reyes	Pomona	91766
Mia Pinto-Cubillo	Pomona	91766
Manuel Mata	Pomona	91766
Benito Garcia	Pomona	91767
Everia Condon	Pomona	91767

Carlos Osorio	Pomona	91767
Cesar Hernandez	Pomona	91767
Kayla Duque	Pomona	91767
Ligia Anderson	Pomona	91767
Jazzmin Oldenbrook	Pomona	91767
Fernanda Hernandez	Pomona	91767
Victor A Guzman	Pomona	91768
Michelle Lopez	Pomona	90201
Rosie Hatch Khan	Pomona	91766
Perla Cabe	Pomona	91767
Icys Paramo	Pomona	91768
Phillip Barron	Pomona	90804
Robert W Peters	Porter Ranch	91326
Elizabeth Hall	Porter Ranch	91326
Nicole Phung	Porter Ranch	91326
Aylin Kazar	Porter Ranch	91326
Anne Gaynor	Porter Ranch	91326
Linda Snow	Porter Ranch	91326
Emilia Rivas	Rancho Palos Verdes	90275
Jonilyn Blandy	Rancho Palos Verdes	90275
David Brown	Rancho Palos Verdes	90275
Leyra Gamborino	Rancho Palos Verdes	90275
Gloria Schwob	Rancho Palos Verdes	90723
Carol Wirth	Rancho Palos Verdes	90275
Rowyn Murray	Ranchos Palos Verdes	90275
Linda Schultz	Redondo Beach	90277
Bob Stevens	Redondo Beach	90277
Paul Tjostem	Redondo Beach	90277
Nancy Steward	Redondo Beach	90278

Kayden Haas	Redondo Beach	90278
David Munoz	Redondo Beach	90278
Joan Puls	Redondo Beach	90278
Favret Heather	Redondo Beach	90278
Karen Fan	Redondo Beach	90723
Diana Gallego	Redondo Beach	90038
Stephanie David	Redondo Beach	90278
Perez Angel	Redondo Beach	90278
James Alan	Redondo Beach	90278
Hailey King	Reseda	91335
Gianna Bautista	Reseda	91335
Ashley Casas	Reseda	91335
Kayla Pineda	Reseda	91335
Dominick Gastelum	Reseda	91335
Andrea Shapiro	Reseda	91335
Francesca Gandarilla	Reseda	91335
Zen Cape	Reseda	91335
Jan Gardner	Rolling Hills Estates	90274
Danielle Morales	Rosemead	91770
Michael Rodriguez	Rosemead	91770
Kris Woods	Rosemead	90717
Elizabeth Given	Rowland Height	90069
Kevin Lee	Rowland Heights	91748
Tiffany Smith	Rancho Palos Verdes	90275
Richard Ludden	San Bernardino	90404
Cork Riopka	San Dimas	91773
Shannon Magallanes	San Dimas	91773
Kyle Clark	San Dimas	91773
Emilee Clark	San Dimas	91773

Donita Kritzell	San Dimas	91773
Erica Jacobo	San Fernando	91340
Martin Lara	San Fernando	91340
Selina Ho	San Gabriel	91775
Roxie Hsu	San Gabriel	91776
Linda Gonzales	San Pedro	90731
Rachel White	San Pedro	90731
Mary Anderson	San Pedro	90731
Lori Kegler	San Pedro	90731
Jennifer Garcia	San Pedro	90731
Jayne Ure	San Pedro	90731
Geralyn Krajeck	San Pedro	90731
Amber Guido	San Pedro	90731
Janet Merrill	San Pedro	90732
Gabriel Alcoset	San Pedro	90732
Krystal Manning	San Pedro	90732
Lisa Colton	San Pedro	90035
Billie Bates	San Pedro	91205
Justina Palicte	San Pedro	90745
Yolanda Gonzales	San Pedro	90255
Melissa Marroquin	San Pedro	90731
Dolores Marquez	San Pedro	90731
Lance Rounick	San Pedro	90731
Amel Baros	Santa Clarita	91356
Carlos Guzman	Santa Fe Springs	90670
Debbie Becerra	Santa Fe Springs	90670
Fallyn Mills	Santa Fe Springs	91204
Kimberlee Mahnken	Santa Monica	90401
Sydney Krasny	Santa Monica	90402

Diane Olson	Santa Monica	90403
Cynthia Carlomagno	Santa Monica	90403
Hernan Rivera	Santa Monica	90403
Dianna Linden	Santa Monica	90403
Paul Stills	Santa Monica	90403
Parker Taylor	Santa Monica	90404
Sierra Carrillo	Santa Monica	90404
Maddie Braun	Santa Monica	90404
Maddie Braun	Santa Monica	90404
Lania Whiteside	Santa Monica	90405
Myra Schegloff	Santa Monica	90405
Jennifer-Lynn Jankesh	Santa Monica	90405
Michael Moore	Santa Monica	90405
Maxine Williams-Gboizo	Santa Monica	90405
Robert Holden	Santa Monica	90405
Jacquelyn Otero	Santa Monica	90755
Lara Ingraham	Santa Monica	90038
Rick Mitton	Santa Monica	90068
Pedro Hernandez	Santa Monica	90744
Ben Anderson	Santa Monica	90403
Marjorie Manley	Sherman Oaks	91403
Marlena Vasquez	Sherman Oaks	91403
Alex Morales	Sherman Oaks	91423
Larsen Cottrell	Sherman Oaks	91423
Kathryn Murray	Sherman Oaks	91423
Paula Laddusire	Sherman Oaks	91423
Gail Greenlee	Sherman Oaks	91303
Michael Higgins	Sherman Oaks	90038
Allen Levin	Sherwood Forest	91325

Collette Snoonian	Sherwood Forest	91325
Lilly Lopez	Signal Hill	90755
Natacha Algarin	Signal Hill	90603
Joana Cadena	Signal Hill	90255
Ariel Lazarus	Los Angeles	90046
Erika Zavala	South El Monte	91733
Samantha Jones	South El Monte	91733
Donna Obregon	South El Monte	91733
Cindy Eckert	South Gate	90280
Katherine Pantoja	South Gate	90280
Josefina Ramirez	South Gate	90280
Abby Castillo	South Gate	90280
Alice Bowen	South Gate	90280
Dalthon Miranda	South Gate	90280
Luz Zepeda	South Gate	90280
Raquelle Miranda	South Gate	90280
Jeffrey Travers	South Gate	90280
Sasha Burroughs	South Gate	91791
Sophia Rivera	South Gate	90280
Travis Graves	South Gate	90280
Betsy Jackson	Studio City	91604
Caren Lieberman	Studio City	91604
Linda Miller	Studio City	91604
Nancy Porras Knight	Studio City	91604
Bob Andres	Studio City	91604
Peifen Ko	Studio City	91105
Robert Abram	Studio City	90011
Wilbert Cortez	Sun Valley	91352
Vanessa Armstrong	Sun Valley	91352

Alexis Martinez	Sun Valley	91352
Bryan Holland	Sun Valley	91352
Rick Mroczek	Sun Valley	91792
Jorge Calixto	Sun Valley	90013
Lindzy Gonzalez	Sun Valley	90670
Angelica Perez	Sun Valley	91352
Christine Hernandez	Sun Valley	91352
Max Pierce	Sunland	91040
Craig Reardon	Sunland	91301
Adam Gonzalez	Sunland	91744
Layla Lepisto	Sunland	91040
Hannah Collins	Sunland	90805
Rosa Garcia	Sylmar	91342
Teresa Puga	Sylmar	91342
Jasmine Minchez	Sylmar	91342
Liliana Mendoza	Sylmar	91342
Rene' Gomez	Sylmar	91342
Samuel Martinez	Sylmar	91342
Kaireen Del Rosario	Sylmar	91342
Alexya Mariscal	Sylmar	91342
Robert Lentz	Sylmar	91342
Carolyn Urrutia	Sylmar	91342
Roger Hollander	Sylmar	91356
Adriana Ferri	Sylmar	91403
Ashlee Martinez	Sylmar	91342
Jessica Sosa	Sylmar	90744
Marissa Brink	Tarzana	91356
Ryan Manning	Tarzana	91356
Marissa Carus	Tarzana	91356

Kay Pen	Tarzana	91356
Marilyn Paladin	Tarzana	91356
Roselyn Anderson	Tarzana	90715
Sophia Zaragoza	Tarzana	91356
Michael Schaller	Temple City	91780
Gail Fierro	Temple City	91780
Abigail Maurer	Thousand Oaks	91361
Joy Mcmahan	Thousand Oaks	91361
Sampath Palaniswamy	Thousand Oaks	91362
Susan Schell Ryan	Thousand Oaks	91362
Robert Labelle	Thousand Oaks	91362
Jeannette Welling	Thousand Oaks	91362
Michael Raysses	Thousand Oaks	91362
Teri Taylor	Thousand Oaks	91362
Isabel Freeman	Topanga	90290
Debie Orrell	Topanga	90290
Jane August	Topanga	90290
Penelope Ward	Topanga	90290
Alanna Ginsberg	Topanga	90290
Beth Goode	Topanga	90290
James Mccue	Torrance	90501
Stephen Martinez	Torrance	90503
Carolyn Garcia	Torrance	90504
Lance Bello	Torrance	90504
Mario Martínez	Torrance	90504
Sylvia Assalit	Torrance	90505
Stephanie Greenwald	Torrance	90808
Debra Mcconville	Torrance	91040
Diane Ortiz	Torrance	91206

Gabi Rodriguez	Torrance	90505
Richard Cupertino	Valley Glen	91401
Danica Mitchell	Valley Village	91607
Michelle Nakamoto	Valley Village	91607
Hope Harris	Valley Village	90814
Cristina Estrada	Valley Village	91607
Amparo Fabiana Chepote	Van Nuys	91401
Bob Druwing	Van Nuys	91401
Helen Miller	Van Nuys	91401
Aleta Halter	Van Nuys	91401
Nancy Walder	Van Nuys	91401
Erik Vanlier	Van Nuys	91405
Ronald Jackson	Van Nuys	91406
Violet Garcia	Van Nuys	91411
Alma Ortiz	Van Nuys	91411
Melissa Phillips	Van Nuys	90210
Diane Noya	Van Nuys	91342
Michael Crosby	Van Nuys	91331
Susan Friedman	Venice	90291
Lydia Ponce	Venice	90291
Quin Potter	Venice	90291
Christina Marquez	Venice	90291
Michelle Appel	Venice	90291
Titiphan Vutiprichar	Venice	90291
Jessica-Rose Garcia	Venice	90292
Alex Sepe	Venice	90291
Katie Dean	Venice	90291
Robert Clark	West Covina	91791
Chrisina Nille	West Hollywood	90069

Deborah Ebersold	West Hollywood	90046
Sara Ulrich	Walnut	91789
Jules Martinez	Walnut	91789
Conan Mendoza	Walnut	91789
Mia Barcelo	Walnut	91789
Ronald Gonzalez	Walnut	91789
Gabriela Rubio	West Covina	91790
Caroline Greenhouse	West Covina	91790
Marie Waltner	West Covina	91790
Gina Perez	West Covina	91791
Alyssa Eller	West Covina	91791
Gael Martinez	West Covina	91791
Jacqueline Vrooman	West Covina	91792
Marisa Reyes	West Covina	90732
Cindy Stanford	West Covina	90505
Analuisa Espinoza	West Covina	90603
Brigitte Beale	West Covina	91790
Brianna Fierro	West Covina	91791
Constance Smith	West Covina	92821
Rebecca Clark	West Hills	91307
James Jones	West Hills	91304
Maerav Chiprut	West Hills	91307
Rebecca Kaplan	West Hills	91307
Iris Grimes	West Hills	90805
Brad Edwards	West Hollywood	90046
Pablo Casados	West Hollywood	90046
Darlene Gobel	West Hollywood	90046
Shirleen Mojica	West Hollywood	90046
Jefferson Stein	West Hollywood	90048

Estie Stoll	West Hollywood	90069
Petra Kovacs	West Hollywood	90069
Sabrina Munoz	West Hollywood	90650
Jana Hinrichs	West Hollywood	90603
Mark Yampolsky	West Hollywood	91607
Lorry Goldman	West Hollywood	90069
Britney Euan	Westlake Village	91361
Carmen Perez	Westlake Village	91361
Antoinette Zanon	Westlake Village	91361
Karin Langer	Westlake Village	91362
Oscar Guzman	West Covina	90712
Hailey Valles	Whittier	90601
Star Valentino	Whittier	90601
Carlos Rodriguez	Whittier	90601
Betsy Kellas	Whittier	90601
Maria Campos	Whittier	90602
Karla Smith	Whittier	90602
Lynda Jones	Whittier	90603
Dawn Hoerner	Whittier	90604
Rebecca Ceniceros	Whittier	90604
Jonan Plueger	Whittier	90604
Madeline Shapiro	Whittier	90605
Alejandro Barcenas	Whittier	90605
Joe Lopez	Whittier	90606
Andy Castillo	Whittier	90004
Jacqueline Graham	Whittier	90804
Alexander Difiore	Whittier	90046
Richard Dawson	Whittier	90026
Rachel Anketell	Whittier	90046

Vivian Valenzuela	Whittier	90603
Aimee Campos	Whittier	90605
Karla Espinoza	Whittier	90606
Rachel Velasquez	Whittier	90605
Steven Running	Wilmington	91702
Lucila Rodriguez	Wilmington	90255
Kianna Estrada	Wilmington	90604
Emilie Germain	Wilmington	90026
Belinda Mitchell	Wilmington	90744
Matthew Peterson	Winnetka	91306
Mark Harris	Winnetka	91306
Michelle Ramnarine	Winnetka	91306
Annahi Tetlalco	Winnetka	91306
Martitia Palmer	Winnetka	91306
Johnny Pujols	Winnetka	90020
Greg Leon	Woodland Hills	91303
Bob Miller	Woodland Hills	91364
Cheri Woods	Woodland Hills	91364
Dylan Fingeret	Woodland Hills	91364
Dakota Mitchell	Woodland Hills	91367
Ruth Kellener-Fehte	Woodland Hills	91367
Michael Milman	Woodland Hills	91367
Mark Shahin	Woodland Hills	91367
Alicia Austin	Woodland Hills	91606
Dana Buchanan	Woodland Hills	90026
Kimberly Palacios	Woodland Hills	91304
Mina Mortezai	Woodland Hills	91364

Empowering People to make Safer Technology Choices

January 6, 2023

Los Angeles Board of Supervisors
Hilda Solis, Holly J. Mitchell, Lindsey Horvath, Janice Hahn, and Kathryn Barger
856 Kenneth Hahn Hall of Administration
500 West Temple Street
Los Angeles, CA 90012

Re: Proposed changes to Titles 16 and 22 to the Los Angeles County Code

Dear Board of Supervisors:

I have just read the anemic changes made by staff for Title 16 & 22. I'm very disappointed.

LA County is on the cusp of approving a wireless ordinance for infrastructure that will impact every individual and business in the County. Instead it's being given less weight than a permit for a shed! It appears that staff want to rubber stamp the permitting process for this infrastructure, that they do not want to take on the challenge of writing a meaningful ordinance and that they consider the responsibility a burden.

It also seems to me that even the weak, anemic additions added to Title 16 & 22 is an admission that your hands are not tied, so why does staff continue to push back? The misinformation that their "*hands are tied*" seems to be a welcome conclusion for them. I implore the Board to take action and direct staff to do their job!

The ordinance as written lacks any fact-finding requirements or evidentiary guidance. Without this, the ordinance is just words on paper and in my opinion a ploy to pacify the Board. I feel we are all being played.

You have had the opportunity to work with the Fiber First LA experts and we have even gone so far as to take the time to draft a redline copy of Title 16 & 22 with meaningful language that would be a win-win for the County.

Isn't it time to roll up our sleeves and create an ordinance that will give the Board, staff and County residents something substantial, meaningful and something to be proud of?

Doing the right thing might be hard, but in the long run, it serves those you purport to want to serve and protect. The unserved and underserved of L.A. County.

Regards,

Jodi Nelson

Director of Californians for Safe Technology

From: Pat Gray
To: ExecutiveOffice
Subject: Fiber Optic cable
Date: Tuesday, January 3, 2023 9:47:14 AM

The LA County Planning Department must be required to prepare an Environmental Impact Report ("EIR") to consider potential environmental impacts, including increased fire risk and impacts to historical resources on ALL telecom permit applications as they relate to Titles 16 and 22 of the County Code.

These Amendments will increase Fire Risk. Four of the last major local fires have been caused by telecommunications equipment**.**

The claim that hundreds of new small cells are required for 911 calls is false. With loss of electricity, all 911 calls will depend solely upon the macro towers that have already been backed up per the California Public Utilities Commission (CPUC) Order.

Wireless broadband uses ten times as much energy as fiber optic broadband, therefore significantly increasing our carbon footprint. The Board of Supervisors should prioritize fast, reliable and secure future-proof fiber to the home for everyone in Los Angeles County.

Do not remove our long standing protections of **CEQA** - California Environmental Quality Act, **NEPA** - National Environmental Policy Act, and **NHPA** - National Historic Preservation Act, that protect us and our neighborhoods.

The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest.

These Amendments would give away the County's ability to decide whether a proposed facility is necessary and in a proper location.

The LA County Board of Supervisors are citizens' first and only line of defense against any irresponsible placement and construction of telecommunications equipment; it is not true that your hands are tied. This is supported by Congress, the FCC and the Courts.

P A Gray

From:	ExecutiveOffice
To:	PublicComments
Subject:	FW: Cell Tower
Date:	Thursday, January 5, 2023 4:16:58 PM

The following correspondence is being forwarded to you for your review/information.

From: Glenda castaneda <cabbagerose33@yahoo.com>
Sent: Thursday, January 5, 2023 12:09 PM
To: First District <firstdistrict@bos.lacounty.gov>; Holly J. Mitchell <HollyJMitchell@bos.lacounty.gov>; Third District <ThirdDistrict@bos.lacounty.gov>; Barger, Kathryn <Kathryn@bos.lacounty.gov>; ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Subject: Cell Tower

I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I/We also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

Best Regards,

From: ExecutiveOffice
To: First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn
Cc: PublicComments
Subject: FW: Oppose Amendments to Titles 16 & 22
Date: Tuesday, January 3, 2023 2:45:43 PM

The following correspondence is being forwarded to you for your review/information.

From: Scot Soller <scot.soller@yahoo.com>
Sent: Tuesday, January 3, 2023 10:56 AM
To: ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Subject: Oppose Amendments to Titles 16 & 22

CAUTION: External Email. Proceed Responsibly.

I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the January 10th LA County Board of Supervisors Meeting.

Don't take away our rights and protections.
I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code.
Please vote NO.
I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

Sincerely,
Scott Soller

From: ExecutiveOffice
To: PublicComments
Subject: FW: Please VOTE NO on Amendments to Titles 16 & 22 of LA County Code at Jan 10 BOS Meeting
Date: Thursday, January 5, 2023 4:10:48 PM

The following correspondence is being forwarded to you for your review/information.

From: Julie Levine <juliemagic2010@gmail.com>
Sent: Thursday, January 5, 2023 7:53 AM
To: Third District <ThirdDistrict@bos.lacounty.gov>; First District <firstdistrict@bos.lacounty.gov>; Holly J. Mitchell <HollyJMitchell@bos.lacounty.gov>; Supervisor Janice Hahn (Fourth District) <fourthdistrict@bos.lacounty.gov>; Barger, Kathryn <Kathryn@bos.lacounty.gov>; ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Subject: Please VOTE NO on Amendments to Titles 16 & 22 of LA County Code at Jan 10 BOS Meeting

CAUTION: External Email. Proceed Responsibly.

Honorable Supervisors,

I urge the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted
by Fiber First LA, and that the Categorical Exemptions to CEQA in Titles 16 & 22 be reversed
so the County Code complies fully with CEQA. I request my written comments be part of the public record
for Amendments to Titles 16 & 22 of LA County Code at the
January 10th LA County Board of Supervisors Meeting.

Don't take away our rights and protections.

I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.
I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

The redline changes from Fiber First LA provide critical safety protections for LA County.

The LA County Planning Department must be required to
prepare an Environmental Impact Report ("EIR") to consider potential environmental impacts, including increased fire risk and impacts to historical resources on ALL telecom permit applications as they relate to Titles 16 and 22 of the County Code.

These Amendments will increase Fire Risk. Four of the last major local fires have been caused by telecommunications equipment.

The claim that hundreds of new small cells are required for 911 calls is false. With loss of electricity, all 911 calls will depend solely upon the macro towers that have already been backed up per the California Public Utilities Commission (CPUC) Order.

Wireless broadband uses ten times as much energy as fiber optic broadband, therefore significantly increasing our carbon footprint. The Board of Supervisors should prioritize fast, reliable and secure future-proof fiber to the home for everyone in Los Angeles County.

Do not remove our long standing protections of **CEQA** - California Environmental Quality Act, **NEPA** - National Environmental Policy Act, and **NHPA** - National Historic Preservation Act, that protect us and our neighborhoods.

Julie Levine
PO Box 1705
Topanga, CA 90290

From: Pat Gray
To: ExecutiveOffice
Subject: Wireless
Date: Tuesday, January 3, 2023 9:44:52 AM

CAUTION: External Email. Proceed Responsibly.

I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the
January 10th LA County Board of Supervisors Meeting.

Don’t take away our rights and protections.
I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.
I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

P A Gray

From: Roy E Tuckman
To: ExecutiveOffice
Subject: 5G
Date: Friday, January 6, 2023 9:09:12 AM

CAUTION: External Email. Proceed Responsibly.

Please STOP the construction and placement of 5G towers.

The FCC has done ONE experiment on their effects -- they do not set fire to 'straw men.'

But what is ignored are 10,000 studies demonstrating the vital damages to our brains from the 'vibrations.' They deserve a look!!

Thank you,

Roy Tuckman
3661 Regal Pl. Apt 5
Los Angeles, CA 90068

From: johannafinney
To: First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject: Vote NO on the proposed amendments to Titles 16 and 22 of the LA County Code
Date: Thursday, January 5, 2023 5:50:42 PM

Dear Supervisors,

I support the residents of Los Angeles County who do not want a cell tower or small cell facility installed right outside their homes or in their neighborhoods without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

Reverse the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

Sincerely,
Johanna Finney

From:	Stephanie de Phillipo
To:	ExecutiveOffice
Subject:	oppose amendments 16 and 22
Date:	Friday, January 6, 2023 2:43:09 PM

Please send to all supervisors.

I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.

I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the
January 10th LA County Board of Supervisors Meeting.

Don’t take away our rights and protections.
I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO. I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

The LA County Planning Department must be required to prepare an Environmental Impact Report (“EIR”) to consider potential environmental impacts, including increased fire risk and impacts to historical resources on ALL telecom permit applications as they relate to Titles 16 and 22 of the County Code.

These Amendments will increase Fire Risk. Four of the last major local fires have been caused by telecommunications equipment**.**

The claim that hundreds of new small cells are required for 911 calls is false. With loss of electricity, all 911 calls will depend solely upon the macro towers that have already been backed up per the California Public Utilities Commission (CPUC) Order.

Wireless broadband uses ten times as much energy as fiber optic broadband, therefore significantly increasing our carbon footprint. The Board of Supervisors should prioritize fast, reliable and secure future-proof fiber to the home for everyone in Los Angeles County.

Do not remove our long standing protections of **CEQA** - California Environmental Quality Act, **NEPA** - National Environmental Policy Act, and **NHPA** - National Historic Preservation Act, that protect us and our neighborhoods.

The radiation emitted from cell towers is not safe for humans or our natural world; therefore the placement of these antennas is a matter of urgent public interest.

These Amendments would give away the County’s ability to decide whether a proposed facility is necessary and in a proper location.

The LA County Board of Supervisors are citizens' first and only line of defense against any irresponsible placement and construction of telecommunications equipment; it is not true that your hands are tied. This is supported by Congress, the FCC and the Courts.

Thank You,
Stephanie de Phillipo

From: market777watch
To: ExecutiveOffice
Subject: Amendments to Titles 16 & 22 of the L.A. County code at the January 10th L.A. County Board of Supervisors Meeting.
Date: Thursday, January 5, 2023 1:08:39 PM
Importance: High

CAUTION: External Email. Proceed Responsibly.

January 5, 2023

To whom it may concern & for your consideration, I live in Redondo Beach, can you please forward to the appropriate person?

I request my written comments be part of the public record for Amendments to Titles 16 & 22 of the L.A. County code at the January 10th L.A. County Board of Supervisors Meeting.

Don't take away our rights and protections. I oppose L.A. County's proposed amendments to Titles 16 & 22 of the L.A. County Code. Please VOTE NO!

I do not want a cell tower or small cell facility installed right outside of my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First L.A.

Thank you,

Linda Jacard

Cc: firstdistrict@bos.lacounty.gov

hollyjmitchell@bos.lacounty.gov

ThirdDistrict@bos.lacounty.gov

FourthDistrict@bos.lacounty.gov

Kathryn@bos.lacounty.gov

executiveoffice@bos.lacounty.gov

Sent from my Galaxy

From: Judy Frankel
To: ExecutiveOffice; First District; Holly J. Mitchell; Third District; Barger, Kathryn; Supervisor Janice Hahn (Fourth District)
Subject: NO on Title 16 and 22! No cell towers without my input
Date: Thursday, January 5, 2023 12:22:42 PM

To the Board of Supervisors,
I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.
I want a reversal of the Categorical Exemptions to CEQA (CA Environmental Quality Act) in Titles 16 & 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

Please, Janice Hahn, vote NO on Title 16 & 22. Stop giving the telecom industry carte blanche for installing their 5G small cell towers wherever they choose without any input from us, the people whose properties are involved!
Sincerely,
Judy Frankel
PS. To my neighbors: the deadline for calling Janice Hahn to tell her to vote NO is January 9th. They are voting on January 10th.

Judy Frankel
Judy's Homegrown
land 310-750-6686
cell 310-594-1198

"Too many of us are not living our dreams because we are living our fears."
- Les Brown

"The most precious gift we can offer others is our presence. When our mindfulness embraces those we love, they will bloom like flowers." --Thich Nhat Hanh

"The first to apologize is the bravest. The first to forgive is the strongest. The first to forget is the happiest." ~Anon

From:	DRP Ordinance Studies
To:	Submit
Cc:	Bruce Durbin; Amy J. Bodek; Elaine Lemke; Roland Trinh; Carole Suzuki; Connie Chung
Subject:	Fwd to LS (mo) FW: For the Public Record. LA County"s proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.
Date:	Monday, January 9, 2023 7:29:32 AM
Attachments:	Expert Letters Filed to FCC Caling For Record Refresh Wireless Radiation .pdf Washington-Spectator-5G 2022Full article .pdf Cell Tower Laws in US and International .pdf EMF and Wildlife Part 2.pdf Doctor Letters on Health Effects of Cell Tower Radiation .pdf Risks to Health and Well-Being From Radio-Frequency Radiation Emitted by Cell Phones and Other Wireless Devices davis copy 4.pdf Thermal and non-thermal health effects of low intensity non-ionizing radiation- An international perspective.pdf Harvard Report.pdf New Scientific Developments in Radiofrequency Radiation FCC EHT Remand-5.pdf European Parliament Report Health Risks of 5G .pdf 31 - Base Stations and Human Hormone Profiles.pdf 30 - Subjective symptoms GSM radiation mobile phone base stations.pdf

ALYSON STEWART (she/her/hers)

SENIOR PLANNER, Ordinance Studies | ALUC

From: Theodora Scarato <Theodora.Scarato@ehtrust.org>
Sent: Saturday, January 7, 2023 5:54 AM
To: DRP Ordinance Studies <ordinance@planning.lacounty.gov>; Elida Luna <ELuna@planning.lacounty.gov>; DRP Info <info@planning.lacounty.gov>; firstdistrict@bos.lacounty.gov; HollyJMitchell@bos.lacounty.gov; Sheila <Sheila@bos.lacounty.gov>; FourthDistrict@bos.lacounty.gov; Barger, Kathryn <Kathryn@bos.lacounty.gov>
Subject: For the Public Record. LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.

We oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.
We also want a reversal of the categorical CEQA exemption as it relates to Titles 16 and 22.

Please ensure this is on the official record for the March 23 Los Angeles County Planning Board Proposed Changes toCounty
Code Title 22:
We are providing information for the Board to ensure they make a well informed decision. Allowing the expansion of wireless networks near homes and schools will adversely impact public health as well as the health of wildlife and trees.

A Climate impact assessment must be done as wireless densification will increase energy consumption. Further an environmental assessment must be done on the proposed networks before deployment as research indicates harm to trees, birds and bees.

All links submitted by reference. Published Research Indicating 5G/4G Densification Will Increase RF Radiation and Harm People, Wildlife and Trees Part1

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Theodora Scarato
Executive Director
Environmental Health Trust
EHTrust.org

Our Mission
To safeguard human health and the environment by empowering people with state-of-the-art information.

Sign up for Environmental Health Trust's newsletter here.

November 24, 2021

The Honorable Jessica Rosenworcel, Commissioner
Acting Chairwoman
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Dear Chairwoman Rosenworcel,

We write to you as scientists and public health experts deeply committed to protecting public health and the environment. As authors of numerous publications and reports in the field we urge that the FCC ensure a robust review of the latest science and expert recommendations in the FCC's upcoming reexamination of its Inquiry on human exposure limits for wireless radiation. The major scientific developments of the last two years must be included in the FCC review- especially in the new 5G environment where wireless is ubiquitous.

We request the FCC reopen Docket #13-84 "Reassessment of FCC Radiofrequency Exposure Limits and Policies" and Docket #03-137 'Proposed Changes to the Commission Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields" in order to refresh the record before issuing a final response to the recent August 13, 2021 judgment by the U.S. Court of Appeals for the District of Columbia Circuit, in Environmental Health Trust et al. v. the FCC.

Furthermore, as the FCC does not have expertise in interpreting scientific studies, it relies on input from federal health agencies and knowledgeable expert organizations to evaluate the scientific evidence and the adequacy of FCC limits. However the relevant US health and safety agencies have not reviewed the research on impacts to flora and fauna; long-term exposures from cell towers; children's unique vulnerability; and health effects such as damage to the brain and reproduction. The court noted that the "silence" of federal agencies such as the National Cancer Institute, the Environmental Protection Agency, the Centers for Disease Control and Prevention, and the National Institute for Occupational Safety and Health does not mean these agencies agree with the FCC's 1996 limits. In fact, none of these agencies has systematically reviewed the totality of science in their respective area of expertise both to develop safety standards and to offer an analysis of the adequacy of FCC's 1996 wireless exposure limits.

Accordingly, we recommend that the FCC record be reopened with ample time to allow for new substantive comments. U.S. safety limits for cell phones and cell towers must rest on sound science to ensure the public and wildlife are protected.

Importantly, we also recommend a full environmental impact review to evaluate 5G and the rapid proliferation of 4G wireless antennas in the USA. A three part review published in Reviews in Environmental Health found the scientific evidence showing adverse effects is sufficient to trigger new regulatory action to protect wildlife, yet the US does not have regulations that were ever designed to protect flora and fauna (1). Instead, the FCC is fast tracking small cell deployment and opening new spectrum disregarding recent research which finds, for example, that the higher frequencies of 5G can result in higher absorption rates into the bodies of pollinators.

In addition, experts are warning that 5G will contribute to climate change and have documented the exponentially increasing energy demands of 5G networks, “smart” wireless devices, and other new communication technologies. As the FCC has projected hundreds of thousands of new wireless facilities, we recommend a full environmental assessment for the 5G rollout and 4G wireless network densification.

The scientific evidence has substantially increased over the last two years (2). In 2020 scientists of the National Institute of Environmental Health Sciences National Toxicology Program published their animal-study findings of “significant increases in DNA damage” in groups of mice and rats after just 14 to 19 weeks of exposure to cell phone radiation (3). A 2021 analysis published by the Environmental Working Group concluded FCC limits should be 200 to 400 times more protective than the whole-body exposure limit set by the FCC in 1996 (4). Unaware of the scientists calling for caution, school districts nationwide are deploying high-capacity Wi-Fi networks in school buildings, testing out 5G networks with students, and signing leases with companies to install cell towers on school property, relying on these outdated FCC limits. As the American Academy of Pediatrics and numerous other specialists have noted, children are uniquely vulnerable to wireless radiation (5).

Health risks should be assessed by experts with no conflicts of interest. The FCC should not rely on the International Commission on Non-Ionizing Radiation Protection (ICNIRP), a small 14 member privately constituted invite only Commission lacking in transparency whose self-appointed membership has conflicts of interest and industry ties (6). ICNIRP has rejected the NTP and Ramazzini Institute animal studies with unfounded criticisms (7). Further, ICNIRP has not shown any systematic review of the totality of the research such as impacts to the developing brain and damage to reproduction. It has never conducted a comprehensive evaluation of human health and environmental risks associated with RF radiation. Their exposure guidelines are based solely on protecting against heating effects, with no change of concept since 1998, two years after the FCC adopted human exposure guidelines in 1996.

Broadband internet provides the connectivity that enables Americans to do their jobs, to participate equally in school learning and health care, and to create a fairer playing field by eliminating the digital divide. The United States must bridge the digital divide with a “future-proof” broadband infrastructure with wired *rather than wireless* connections to and through homes, schools and businesses that is affordable, reliable, high-speed, and sustainable.

Wherever possible, we urge that the broadband system rely on wired connections, rather than wireless connections. Wired connections are safer, faster, more secure, more energy efficient, and more reliable. Wired connections are especially important for schools and other institutions where they will save money and reduce exposure to wireless radiation.

Our experts stand ready to provide more detailed information to you on this important issue, including elaborating on materials and assistance with evaluating the science and impacts on humans, climate, animals, and wilderness.

Sincerely,

Linda S. Birnbaum, PhD
Scientist Emeritus and Former Director
National Institute of Environmental Health Sciences and National Toxicology Program
Scholar in Residence, Duke University, Former President, Society of Toxicology
Adjunct Professor, Yale University and UNC, Chapel Hill, Visiting Professor, Queensland University

Ronald L Melnick, PhD
retired from 28 years at National Institutes of Health
former Director of Special Programs in the Environmental Toxicology Program at the National Institute of Environmental Health Sciences at NIH

Jerome A. Paulson, MD, FAAP
Professor Emeritus of Pediatrics and of Environmental & Occupational Health
George Washington University School of Medicine and Health Sciences and George Washington University Milken Institute School of Public Health

Devra Davis, PhD, MPH
Fellow, American College of Epidemiology
Associate Editor, Frontiers in Radiation and Health
President and Co-Founder, Environmental Health Trust

Ronald M. Powell, PhD
U.S. Government career scientist (Applied Physics)
Retired from the National Institute of Standards and Technology

David O. Carpenter, MD
Director, Institute for Health and the Environment
A Collaborating Center of the World Health Organization
University at Albany, New York

Anthony Miller, MD
Professor Emeritus of University of Toronto
Senior Advisor to Environmental Health Trust
Former Assistant Executive Director (Epidemiology), National Cancer Institute of Canada
Former Director, Epidemiology Unit, National Cancer Institute of Canada, Toronto
Former Director, M.Sc./PhD Programme in Epidemiology, Graduate Dept. of Community Health, University of Toronto
Former Chairman, Department of Preventive Medicine and Biostatistics, University of Toronto

Kent Chamberlin, PhD
Professor & Chair Emeritus
Department of Electrical & Computer Engineering
University of New Hampshire
Commission Member on the New Hampshire Commission on 5G

Dr. Fiorella Belpoggi
Scientific Director, Ramazzini Institute
Bologna Italy

Livio Giuliani, PhD
European Cancer Research Institute
International Commission for Electromagnetic Safety

Morando Soffritti, MD
Honorary President and Former Scientific Director of Ramazzini Institute
Bologna, Italy

Rodolfo E. Touzet, PhD
Latinamerican Federation for Radiological Protection (past-president)
National Cancer Institute - Advisory Board Member
International Radiological Protection Association- Exec. Committee Elected member

Theodora Scarato, MSW
Executive Director, Environmental Health Trust

Colin L. Soskolne, PhD
Professor Emeritus, University of Alberta, Canada
Emeritus Fellow, American College of Epidemiology
Emeritus Fellow, Collegium Ramazzini
Recipient of the 2021 RESEARCH INTEGRITY AWARD of the
International Society for Environmental Epidemiology

Paul Héroux, PhD
Professor of Toxicology and Health Effects of Electromagnetism
McGill University Medicine
Department of Surgery, McGill University Health Center
InVitroPlus Laboratory

Paul Ben-Ishai, PhD
Department of Physics, Ariel University, Israel
Advisor to Environmental Health Trust

Meg Sears PhD
Sr. Clinical Research Associate, Ottawa Hospital Research Institute, Canada
Chairperson, Prevent Cancer Now

Claudio Fernández Rodríguez
Associate Professor, Federal Institute of Technology of Rio Grande do Sul, IFRS, Brazil

Alvaro Augusto de Salles, PhD
Professor and Chair, Federal University of Rio Grande do Sul, P. Alegre, Brazil

Igor Belyaev, PhD, DrSc
Associate Professor, Head of Department of Radiobiology
Cancer Research Institute, Biomedical Research Center, Slovak Republic

Marc Arazi MD
President Phonegate Alert NGO

Frank Clegg
CEO, Canadians For Safe Technology
Former President of Microsoft Canada

John Frank MD, CCFP, MSc, FRCPC, FCAHS, FFPH, FRSE, LLD,
Professorial Fellow (formerly Chair, Public Health Research and Policy,
and Director of Knowledge Exchange and Research Impact),
Usher Institute (of Population Health Sciences and Informatics), University of Edinburgh;
Professor Emeritus, Dalla Lana School of Public Health, University of Toronto;
Honorary Public Health Consultant, Public Health Scotland

David Gee
Centre for Pollution Research and Policy, Brunel University

Suleyman Dasdag, Full Professor of Biophysics,
Medical School of Istanbul Medeniyet University,
Istanbul, Turkey

Christos D. Georgiou, PhD
Professor Emeritus of Biochemistry
Biology Department, University of Patras, Greece
URL: http://www.biology.upatras.gr/wp-content/uploads/cv/CV_Ch.Georgiou_EN.pdf

Prof. Dominique Belpomme, MD, Director, European Cancer and Environment Research Institute (ECERI); Bruxelles, Belgium; President, Association for Research on Treatment against Cancer (ARTAC), Paris, France

Philippe Irigaray, PhD. Association for Research on Treatment against Cancer (ARTAC), Paris, France

Dr. Pierre Madl, EE MSc,PhD, Paris Lodron University of Salzburg (PLUS), Radiological Measurement Laboratory Salzburg (RMLS), Edge Institute (AT), Austria

Stella Canna Michaelidou, PhD
Expert on the Impact of Toxic Factors on Children's Health
President of the National Committee on Environment and Children's Health, Cyprus

Adejoke Olukayode Obajuluwa PhD
Senior Lecturer & Coordinator, Biotechnology Programme
Specialization: Molecular Toxicology and Neuroscience
Afe Babalola University, Ado Ekiti, Nigeria.

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3. Smith-Roe, SL., et al. (2020) "Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure." Environmental and molecular mutagenesis, Feb;61(2):276-290
4. Uche, U.I., Naidenko, O.V. (2021) "Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach." Environmental Health 20, 84 (2021)

5. American Academy of Pediatrics Letter to the FCC on "Reassessment of Exposure to Radiofrequency Electromagnetic Fields Limits and Policies"August 29, 2013; Fernández, C., de Salles, A., Sears, M., Morris, R., & Davis, D. (2018). "Absorption of wireless radiation in the child versus adult brain and eye from cell phone conversation or virtual reality." Environmental Research, 167, 694-699. https://doi.org/10.1016/j.envres.2018.05.013
6. James C. Lin. Science, Politics, and Groupthink [Health Matters]. IEEE Microwave Magazine. 22(5):24-26.May 2021; Lennart Hardell, Michael Carlberg, Health risks from radiofrequency radiation, including 5G, should be assessed by experts with no conflicts of interest. Oncol Lett. 2020 Oct;20(4):15.; Lennart Hardell, Mona Nilsson, Tarmo Koppel, Michael Carlberg. Aspects on the International Commission on Non-Ionizing Radiation Protection (ICNIRP) 2020 Guidelines on Radiofrequency Radiation. J Cancer Sci Clin Ther. 2021; 5(2): 250-285; Hardell L. "World Health Organization, radiofrequency radiation and health – a hard nut to crack (Review)" Int J Oncol 51 (2017): 405-413; Hans van Scharen, Tomas Vanheste, Erik Lambert for European Members of Parliments Michèle Rivasi and Dr. Klaus Buchner "The International Commission on Non-Ionizing Radiation Protection: Conflicts of Interest, Corporate Capture and the Push for 5G." (PDF)
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November 19, 2021

The Honorable Jessica Rosenworcel
Chairwoman
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

Dear Chairwoman Rosenworcel,

The Environmental Working Group, a nonprofit public health research and advocacy organization with offices in Washington, D.C, Minneapolis, and Sacramento, Calif., requests that the Federal Communications Commission reopen Docket #13-84, "Reassessment of FCC Radiofrequency Exposure Limits and Policies," and Docket #03-137, "Proposed Changes to the Commission Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields," to allow robust review and consideration of scientific evidence published in the past two years and in response to the court ruling in *Environmental Health Trust et al. v. the FCC*.

Since 2009, the Environmental Working Group has extensively researched the topic of the human and environmental health impacts of radiofrequency radiation emitted from wireless communication devices. EWG also closely follows regulatory approaches and recommendations on radiofrequency radiation made by authoritative health agencies around the world. The World Health Organization states on its website:

> *… during the 20th century, environmental exposure to man-made sources of EMF steadily increased due to electricity demand, ever-advancing wireless technologies and changes in work practices and social behaviour. Everyone is exposed to a complex mix of electric and magnetic fields at many different frequencies, at home and at work, and concern continues to grow over possible health effects from overexposure.*[1]

Extensive research literature points to the potential health risks of radiofrequency radiation, particularly for the developing child. Peer-reviewed studies show that the

[1] World Health Organization, web page not dated, "Supporting the development of national policies on electromagnetic fields". https://www.who.int/activities/supporting-the-development-of-national-policies-on-electromagnetic-fields Accessed Nov. 16, 2021.

bodies of children absorb more radiofrequency radiation, compared to adults, putting children at greater health risk as a result to such exposure.[2]

Scientists and public health advocates have raised concerns for decades about the adverse health effects of exposure to electromagnetic radiation. Recent research publications highlight the severity of these impacts, especially among vulnerable populations, and the need for more stringent health-based exposure standards. In 2011, the International Agency for Research on Cancer (IARC), an agency of the World Health Organization, classified radiofrequency electromagnetic fields as "possibly carcinogenic to humans."[3]

For today's generation of children, exposure to radiofrequency radiation from wireless communication devices starts from the fetal development period as a result of wireless devices in the pregnant person's everyday environment. Following birth, today's children will be exposed to radiofrequency radiation throughout their lives – an exposure scenario that is drastically different from the very limited consumer use and exposure to wireless radiation of the 1980s and 1990s, when the basis for current FCC standards was established.

This comment letter highlights two key considerations that point to the need for the FCC to reassess existing radiofrequency exposure limits and policies:

1. A 2021 peer-reviewed publication we authored that uses Environmental Protection Agency methodology to determine protective health-based exposure limits for radiofrequency radiation, based on the U.S. government's landmark 2018 laboratory study; and
2. Recent literature that documents a range of effects of non-ionizing electromagnetic radiation on different body systems that current FCC standards do not take into account.

1. Health-based limits developed with consideration for children's health

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[2] Fernández C, de Salles AA, Sears ME, Morris RD, Davis DL. Absorption of wireless radiation in the child versus adult brain and eye from cell phone conversation or virtual reality. Environ Res. 2018; 167:694-699. https://doi.org/10.1016/j.envres.2018.05.013; Gandhi OP, Morgan LL, de Salles AA, Han YY, Herberman RB, Davis DL. Exposure limits: the underestimation of absorbed cell phone radiation, especially in children. Electromagn Biol Med. 2012; 31(1):34-51. https://doi.org/10.3109/15368378.2011.622827

[3] International Agency for Research on Cancer. IARC classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans. Press Release N: 208. 2011. https://www.iarc.who.int/wp-content/uploads/2018/07/pr208_E.pdf Accessed Nov. 16, 2021.

A peer-reviewed article published by our organization in 2021 (Uche & Naidenko, 2021)[4] documented how the current FCC exposure limit for radiofrequency radiation is not sufficient to protect the general population, especially children, against the adverse impacts associated with radiofrequency radiation exposure. The current limit, last revised a quarter-century ago – well before wireless devices became ubiquitous – needs to be updated with the latest science to be fully health protective for all users of wireless communication technologies.

Our study, published in the journal *Environmental Health*, recommends strict, lower health-based exposure standards for both children and adults for radiofrequency radiation emitted from wireless devices. This recommendation draws on data from a landmark 2018 study from the National Toxicology Program, one of the largest long-term laboratory studies on the health effects of radiofrequency radiation exposure.[5]

EWG's study used an approach similar to the methodology that the U.S. EPA developed to assess human health risks arising from toxic chemical exposures. EWG study recommends a whole-body specific absorption rate (SAR) limit of 0.2 to 0.4 mW/kg for children, which is 200 to 400 times lower than the current federal whole-body exposure limit. For adults, EWG recommends a whole-body specific absorption rate limit of 2 to 4 mW/kg, which is 20 to 40 times lower than the federal limit (Uche & Naidenko, 2021).[4]

EWG's analysis and recommendation for a much stricter limit for radiofrequency radiation exposure is a step toward advancing a re-evaluation of the existing federal limit for radiofrequency radiation exposure while reviewing the latest research on radiofrequency radiation exposure.

2. Wide range of potential impacts of non-ionizing electromagnetic radiation on human health not accounted for in the current FCC standard

[4] Uche UI, Naidenko OV. Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach. Environ Health. 2021; 20(1):84. https://doi.org/10.1186/s12940-021-00768-1

[5] National Toxicology Program. 595: NTP Technical Report on the Toxicology and Carcinogenesis Studies in Hsd: Sprague Dawley SD Rats Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. National Toxicology Program, US Department of Health and Human Services. 2018. https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr595_508.pdf?utm_source=direct&utm_medium=prod&utm_campaign=ntpgolinks&utm_term=tr595

The current FCC standard was based on the 1986 recommendations of the National Council on Radiation Protection and Measurements[6] and 1991 recommendations of the Institute of Electrical and Electronics Engineers,[7] which chose an exposure level based on behavioral changes observed in laboratory animals exposed to radiofrequency radiation for a duration of minutes to hours in studies conducted in the 1970s and 1980s. With extensive current research linking radiofrequency exposure to adverse impacts, even at exposure levels below the current federal limit, the FCC needs to review the latest science and update the allowable exposure limits.

Among the reported biological effects of electric and magnetic fields are harm to fetal growth and development (Ozgur et al., 2013);[8] changes in brain activity (Wallace and Selmaoui, 2019);[9] changes in heart rate variability (Wallace et al., 2020);[10] DNA damage (Smith-Roe et al., 2020);[11] cognitive effects (Azimzadeh and Jelodar);[12] and increased risk of cancer, including gliomas,[3] parotid gland tumors (Sadetzki et al., 2008),[13] thyroid cancers (Luo et al., 2019).[14] These adverse health effects may be associated with different mechanistic pathways, such as changes in the activity of voltage-gated calcium

[6] National Council on Radiation Protection and Measurements. Biological effects and exposure criteria for radiofrequency electromagnetic fields: NCRP Report No. 86; 1986. Available from: https://ncrponline.org/shop/reports/report-no-086-biological-effects-and-exposure-criteria-for-radiofrequency-electromagnetic-fields-1986/

[7] Institute of Electrical and Electronics Engineers. (Revision of ANSI C95.1–1982). IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz. IEEE Std C95. 1991. https://doi.org/10.1109/IEEESTD.1992.101091

[8] Ozgur E, Kismali G, Guler G, Akcay A, Ozkurt G, Sel T, et al. Effects of prenatal and postnatal exposure to GSM-like radiofrequency on blood chemistry and oxidative stress in infant rabbits, an experimental study.
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[14] Luo J, Deziel NC, Huang H, Chen Y, Ni X, Ma S, et al. Cell phone use and risk of thyroid cancer: a population-based case–control study in Connecticut. Ann Epidemiol. 2019; 29:39–45. https://doi.org/10.1016/j.annepidem.2018.10.004

channels (Blackman et al., 1991);[15] changes in the concentrations of reactive oxygen species and redox homeostasis (Ertilav et al., 2018);[16] changes in intracellular enzymes and gene expression (Fragopoulou et al.,2018);[17] and changes in membrane permeability (Perera et al., 2018).[18]

Table 1. Extensive research points to effects of non-ionizing electromagnetic radiation on individual body systems that are not considered by the current FCC standards for cell phone radiation.

Reported health effects	**Key studies**
Elevated risk of brain cancer, breast cancer, parotid gland tumors, and thyroid cancer	Choi YJ, Moskowitz JM, Myung SK, Lee YR, Hong YC. Cellular Phone Use and Risk of Tumors: Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2020; 17(21):8079. West JG, Kapoor NS, Liao SY, Chen JW, Bailey L, Nagourney RA. Multifocal Breast Cancer in Young Women with Prolonged Contact between Their Breasts and Their Cellular Phones. Case Rep Med. 2013; 2013:354682 Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdevani S, et al. Cellular phone use and risk of benign and malignant parotid gland tumors – a nationwide case-control study. American journal of epidemiology 2008; 167(4):457-67. Luo J, Li H, Deziel NC, Huang H, Zhao N, Ma S, et al. Genetic susceptibility may modify the association between cell phone

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	use and thyroid cancer: A population-based case-control study in Connecticut. Environmental Research. 2020; 182:109013.
Eye strain, damage to eye tissues cataracts	Bormusov E, P Andley U, Sharon N, Schächter L, Lahav A, Dovrat A. Non-thermal electromagnetic radiation damage to lens epithelium. Open Ophthalmol J. 2008; 2:102-6
Cardiomyopathy, heart rate variability	National Toxicology Program. 2018. Technical Report on the Toxicology and Carcinogenesis Studies in Hsd: Sprague Dawley SD Rats Exposed to Whole-Body Radio Frequency Radiation at a Frequency (900 MHz) and Modulations (GSM and CDMA) Used by Cell Phones. Wallace J, Andrianome S, Ghosn R, Blanchard ES, Telliez F, Selmaoui B. Heart rate variability in healthy young adults exposed to global system for mobile communication (GSM) 900-MHz radiofrequency signal from mobile phones. Environmental Research 2020; 191:110097
Damage to sperm, decreased male fertility	Kesari KK, Agarwal A, Henkel R. Radiations and male fertility. Reprod Biol Endocrinol. 2018; 16(1):118
Changes in brain activity Changes in blood-brain barrier	Volkow ND, Tomasi D, Wang G-J, Vaska P, Fowler JS, Telang F, et al. Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. JAMA 2011; 305(8):808-13 Wallace J, Selmaoui B. Effect of mobile phone radiofrequency signal on the alpha rhythm of human waking EEG: A review. Environmental research. 2019; 175:274-86
Changes in the immune system function	Piszczek P, Wójcik-Piotrowicz K, Gil K, Kaszuba-Zwoińska J. Immunity and electromagnetic fields. Environ Res. 2021; 200:111505.

As documented in Table 1, exposure to non-ionizing electromagnetic fields can harm a variety of organs and body systems, highlighting the urgency of a public-health-focused reassessment of existing exposure limits for radiofrequency radiation. Further, exposure to non-ionizing electromagnetic fields during pregnancy has been associated with an increased risk of miscarriage (Li et al., 2017)[19] and an increased frequency of hyperactivity and inattention during early childhood (Birks et al., 2017).[20]

In conclusion, the Environmental Working Group urges the FCC to open its record for a more comprehensive evaluation of radiofrequency radiation and update its standard to ensure the safety of wireless radiation devices for everyone, especially young children.

Submitted on behalf of the Environmental Working Group,

Uloma Igara Uche, Ph.D.
Environmental Health Science Fellow
Environmental Working Group

Olga V. Naidenko, Ph.D.
Vice President, Science Investigations
Environmental Working Group

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University of New Hampshire

College of Engineering and Physical Sciences
Department of Electrical and Computer Engineering

Kingsbury Hall
33 Academic Way
Durham, NH 03824-2619

V: 603.862.1357
F: 603.862.1832
TTY: 7.1.1 (Relay NH)

www.ceps.unh.edu/ece ece.dept@unh.edu

November 9, 2021

The Honorable Jessica Rosenworcel, Commissioner
Acting Chairwoman
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Dear Chairwoman Rosenworcel,

I am writing to request that the FCC re-open Docket #13-84 "Reassessment of FCC Radiofrequency Exposure Limits and Policies" and Docket #03-137" Proposed Changes to the Commission Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields- in order to refresh the record before responding to the mandate of the August 13, 2021 judgment by the U.S. Court of Appeals for the District of Columbia Circuit, in Environmental Health Trust et al. v. the FCC.

I am Professor and Chair Emeritus at the University of New Hampshire Department of Electrical & Computer Engineering and served on the New Hampshire State Commission on 5G Technology. After a year of investigation we issued our final report on November 1, 2020.

I want to ensure the fifteen recommendations of the expert New Hampshire State Commission are considered by the FCC. If the FCC does not re-open the record, the Report will not be available to the Commission as it was finalized in 2020.

Sincerely

Kent Chamberlin

Digitally signed by Kent Chamberlin
Date: 2021.11.09 21:21:17 -05'00'

Kent Chamberlin, PhD
Professor & Chair Emeritus

New Hampshire State Commission on 5G Technology Final Report Recommendations

RECOMMENDATION 1

Propose a resolution of the House to the US Congress and Executive Branch to require the Federal Communication Commission (FCC) to commission an independent review of the current radiofrequency (RF) standards of the electromagnetic radiation in the 300MHz to 300GHz microwave spectrum as well as a health study to assess and recommend mitigation for the health risks associated with the use of cellular communications and data transmittal.

RECOMMENDATION 2

Require that the most appropriate agency (agencies) of the State of New Hampshire include links on its (their) website(s) that contain information and warnings about RF-radiation from all sources, but specifically from 5G small cells deployed on public rights-of-way as well as showing the proper use of cell phones to minimize exposure to RF-radiation, with adequate funding granted by the Legislature. In addition, public service announcements on radio, television, print media, and internet should periodically appear, warning of the health risks associated with radiation exposure. Of significant importance are warnings concerning the newborn and young as well as pregnant women.

RECOMMENDATION 3

Require every pole or other structure in the public rights of- way that holds a 5G antenna be labeled indicating RF-radiation being emitted above. This label should be at eye level and legible from nine feet away.

RECOMMENDATION 4

Schools and public libraries should migrate from RF wireless connections for computers, laptops, pads, and other devices, to hardwired or optical connections within a five-year period starting when funding becomes available.

RECOMMENDATION 5

Signal strength measurements must be collected at all wireless facilities as part of the commissioning process and as mandated by state or municipal ordinances. Measurements are also to be collected when changes are made to the system that might affect its radiation, such as changes in the software controlling it. Signal strength is to be assessed under worst-case conditions in regions surrounding the tower that either are occupied or are accessible to the public, and the results of the data collection effort is to be made available to the public via a website. In the event that the measured power for a wireless facility exceeds radiation thresholds, the municipality is empowered to immediately have the facility taken offline. The measurements are to be carried out by an independent contractor and the cost of the measurements will be borne by the site installer.

RECOMMENDATION 6

Establish new protocols for performing signal strength measurements in areas around wireless facilities to better evaluate signal characteristics known to be deleterious to human health as has been documented through peer-reviewed research efforts. Those new protocols are to take into account the impulsive nature of high-data-rate radiation that a growing –body of evidence shows as having a significantly greater negative impact on human health than does continuous radiation. The protocols will also enable the summative effects of multiple radiation sources to be measured.

RECOMMENDATION 7

Require that any new wireless antennas located on a state or municipal right-of-way or on private property be set back from residences, businesses, and schools. This should be enforceable by the municipality during the permitting process unless the owners of residences, businesses, or school districts waive this restriction.

RECOMMENDATION 8

Upgrade the educational offerings by the NH Office of Professional Licensure and Certification (OPLC) for home inspectors to include RF intensity measurements.

RECOMMENDATION 9

The State of New Hampshire should begin an effort to measure RF intensities within frequency ranges throughout the state, with the aim of developing and refining a continually updated map of RF exposure levels across the state using data submitted by state-trained home inspectors.

RECOMMENDATION 10

Strongly recommend all new cell phones and all other wireless devices sold come equipped with updated software that can stop the phone from radiating when positioned against the body.

RECOMMENDATION 11

Promote and adopt a statewide position that would strongly encourage moving forward with the deployment of fiber optic cable connectivity, internal wired connections, and optical wireless to serve all commercial and public properties statewide.

RECOMMENDATION 12

Further basic science studies are needed in conjunction with the medical community outlining the characteristics of expressed clinical symptoms related to radio frequency radiation exposure.The majority of the Commission feels the medical community is in the ideal position to clarify the clinical presentation of symptoms precipitated by the exposure to radio frequency radiation consistent with the Americans with Disabilities Act (ADA) which identifies such a disability. The medical community can also help delineate appropriate protections and protocols for affected individuals. All of these endeavors (basic science, clinical assessment, epidemiological studies) must be completely independent and outside of commercial influence.

RECOMMENDATION 13

Recommend the use of exposure warning signs to be posted in commercial and public buildings. In addition, encourage commercial and public buildings, especially healthcare facilities, to establish RF-radiation free zones where employees and visitors can seek refuge from the effects of wireless RF emissions.

RECOMMENDATION 14

The State of New Hampshire should engage agencies with appropriate scientific expertise, including ecological knowledge, to develop RF-radiation safety limits that will protect the trees, plants, birds, insects, and pollinators.

RECOMMENDATION 15

The State of New Hampshire should engage our Federal Delegation to legislate that under the National Environmental Policy Act (NEPA) the FCC do an environmental impact statement as to the effect on New Hampshire and the country as a whole from the expansion of RF wireless technologies.

ALERT PHONE GATE

PROTECT USERS' HEALTH

November 24, 2021

The Honorable Jessica Rosenworcel
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Dear Chairwoman Rosenworcel,

I am a physician in France and for the past fifteen years I have been working on the documented health issues related to cell phone radiation as well as the cell phone SAR test procedures.

In regards to the recent U.S. DC Circuit Court of Appeals' ruling in EHT v FCC, we are writing to request that the FCC re-open Dockets #13-84 and #03-137 to allow new, significant policy developments and research be included for consideration because of it's relevance to the FCC examining its cell phone SAR testing procedures.

I am President of the Phonegate Alerte Association, formed in 2018 and our efforts to ensure transparency have led to the French government's actions to withdraw or update at least 23 models of cell phones from different manufacturers (Xiaomi, Nokia, Huawei, Wiko, Alcatel, etc.) because they were found to exceed European Union regulatory SAR limits for human exposure to radiofrequency radiation.

Similar to the FCC's regulations on cell phone test procedures, European Union regulations allow manufacturers to test cell phones at 5 mm separation distance from the body. They do not force companies to test cell phones or wireless devices at positions that are directly against the body (0 mm separation distance) *despite the reality that billions of people are using cell phones close to the body.*

The French Government is Requesting 0 mm Cell Phone Radiation Testing

In late 2019, the French government health agency ANSES issued a report[1] on the possible health effects associated with high radiation from mobile telephones carried close to the body and recommended that cell phones be tested at 0 millimeters, instead of 5 mm as the European Commission regulations require. Subsequently, France submitted a formal objection[2] to the European Commission in regards to the

[1] https://www.anses.fr/en/content/exposure-mobile-telephones-carried-close-body
[2] https://ec.europa.eu/docsroom/documents/43448

current compliance test separation distance requirements of only 5 mm. The authorities have requested that compliance test distances be revised to 0 mm

> "*Developments in the use of mobile telephones have led to a wide variety of situations in which telephones are no longer exclusively held close to a person's ear in order to hold a conversation, since they are now also used to send and receive data through various applications for listening to music, playing video games or making video calls, which means that the equipment is used in ways which were not previously foreseen. There is also a growing trend for telephones to be networked with numerous connected objects, such as headsets or watches, which tend to result in lengthy connections between a telephone and the mobile network without the telephone being held in the hand, since it is often carried in clothing and is therefore closer to – or in contact with – the trunk.*
>
> *For this reason, the French authorities believe that it is necessary to revise the harmonised standard EN 50566: 2017 concerning measurements of the SAR of devices that are hand-held or body-mounted in close proximity to the human body so that a maximum distance of 0 mm from the body is taken into consideration."*

The FCC should ensure that cell phones are tested in body contact positions at 0 mm.

For background, in 2016, the French National Frequency Agency (ANFR) officially tested various models of cell phones and found that the majority exceeded regulatory limits when tested in body contact positions - with 0 mm between the phone and simulated body testing device (aka "phantom").

Cell Phones Violate Radiation Limits

Since December 4, 2019 ANFR has posted *143 new cell phone SAR test reports*. Despite the fact that the European Union strengthened their requirements to ensure cell phones were tested at 5 mm from the body, many cell phone models are still violating the limit of 2.0 W/kg for trunk SAR when tested by ANFR (10 g of tissue). All of the test results are posted online[3].

Examples of smartphones that **violated the EU limits of 2.0 W/kg as well as the FCC limit of 1.6 W/kg when SAR radiation tested by the ANFR at 5mm include:**

- February 26, 2020: Sony Xperia 5 violated the limit at 2.64 W/kg.
- November 12, 2020: Essential Heyou 40 violated the limit at 2.54 W/kg[4]
- September 9, 2020: Essential Heyou 60 violated the limit at 2.86 W/kg[5]
- February 26, 2020: Xiaomi Mi Note 10 violated the limit at 2.45 W/kg[6]

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3 https://data.anfr.fr/explore/dataset/das-telephonie-mobile/table/?disjunctive.marque&disjunctive.modele&dataChart=eyJxdWVyaWVzIjpbeyJjb25maWciOnsiZGF0YXNldCI6ImRhcy10ZWxlcGhvbmllLW1vYmlsZSIsIm9wdGlvbnMiOnsiZGlzanVuY3RpdmUubWFycXVlIjp0cnVlLCJkaXNqdW5jdGl2ZS5tb2RlbGUiOnRydWV9fSwiY2hhcnRzIjpbeyJ0eXBlIjoibGluZSIsImZ1bmMiOiJBVkciLCJ5QXhpcyI6ImRhc190ZXRlX25vcm1lX25mX2VuXzUwMzYwIiwic2NpZW50aWZpY0Rpc3BsYXkiOnRydWUsImNvbG9yIjoiIzY2YzJhNSJ9XSwieEF4aXMiOiJkYXRlX2R1X2NvbnRyb2xlX3Bhcl9sX2FuZnIiLCJtYXhwb2ludHMiOiIiLCJ0aW1lc2NhbGUiOiJ5ZWFyIiwic29ydCI6IiJ9XX0%3D&sort=das_tronc_au_contact

4 https://www.anfr.fr/das/COM054200035

5 https://www.anfr.fr/das/COM054200035

6 https://www.anfr.fr/das/COM006200006/

Examples of smartphones **that would be compliant with the EU limit but would violate the FCC limits of 1.6 W/kg when SAR radiation tested by the ANFR at 5mm include:**

- September 16, 2020 Logicom Le Fleep 178 violated FCC's limit at 1.94 W/kg[7]
- September 16, 2020: Sky 55 Konrow violated FCC's limit at 1.91 W/kg[8]
- September 30, 2020: Wiki Lubi 5 Plus violated FCC's limit at 1.9 W/kg [9]
- September 29, 2020: Nokia 5.1 violated FCC's limit at 1.82 W/kg[10]
- April 8, 2021: Wiko F 300 violated FCC's limit at 1.8 W/kg[11]

As European Union and FCC test procedures utilize different averaging volumes, one cannot directly compare the measurements. However, FCC test procedures could result in even higher SAR violations (Gandhi 2019)[12].

Unfortunately ANFR no longer tests cell phones in body contact positions with 0 mm distance from the phone to the body phantom. If they did, far more of the 143 cell phones tested in the last two years would violate FCC and EU limits because every millimeter can significantly increase exposure. Further, due to the averaging volume differences between the FCC and EU limits, several of the phones that ANFR finds are compliant with the 1.6 W/kg limit would violate the FCC's test procedures.

The FCC presently allows manufacturers to SAR test cell phones with a separation distance between the phone and body (which can be up to approximately one inch from the body in some models of phones still in use in the USA) inaccurately measuring SAR levels into the body. Actual SAR exposure in direct body contact positions would be much higher than FCC test measurements.

New Research on Metal and Radiation Levels

Studies on SAR in human tissue published since 2019 related to cell phone test procedures need to be included in the FCC re-examination. Metal can reflect and refocus cellular radiation, resulting in much higher absorption rates. The FCC, states, "Electrically conductive objects in or on the body may interact with sources of RF energy in ways that are not easily predicted. Examples of conductive objects in the body include implanted metallic objects. Examples of conductive objects on the body include eyeglasses, jewelry, or metallic accessories."

- In January 2021 the study "Experimental Validation for Temperature Rise in Human Tissue Due to Implanted Metal Plates with Screw Holes Using Translucent Solid Phantom" was published in 2020 International Symposium on Antennas and Propagation (ISAP), Osaka, Japan IEEE, 2021 and found increases in SAR enhancement due to the implanted metallic plates observed at specific frequencies. [13]
- On December 2020, the study The effect of metal objects on the SAR and temperature increase in the human head exposed to dipole antenna (numerical analysis) published in Case Studies in Thermal Engineering found "the presence of metal objects in proximity to the head alters SAR and temperature increase within the tissues. In most cases, metal objects redistribute the EM

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[7] https://www.anfr.fr/das/COM044200035
[8] https://www.anfr.fr/das/COM044200036
[9] https://www.anfr.fr/das/COM046200002
[10] https://www.anfr.fr/das/COM085200003
[11] https://www.anfr.fr/das/COM057210009
[12] https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8688629
[13] https://ieeexplore.ieee.org/document/9391129

field incident upon them to a smaller region increasing power absorption, thereby increasing SAR and temperature in that region. The power absorption in head layers is found to be sensitive to metal object's size and shape, and distance of the antenna from the objects".[14]

These are just *a few* of the published studies on radiation levels will not be included in the FCC's examination of cell phone test procedures *unless the FCC refreshes the record.*

Investigative Reports on Telecom Influence

In September 2020, the editor-in-chief of the Program 66 minutes interviewed Chicago Tribune journalist and Pulitzer Prize winner Sam Roe and myself discussing how FCC's cell phone test procedures allow violations of FCC limits because they do not requite cell phones to be tested at 0 mm.[15]

On November 12, 2020, France Télévisions Complément d'Investigation "5G A Wave of Doubt" directed by investigative journalist Nicolas Vescovacci was broadcast on France 2[16]. The investigation described how cell phones exceed radiation thresholds when tested against the body and how cell phones are being taken off the market in response. Importantly, the industry ties of members of International Commission on Non-Ionizing Radiation Protection (ICNIRP) were revealed. In June 2020, a report released by European Members of Parliment Michèle Rivasi (Europe Écologie) and Dr. Klaus Buchner (Ökologisch-Demokratische Partei) found that ICNIRP has long ignored the science on non thermal effects[17].

This 2020 investigative research must be included in the FCC's record review so that the FCC does not inadvertently allow the wireless industry to influence its review of the record and decision.

There is Not a 50-Fold Safety Factor for Cell Phone Local SAR

Furthermore, we would like to importantly note that after we questioned ICNIRP President Rodney Croft and Vice President Eric Van Rongen, we received confirmation that there is not a 50 fold safety factor when it comes to ICNIRP's cell phone local SAR limit.

Here is what Mr. Van Rongen wrote about this:

> "Anyone who states that a reduction factor of 50 applies to local exposures obviously misinterprets the guidelines, although the 1998 guidelines might not have been very clear in that respect the 2020 ones provide more clear information."

On December 17, 2019 Environmental Health Trust and Phonegate Association write members of Congress a letter[18] and Background and Facts document[19] on the urgent need for a hearing regarding cell phone radiation test procedures, due to the excessive radiation the phone can expose the user to in body contact positions.

[14] https://www.sciencedirect.com/science/article/pii/S2214157X20305311?via%3Dihub
[15] Phonegate : entretien avec le journaliste américain et prix Pulitzer Sam Roe
[16] https://www.francetvinfo.fr/replay-magazine/france-2/complement-d-enquete/complement-d-enquete-5g-londe-dun-doute_4152949.html
[17] https://ehtrust.org/wp-content/uploads/ICNIRP-report-FINAL-JUNE-2020.pdf
[18] https://ehtrust.org/wp-content/uploads/Signed-Letter-to-US-Congress-phonegate-.pdf
[19] Background and Facts Documenting PhoneGate and Our Call for Congressional Action https://ehtrust.org/wp-content/uploads/Background-and-Facts-on-PhoneGate-1-1.pd

We have a significant amount of new data on SAR test methods from 2020 and 2021 to share with the FCC in order to ensure the protection of cell phone users, especially children. SAR tests are thermally based and they are an inadequate measurement to ensure safety. Stronger regulations which protect users from thermal and non-thermal effects are needed.

New Law To Require Radiation Testing of Wi-Fi Laptops, Router and Electronics

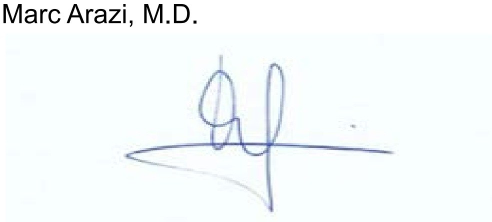
In addition, there has been new legislation regarding transparency on wireless radiation in France. Starting in July 2020, the wireless industry must label tablets, laptops, Wi-Fi routers, DECT phones and other wireless connected electronics with the radiofrequency radiation SAR exposure levels for consumers **at point of sale and for all advertising**. This includes the SAR for the head, trunk and extremities. All equipment used close to the head, hand-held or carried close to the body is potentially covered. From the SAR Regulation Guide provided by ANFR, you can find a non-exhaustive list of equipment qualified as radio equipment that required SAR testing.

Note: For years France law[20] has ensured cell phones were SAR radiation labeled, banned the sale of cell phones designed for young children, prohibited advertising to children under 14 years of age[21] and warned[22] users to keep devices away from the body.

It is imperative that the two above-mentioned dockets are re-opened to allow recent developments to be submitted for a proper assessment of FCC's testing protocol.

Sincerely,

Marc Arazi, M.D.



President, PhoneGate Alert Association
35 rue François Rolland 94130
Nogent-sur-Marne – France

DrArazi@phonegatealert.org

www.phonegatealert.org/en/

A book on Phonegate was published by Massot Editions on this international health scandal.   An English version is planned and we will be sure to send it to you when it is released in the United States.

[20] Article 183 - LOI n° 2010-788 du 12 juillet 2010 portant engagement national pour l'environnement (1)
[21] **Law on sobriety, transparency, information and consultation for exposure to electromagnetic waves**
[22] **Order of November 15, 2019 relating to the display of the specific absorption rate of radioelectric equipment and to consumer information NOR: SSAP1834792A**

November 18, 2021

The Honorable Jessica Rosenworcel, Commissioner
Acting Chairwoman
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Dear Chairwoman Rosenworcel,

We are writing to request that the FCC re-open the relevant Dockets to ensure the latest science be included in the FCC's reexamination of the adequacy of its human exposure limits and regulations for radiofrequency radiation exposures.

We urge the Commission to look at new scientific evidence published since December 4, 2019. Of 39 new genetic effect studies, 79 % (31 studies) showed effects and 21 % (8 studies) did not show significant effects. Of 33 new neurological effect studies, 85 % (28 studies) showed effects and 15 % (5 studies) did not show significant effects. Of 30 new oxidative effect studies, 93% (28 studies) showed effects and 7 % (2 studies) did not show significant effects. The preponderance of scientific research on RFR continues on an upward trend.

There is a broad consensus among those in the scientific research community who are knowledgeable on the published literature, that new, biologically-based public safety limits for chronic exposure to radiofrequency radiation (RFR) are warranted now. The available evidence for health risks due to low intensity radiofrequency radiation exposures from wireless technology applications is sufficient and compelling. Research published over the last two years has added significant additional weight to the body of evidence which indicates that FCC public safety exposure limits are grossly inadequate to protect public health given the proliferation of RFR-emitting devices now in common usage.

The evidence for health risks comes directly from hundreds of published scientific and public health studies reporting that low-intensity RFR is capable of producing health harm across very large populations of exposed people.

The BioInitiative Working Group has been gathering and evaluating hundreds of such studies since 2006, and has published two large reports detailing this evidence. The group concluded that the scientific evidence was more than sufficient in 2007, and certainly in 2012 (www.bioinitiative.org) to establish new biologically-based exposure safety standards. Further, we have submitted numerous comments to the FCC since 2013 advising that the Commission has not struck the right balance between the wireless technologies rollout and managing resulting health impacts for Americans, particularly for children. The increased risk for cancers, neurological diseases, fertility and reproduction, immune disfunction, memory and learning impairment, and other serious medical problems associated with exposure to low-intensity RF are documented and analyzed for the Commission to review at: https://bioinitiative.org/research summaries/

When the cumulative body of evidence is assessed over the last decades of research, the overall picture for studies on radiofrequency radiation effects shows clear and consistent patterns of effects on living tissues. Chronic RFR exposures at environmental levels common today can reasonably be presumed to produce health harm at and below current FCC safety limits for humans and should be substantially lowered.

Genetic effects: Effect= 67% (259 studies); No Effect= 33% (129 studies) (literature up to November 12, 2021)

Neurological effects: Effect= 74% (271 studies); No Effect= 26% (97 studies) (literature up to November 12, 2021)

Oxidative effects: Effect= 92% (258 studies); No Effect= 8% (23) studies) (literature up to November 12, 2021)

Respectfully submitted on behalf of the BioInitiative Working Group by**:**

Cindy Sage, M.A., Sage Associates
Co-Editor, the BioInitiative Reports 2007 and 2012
Email: sage@silcom.com

David O. Carpenter, MD
Co-editor, the BioInitiative Reports 2007 and 2012
Directo, Institute for Health and the Environment,
University at Albany
5 University Pl., Rm. A217
Rensselaer, NY 12144, USA
Email: dcarpenter@albany.edu

Lennart Hardell, M.D., Ph.D., Professor (retired)
Department of Oncology, University Hospital, SE-701 85 Örebro, Sweden
Present address:, USA The Environment and Cancer Research Foundation
Studievägen 35
SE 702 17 Örebro, Sweden
www.environmentandcancer.com

Prof. Henry Lai, Ph.D. (emeritus)
Department of Bioengineering
University of Washington
Seattle, Washington 98195
Email: hlai@uw.edu

Editors

Cindy Sage, MA
David O. Carpenter, MD
BioInitiative 2007 and 2012 Reports

Contributing Authors of the the 2007 and 2012 BioInitiative Working Groups

Jitendra Behari, PhD, India
Carlo V. Bellieni, MD, Italy
Igor Belyaev, Dr.Sc., Slovak Republic
Carl F. Blackman, PhD, USA
Martin Blank, PhD, USA
Michael Carlberg, MSc, Sweden
David O Carpenter, MD, USA
Zoreh Davanipour, DVM, PhD USA
Adamantia F. Fragopoulou, PhD, Greece
David Gee, Denmark
Yuri Grigoriev, MD, Russia
Kjell Hansson Mild, PhD, Sweden
Lennart Hardell, MD, PhD, Sweden
Martha Herbert, PhD, MD, USA
Paul Héroux, PhD, Canada
Olle Johansson, PhD, Sweden
Michael Kundi, PhD, Austria
Henry Lai, PhD, USA
Ying Li, PhD, Canada
Abraham R. Liboff, PhD, USA
Lukas H. Margaritis, PhD, Greece
Henrietta Nittby, MD, PhD, Sweden
Gerd Oberfeld, MD, Austria
Bertil R. Persson, PhD, MD, Sweden
Iole Pinto, PhD, Italy
Paulraj Rajamani, PhD, India
Cindy Sage, MA, USA
Leif Salford, MD, PhD, Sweden
Eugene Sobel, PhD, USA
Amy Thomsen, MPH, MSPAS, USA

Consumers for Safe Cell Phones

November 24, 2021

The Honorable Jessica Rosenworcel
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Dear Chairwoman Rosenworcel,

As one of the petitioners who recently sought the DC Circuit Court of Appeal's review of the FCC's December 4th, 2019 decision to maintain their outdated 25 year old wireless exposure guidelines, we write to urge the Commission to follow the Court's directive to properly review the evidence that had been submitted into Dockets #13-84 and #03-137. A proper review requires that the two dockets be re-opened to allow newly published research and documents (made public over the past 2 years) to be included in the analysis. This will provide the FCC with up-to-date information to use in undertaking the Court's required thorough analysis.

The Court's ruling stated that the Commission "*must, in particular, (i) provide a reasoned explanation for its decision to retain its testing procedures for determining whether cell phones and other portable electronic devices comply with its guidelines*…"

Of particular concern to the Court is the failure of the FCC to review the evidence in the record related to assessing their inadequate cell phone testing guidelines. Since the GAO released their 2012 report[1] stating, "*The Federal Communications Commission's (FCC) RF energy exposure limit may not reflect the latest research, and testing requirements may not identify maximum exposure in all possible usage conditions… Some consumers may use mobile phones against the body, which FCC does not currently test, and could result in RF energy exposure higher than the FCC limit."* - we have been calling on the FCC to test phones directly against the body with zero separation to simulate the manner in which they are typically used by consumers.

[1] "Telecommunications: Exposure and Testing Requirements for Mobile Phones Should Be Reassessed" - GAO-12-77: Published: Jul 24, 2012

FCC's current testing protocol allows a separation distance between the phone and the torso simulating use in a holster or belt clip, enabling a phone to pass the FCC compliance test when in fact, the exposure from phones used in real life usage positions will likely exceed the federal "safety" limit. This is because it is commonplace for today's consumer to carry a transmitting phone in a pants or breast pocket or tucked into a bra with no separation between the antennas and the body.

Here are some examples of the RF warnings for wireless devices currently on the market in 2021:

- The Apple iPhone 13 Pro Max RF Exposure statement[2] reads, *"iPhone is evaluated in positions that simulate uses against the head, with no separation, and when worn or carried against the torso of the body, with 5mm separation."* [Users will likely carry and use transmitting phones in pockets and bras against their body unaware because the RF "safety" warning is located in the small print of the legal section deep within menus on the phone where it is not likely to be found.]
- The Miku Pro Smart Baby Monitor manual states[3], *"RF EXPOSURE WARNING: ….This equipment should be installed and operated with minimum distance 20cm between the radiator and your body."* [Yet many parents will locate these RF transmitting monitors close to the crib or in a child's playroom unaware that these RF warnings are in the manual.]
- The AT&T DECT 6.0 Home Cordless Phone manual[4] states, "*The telephone base shall be installed and used such that parts of the user's body other than the hands are maintained at a distance of approximately 20 cm (8 inches) or more*." [Yet many people install the base unit on the desk just inches from their head or on their bedside table unaware of these instructions.]

Key evidence has been published in the past two years that indicates cell phones directly in body contact (as when worn and used in a pants or shirt pocket or sports bra) are associated with an increased risk for breast tumors and sperm damage.

As examples, these 2020 and 2021 published studies referenced below must be included in a thorough FCC assessment of their cell phone testing protocol in order to perform a more "reasonable analysis" of the testing protocol:

I. "The Association Between Smartphone Use and Breast Cancer Risk Among Taiwanese Women: A Case-Control Study" - Cancer Manag Res 2020 Oct 29;12:10799-10807 doi: 10.2147/CMAR.S267415.

> Results: "*Participants who carried their smartphone near their chest or waist-abdomen area had significantly increased 5.03-fold and 4.06-fold risks of breast cancer*"

II. "Effects of mobile phone usage on sperm quality - No time-dependent relationship on usage: A systematic review and updated meta-analysis" - 2021 Nov; 202:111784. doi: 10.1016/j.envres.2021.111784. Epub 2021 Jul 30

> Results: "*Exposure to mobile phones is associated with reduced sperm motility, viability, and concentration*." 18 studies were evaluated including 4280 samples.

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2 https://www.apple.com/legal/rfexposure/iphone14,3/en/

3 https://cdn.shopify.com/s/files/1/2621/9254/files/mikucare.com_quick_setup-guide.pdf?v=1589825520

4 https://att.vtp-media.com/products/CL/CL82X07/CL82X07_WEBCIB_i5.0_20201217.pdf

If the past two years of important research and evidence are not allowed to be included in the re-assessment of the FCC’s cell phone testing protocol, it is certain that the public’s distrust of the safety of phones and other wireless consumer devices will become even more widespread. The public’s trust is dependent upon the FCC’s thorough evaluation of the current, up to date body of research, especially with the advent of the novel and more powerful exposures expected with 5G.

Respectfully submitted,

Cynthia Franklin, Director
Consumers for Safe Cell Phones

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Federal Court Instructs FCC to Review Electromagnetic Radiation Standards

By Barbara Koeppel

For 25 years—through five Democratic and Republican administrations—the Federal Communications Commission has refused to revise the regulations it set in 1996 that address what level of radiation from cell phones should be considered safe. Labeled radio-frequency radiation (RFR), these emissions are discharged from all wireless devices, Wi-Fi networks, and the thousands of towers stretched across the United States that transmit and receive the signals.

The FCC's power is promethean. It is the sole U.S. agency that determines the acceptable RFR exposure from wireless devices for people of all ages, wildlife, and the environment. And it insists its original 1996 limits are fine.

However, scientists who've reviewed hundreds of studies published over the last two decades claim the FCC ignores critical findings that show a "statistically significant" link between heavy cell phone use (10 or more years) and brain and thyroid tumors, especially on the side of the head where people hold their phones. Professional groups such as the American Academy of Pediatrics and the California Medical Association have asked the FCC to update its numbers.

The scientists and physicians worry that the FCC simply repeats the industry's line that all is well—which is particularly troubling since millions more people around the world are exposed each year. In the United States, for example, only 44 million people had cell phones in 1996; today, the number has soared to about 300 million, and that doesn't include the tablets, watches, and other wireless products that increase RFR exposure exponentially.

Thus, in 2019, the Environmental Health Trust (EHT), Consumers for Safe Cell Phones, Children's Health Defense, and 11 other petitioners sued the FCC. They argued that although the U.S. Government Accountability Office told the FCC in 2013 to review its 1996 limits in light of new research, six years later, the FCC was still repeating its all-is-safe mantra. In a 2019 press release, the FCC said that "after a thorough review of the record, we find it appropriate to maintain the existing radiofrequency limits, which are among the most stringent in the world for cell phones."

At the least, this assurance is doubtful. The lawsuit against the FCC argues precisely the opposite: that the Commission has *not* reviewed "the record." Also, researchers point out that countries such as Italy, Switzerland, France, Israel, China, India, and Russia have more stringent limits than the United States regarding the use of Wi-Fi in schools and day care centers, and on acceptable levels of radiation emissions from cell towers. In addition, some have banned all cell phone ads pitched to children.

Photo by BearFotos

The lawsuit notes that the FCC even ignored the landmark 10-year, $30 million National Toxicology Program study carried out under the National Institutes of Health—which produced unequivocal results in 2019. Having exposed rats and mice to cell phone radiation for two years, the NTP researchers reported "clear evidence of cancer in the male rats' heart cells, some evidence of increased brain gliomas (brain cancer), and adrenal gland tumors, DNA damage in the brains of male and female rats and mice, and lower birth weights of female rats' offspring."

Two years after the suit was filed, the U.S. Court of Appeals of the D.C. Circuit ruled in August 2021 that the FCC had to reexamine the research to determine if its regulations should be updated. Further, the court called the commission's behavior "arbitrary and capricious," since it had ignored evidence of the harm to children's brains (which are not fully developed) and to

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male and female reproductive systems. It also ruled that because the FCC never produced regulations about radiofrequency radiation's effects on wildlife, it had "completely failed" to address the evidence of potential environmental harm.

However, the court did not set a date for the FCC to comply—which meant the commission could retain its old regulations indefinitely. Also, the court did not address the issue of whether RFR exposures cause cancer; instead it said the FCC had passed the "minimum legal requirement" to assure it had evaluated the research on cancer and radiation exposure. Thus, scientists are concerned that the FCC will again find ways to defer serious examination of the voluminous literature on the subject.

How could this be, given the NTP findings and other research? To bolster its no-cancer claims, the FCC points to a letter the U.S. Food and Drug Administration wrote the commission, which claimed the NTP results weren't relevant to humans since the study was done on rats and mice (although 10 years earlier, the FDA itself had approved the animal study). Dr. Joel Moskowitz, director of the Center for Family and Community Health at the University of California, Berkeley and a leading authority on radiofrequency radiation, says, "The FDA wrote a biased review of the research regarding cancer risk from cell phone radiation."

[Dr. Joel Moskowitz:] "The FDA wrote a biased review of the research regarding cancer risk from cell phone radiation."

Also, the FCC cited reports from organizations that have undeclared conflicts of interest (ties to the wireless industry), which contest the cancer links. Dr. Ronald Melnick, the lead designer of the NTP study, has published two articles stating that the results from these groups' reports were "unfounded."

In fact, the FCC failed on several fronts. Besides ignoring the NTP study, the commission dismissed the American Academy of Pediatrics' request for regulations that reflect the special effects RFR have on children and pregnant women. It never explained why it ignored research that showed children's brains absorb higher levels of the radiation. Instead, it has insisted for 20-plus years that RFR is only harmful if it overheats the human body by at least one degree centigrade. This is a red herring, since wireless devices don't emit the kind of radiation that produces higher temperatures. Also, the FCC didn't consider the effects of long-term exposures.

Many researchers insist these links have been proven. As noted in an earlier article in this journal ("Wireless Hazards," *Washington Spectator*, December 2020), studies over the past 20 years have found strong evidence of brain tumors and leaks in the blood-brain barrier, acoustic neuromas (tumors on the nerves leading from the inner ear to the brain), thyroid tumors, and cognitive impairment. They also showed a link to male infertility: when men carried phones in their pants' pockets, their sperm were weakened and reduced. Also, physicians and scientists found that some individuals are particularly sensitive to RFR radiation, which can cause tinnitus, vertigo, headaches, fatigue, and loss of memory. Early this month, some experts studying the U.S. diplomats' and CIA agents' "Havana Syndrome" symptoms suggested they could be related to radiofrequency radiation.

The latest evidence

Theodora Scarato, the executive director of the Environmental Health Trust, says that since the FCC had not yet responded to the court's August ruling by last November, the EHT asked the commission to consider additional studies that were completed after 2019, when the suit was filed.

For example, in late 2019, the European Parliamentary Research Service said that electromagnetic fields (EMFs) emitted by 2G, 3G, and 4G cell phones (which operate at 450 to 6,000 megahertz) are "probably carcinogenic for humans," particularly in causing gliomas, acoustic neuromas, and meningiomas (slow-growing, mostly nonmalignant brain tumors).

In 2020, Yoon-Jung Choi and Joel Moskowitz (the lead authors) and three other scientists reviewed 46 "case-controlled studies" and published their findings in "Cellular Phone Use and Risk of Tumors: Systematic Review and Meta-Analysis," in the November *International Journal of Environmental Research and Public Health*. Moskowitz says, "This study updated our earlier analysis published in 2009." Evidence from the new study, he says, links cell phone use to increased tumor risk. The researchers' numbers are compelling: 1,000 or more hours of cell phone use, or about 17 minutes a day over 10 years, was associated with a statistically significant 60 percent increase in brain tumor risk.

Also in 2020, Devra Davis (an epidemiologist and co-founder of the Environmental Health Trust), Aaron Pilarcik (a biophysicist at the Worcester Polytechnic Institute), and Anthony Miller (an epidemiologist specializing in cancer etiology and an adviser to the World Health Organization) reviewed data on colon and rectal cancer from the U.S. Centers for Disease Control, the U.S. SEER Program at the National Cancer Institute, and the Iranian National Cancer Registry. They found that the colon cancer risk for adults born in the 1990s had doubled and the rectal cancer risk had increased fourfold by the time they were 24 years old—when compared to those born 60 years ago. They hypothesized that cell phone radiation could play a role in the increased risk and recommended the FCC set limits to reduce the exposure. Their study, "Increased Generational Risk of Colon and Rectal Cancer in Recent Birth Cohorts Under Age 40—the Hypothetical Role of Radiofrequency Radiation from Cell Phones," was published in the *Annals of Gastroenterology and Digestive Disorders.*

In 2020, Henry Lai (a retired University of Washington scientist) reviewed the research on genetic effects and found that exposure to RFR can break DNA strands and affect the central nervous system. The review, "Genetic Effects of Non-Ionizing Electromagnetic Fields" was published in the December 2020 issue of *Electromagnetic Biology and Medicine.*

In 2021, Henry Lai, with Albert Manville (a biologist formerly at the U.S. Fish and Wildlife Service) and Blake Levitt (an environmental journalist), studied the effects of cell phone towers in various countries, comparing data from the 1980s to the present. They found that the toxic effects of EMFs on cells and genes had altered "the wildlife's orientation and migration patterns, their ability to find food, mate, reproduce, build nests and dens, and maintain and defend their territory." Yet the FCC has still set no standards for long-term, low-level EMF exposure on wildlife. The scientists' three-part research was published in *Reviews on Environmental Health,* "Effects of Non-Ionizing Electromagnetic Fields (EMF) on Flora and Fauna."

Also in 2021, the journal *Andrologia* published a study by Iranian scientists who found DNA fragmentation in sperm and recommended that men keep cell phones "away from the pelvis as much as possible."

Further, from 2015 to the present, the French government has tested the radiation from cell phones when people hold them next to their bodies. Their findings are dramatic: They reported exposures to RFR up to 11 times higher than those approved in FCC guidelines. Thus, the government passed a ministerial order in 2019 urging the public to limit children's cell phone use and "keep the phones away from the belly of pregnant women and the lower abdomen of adolescents."

Moreover, the National Institutes of Health and the American Cancer Society funded a study in 2019 and 2020 at Yale University that found increased thyroid cancer among heavy cell phone users.

The accompanying table enumerates many of the ways that doctors and vigilant public jurisdictions have identified to help people reduce the health risks that could be associated with exposure to RFR and cell phone radiation emissions.

The EHT's Scarato reminds readers concerned about RFR emissions exposure to "contact their senators and representatives to raise the issues with the committees." In the Senate, the Committee on Commerce, Science, and Transportation, along with its Subcommittee on Communications, Media, and Broadband oversees the FCC. In the House, the FCC reports to the Energy and Commerce Committee and its Communications and Technology Subcommittee. Public pressure on the members of these committees will help to prod the FCC to review the research and respond to the ruling of the Court of Appeals. ■

Barbara Koeppel is a Washington, D.C.-based investigative reporter who covers social, economic, political, and foreign policy issues.

PROTECT YOURSELF FROM WIRELESS RADIATION

The California Department of Public Health recommends these precautions:

- **Use headsets—not ear buds—but remove them when not talking, since even headsets release small amounts of radiation when not in use.**
- **Text instead of talk.**
- **Carry phones away from your body in backpacks, tote bags, handbags, and briefcases.**
- **Keep phones away from your head when streaming.**
- **Download movies instead of streaming them.**
- **Don't use cell phones when reception is poor and they show just one or two bars—in subways, cars, basements, or rural areas. Under such circumstances cell phones often need vastly more energy to communicate with cell towers and other phones, and radiation levels intensify.**
- **Men should not carry phones in pants' pockets. Cleveland Clinic Center for Male Fertility researchers found this weakened and reduced sperm, which can cause infertility.**

Go to page 8 for more information

(Continued from page 3)

PROTECT YOURSELF FROM WIRELESS RADIATION

Countries must adopt tough laws

- Belgium and France banned companies from designing phones to appeal to children.
- Israel and Cyprus banned Wi-Fi in day care centers and kindergartens, requiring connections be wired. Israel limited Wi-Fi use in first and second grades to three hours a week.
- France ordered cities to map the locations of antennae, measure their radiation levels, and tell the public. Also, it banned ads showing people holding phones next to their heads and ordered companies to list phones' exposure levels. If they don't, they can be fined up to 75,000 euros.
- India ordered companies to remove towers located near hospitals and schools.
- Israel ordered companies to list phones' radiation levels.
- Geneva (Switzerland) placed a moratorium on the rollout of 5G.

Scientists also recommend these steps:

- Use corded landlines at home, but put satellite or cordless handsets on speakerphone, since they emit even more radiation than cell phones.
- Push for laws to protect children.
- Get states to create expert commissions to study radiation emissions' effects. New Hampshire's commission recommended that towers and antennae be placed farther from schools and homes.

ENVIRONMENTAL HEALTH TRUST

US POLICY

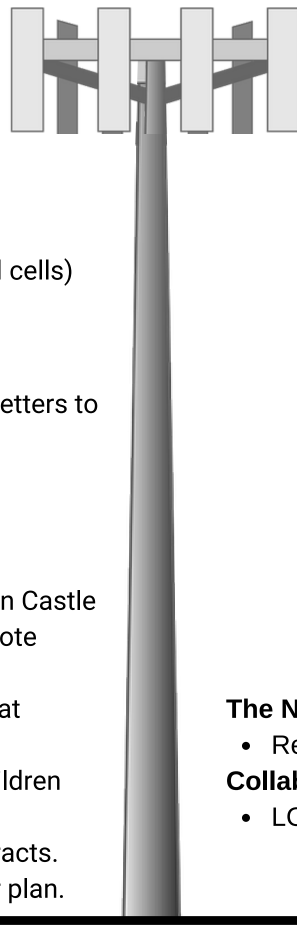
CELL TOWERS NEAR SCHOOLS

SCHOOL CELL TOWER SETBACKS

Many communities have policies, ordinances or zoning that ensures cellular antennas are restricted to a specific minimum distance from schools. Hempstead, New York requires a special use permit for cell towers near schools.

Examples of cell tower/school setbacks:

- **Palo Alto, California:** 1,500 feet
- **Los Altos , California**: 500 feet (small cells)
- **Walnut City, California**: 1,500 feet
- **Bar Harbor, Maine: 1**,500 feet
- **Sallisaw, Oklahoma:** 1,500 feet
- **Stockbridge, Massachusetts**: 1,500 feet
- **San Diego County California** 1,000 feet (small cells)
- **Ithaca, New York** - 250 feet (small cells)



The Greenbelt Maryland City Council

- Voted to oppose school cell towers and sent letters to the school board and County Executive.

CELL TOWERS REMOVED FROM SCHOOL GROUNDS

- **Milpitas California:** School Board asked Crown Castle and T-Mobile to relocate the cell tower to remote location.
- **Ripon California:** Sprint moved the cell tower at Weston Elementary after students and staff developed cancer and parents argued that children should not be guinea pigs.
- **Alameda California** cancelled cell tower contracts.
- **Dekalb County Georgia** dropped school tower plan.

SCHOOL BOARDS

- **Los Angeles California School District**: Resolutions opposing cell towers on school property and a cautionary level" for radiofrequency radiation 10,000 times lower than FCC limits.
- **Palo Alto Unified School District**: Resolution No. 2018-19.19 supports the City 1,500 setback and opposes cell tower "on or in close proximity to schools to ensure individuals, especially children, are protected from the potential negative effects associated with radiation exposure"
- **West Linn-Wilsonville Oregon School Board** prohibits cell towers on school property.
- **Vancouver School Board:** Resolution prohibiting cell antennas within 1,000 feet of school property.
- **Montgomery County Maryland Schools** policy does not allow cell towers on elementary schools.
- **Prince George's County Maryland** School Board decided not to renew a cell tower construction master leasing agreement that had allowed over 60 schools to be marketed as cell tower sites.
- **Portland Oregon Schools** ended leases for cell towers at schools .

The New Hampshire 5G Commission Report

- Recommends a setback of 1640 feet for schools.

Collaborative For High Performance Schools

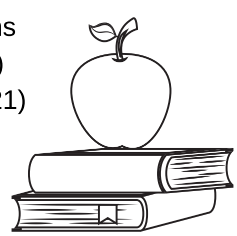
- LOW EMF Criteria- no cell towers on school property.

THE EPA SCHOOL SITING GUIDELINES

Lists exposure to electromagnetic fields and the fall distance as "potential hazards" from cell towers. The EPA guidelines recommend schools "identify and evaluate cell towers within ~200 feet of prospective school locations."

PUBLISHED RESEARCH

- 500 Meter buffer recommended for schools (Pearce 2019)
- A moratorium on 5G pending safety research (Frank 2020)
- A precautionary approach is better suited to State obligations under international human rights law (Roda and Perry 2014)
- Increased cancer deaths near cell antennas (Rodrigues 2021)
- Studies find: DNA Damage(Zothansiama 2017), Diabetes (Meo 2015), Cognitive effects (Meo 2018), sleep problems and headaches (Abdel-Rassoul 2007, Levitt & Lai 2010, Shahbazi-Gahrouei 2013)



THE AMERICAN ACADEMY OF PEDIATRICS says:

"An Egyptian study confirmed concerns that living nearby mobile phone base stations increased the risk for developing:

- Headaches
- Memory problems
- Dizziness
- Depression
- Sleep problems

"In large studies, an association has been observed between symptoms and exposure to these fields in the everyday environment."

UNITED STATES OF AMERICA

5G & CELL TOWERS

ENVIRONMENTAL HEALTH TRUST

HAWAI'I

- **Hawai'i County Council HI** passed a Resolution to halt 5G

NEW HAMPSHIRE

- Proposed State Bill - 1640 ft setbacks.
- **Keene NH Resolution** to halt 5G
- **Bedford NH** 750 ft. setback

MASSACHUSETTS

Randolph MA 500 ft setback. Yearly RFR measurements.
Lunenburg and Great Barrington MA 500 ft setback
Stockbridge MA prohibits a tower from being built 1000 feet from a school, park or athletic field and 600 ft from residence.

CALIFORNIA

Numerous CA cities restrict cell antennas near homes with setbacks and strict ordinances including: **Los Altos, Petaluma, Mill Valley, Malibu, Santa Barbara, Nevada City, Suisin, Calabasas, San Clemente, Westlake, Sonoma, Sebastopol, San Rafael, Ross Valley, Encinitas, Fairfax, Palo Alto, Walnut City** and **San Diego County.**

As an example of CA ordinances, the **Los Altos City ordinance:**

- prohibits installation of small cells on public utility easements in residential neighborhoods
- 500 foot setbacks for small cells for multi-family residences in commercial districts
- 500 ft separation from schools
- 1500 ft separation between nodes

San Diego County, California

- “SCWs shall not be located within 1,000 feet of schools, child care centers, hospitals, or churches.”

WISCONSIN

- **Greendale WI** passed Resolution R2018-20 referring to the FCC’s actions stripping local authority as “an unprecedented attack on local control.”

New York

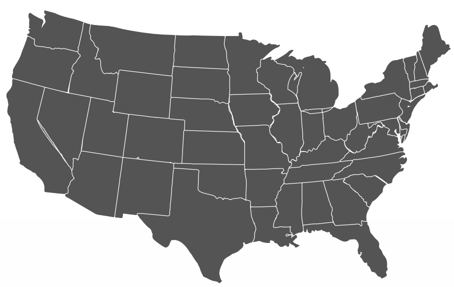
- **Scarsdale NY: 500 foot setbacks to homes preferred.**
- **Copake NY**: Pre/post testing by RF engineer. No repeater closer than 200 ft to dwelling. No tower closer than 1500 ft to residence/church.

MAINE

- Bar Harbor ME 1,500 ft setback - cell towers near schools/daycare .

ILLINOIS

- **Oak Brook IL** Resolution calls for local control re small cels.



CONNECTICUT

- **Easton CN City Council** passed a 5G cease and desist resolution
- **Warren, Connecticut** Policy defines "adequate coverage" and "adequate capacity." and was designed “to locate towers and/or antennas in a manner which protects property values, as well as the general safety, health, welfare and quality of life of the citizens.“ Coverage is considered to be “adequate” within that area surrounding a Base Station where the predicted or measured median field strength of the transmitted signal is such that the majority of the time, transceivers properly installed and operated will be able to communicate with the base station.

OHIO

- **Mason OH** Zoning Ordinance No small cells in residential areas or within 100 feet of residential prop; 2000 feet apart (unless colocated); equipment should be underground or wholly contained.

OKLAHOMA

- Sallisaw OK 1,500 feet setback

TENNESSEE

- **Farragut City** Resolution to halt 5G

NEW JERSEY

- **Little Silver, NJ** Carriers should provide notice to property owners within 500 feet of proposed facility.
- City of Jersey City, NJ Resolution 20-362 calls for local controls re small cells.

INDIANA

Carmel City IN Council resolution asks state lawmakers, FCC and Congress to limit 5G until health effects fully understood.

FLORIDA

- **Coconut Creek FL** Commission adopted a Resolution on 5G and radiofrequency radiation.
- **Hallandale Beach FL** Resolution urges the federal government to initiate independent health studies on 5G.
- **Lavallette FL** Resolution 2021-58: Applicant shall obtain certification from the Federal Aviation Administration and the United States Dept. of Defense demonstrating that the installation does not emit RF frequencies which may interfere with avionics of any approaching civil or military aircraft.” The City also requires the applicant to provide RF meters used by their technicians and train City employees. Verizon cannot install more than a total of 20 "small cell" nodes throughout the Borough to support 5G.

Links to ordinances at ehtrust.org

WORLDWIDE POLICY

5G & CELL TOWERS

ENVIRONMENTAL HEALTH TRUST

EUROPE
- Resolutions to halt 5G in numerous European cities including Trafford, UK, Lille, France, Ormidia, Cyprus, several Councils in Ireland and more.

SWITZERLAND
- Parliament refused to weaken radio frequency radiation (RFR) limits after 5G Report.

FRANCE
- 60 mayors/officials petition to halt 5G.
- Federal health agency investigating 5G
- 5G antenna RFR levels measured and publicly posted.

BULGARIA
- Mezdra and Balchik have banned 5G.

CANADA
- City of Toronto "Prudent Avoidance Policy" for Cell Towers.

NETHERLANDS
- Health Council recommends against 26 GHz for 5G due to lack of safety data.

ITALY
- 600+ municipalities have passed resolution to halt 5G.

ISRAEL
- Cell tower setback 100m from schools/ homes.

RUSSIA
No cell towers near schools.

CYPRUS
- Cyprus National Committee on Environment and Child Health 5G Position Paper calls for 5G free zones.

UNITED STATES
- Resolutions to halt 5G passed in Hawaii County HI, Farragut TN, Keene NH & Easton CT.
- Numerous cities restrict cell antennas near homes including: Los Altos, Petaluma, Mill Valley, Malibu and San Diego County CA, Bedford NH and more.
- New Hampshire 5G Commission's 15 Recommendations include increasing transparency, reduce public exposure, research health effects and protect wildlife and trees.
- Oregon investigating health effects of wireless.
- Los Angeles CA Public Schools: RFR Limit 10,000x less than FCC.
- Palo Alto, Los Angeles LA Schools Greenbelt MD, Bar Harbor ME; No school cell towers

AUSTRALIA
- New South Wales Dept. of Education policy objects to towers on/near schools.

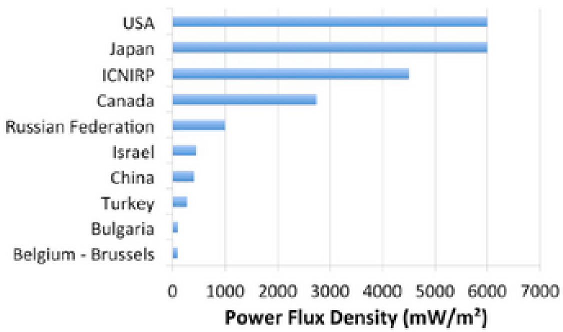
LITHUANIA
- Cell antennas prohibited on kindergartens and hospitals.

CHILE
- Cell antennas prohibited in “sensitive areas" -kindergartens, hospitals and nursing homes.

INDIA
- RFR limit tightened to 1/10 of CNIRP limits after Inter-Ministerial Report on impacts to wildlife.
- Mumbai, Zilla Parishad & Karnataka: Cell towers prohibited/removed near schools, colleges, orphanages and old age homes.
- Brihanmumbai Municipal: Cell towers banned at parks and playgrounds.
- State of Rajasthan: Supreme Court of India upheld removal of “hazardous to life" cell towers from vicinity of schools, hospitals/playgrounds.

BANGLADESH
- No cell towers on homes, schools, colleges, playing fields, populated areas and heritage areas.

Numerous Countries Have Cell Tower Network RFR Exposure Limits Far More Stringent Than ICNIRP/FCC (USA):



RFR power flux density exposure limits at 900 MHz (Clegg 2020)

China	Belarus	Turkey
Russia	Serbia	Greece
Italy	Slovenia	Liechtenstein
India	Montenegro	Tajikistan
Israel	Bulgaria	Kazakhstan
Chile		Uzbekistan
Switzerland		Kyrgyzstan
Brussels, Belgium		

These Governments Measure & Publish RFR Levels Online

France	Switzerland
Spain	Bulgaria
Austria	Tunisia
Greece	Malta
Turkey	Bhuton
India	Brazil
Israel	Bahrain
Gibraltar	Monaco
Brussels Belgium	French Polynesia

Text is hyperlinked to sources. More policy at ehtrust.org

Review Article

B. Blake Levitt*, Henry C. Lai and Albert M. Manville II

Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: how species interact with natural and man-made EMF

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Abstract: Ambient levels of nonionizing electromagnetic fields (EMF) have risen sharply in the last five decades to become a ubiquitous, continuous, biologically active environmental pollutant, even in rural and remote areas. Many species of flora and fauna, because of unique physiologies and habitats, are sensitive to exogenous EMF in ways that surpass human reactivity. This can lead to complex endogenous reactions that are highly variable, largely unseen, and a possible contributing factor in species extinctions, sometimes localized. Non-human magnetoreception mechanisms are explored. Numerous studies across all frequencies and taxa indicate that current low-level anthropogenic EMF can have myriad adverse and synergistic effects, including on orientation and migration, food finding, reproduction, mating, nest and den building, territorial maintenance and defense, and on vitality, longevity and survivorship itself. Effects have been observed in mammals such as bats, cervids, cetaceans, and pinnipeds among others, and on birds, insects, amphibians, reptiles, microbes and many species of flora. Cyto- and geno-toxic effects have long been observed in laboratory research on animal models that can be extrapolated to wildlife. Unusual multi-system mechanisms can come into play with non-human species — including in aquatic environments — that rely on the Earth's natural geomagnetic fields for critical life-sustaining information. Part 2 of this 3-part series includes four online supplement tables of effects seen in animals from both ELF and RFR at vanishingly low intensities. Taken as a whole, this indicates enough information to raise concerns about ambient exposures to nonionizing radiation at ecosystem levels. Wildlife loss is often unseen and undocumented until tipping points are reached. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as 'habitat' so EMF can be regulated like other pollutants. Long-term chronic low-level EMF exposure standards, which do not now exist, should be set accordingly for wildlife, and environmental laws should be strictly enforced — a subject explored in Part 3.

Keywords: cell phone towers/masts/base stations; Earth's geomagnetic fields; magnetoreception, radiofrequency radiation (RFR); nonionizing electromagnetic fields (EMF); plants; wildlife.

Introduction: electromagnetic fields — natural and man-made

In Part 1 of this three-part series, rising ambient EMF levels were explored. Part 2 focuses specifically on the unique magnetoreception physiologies found in wildlife as well as the mechanisms by which they interact with the Earth's natural geomagnetic fields and man-made EMF at intensities now commonly found in the environment. Part 2 Supplements contain tables of studies showing effects at extremely low intensity exposures comparable to today's ambient levels.

Energy is a part of nature affecting every living thing in positive, negative and neutral ways. The Earth itself is a dipole magnet with a north and a south pole. All living things have evolved within the protective cradle of the Earth's natural geomagnetic fields. In fact, magnetic oscillations emanate from the Earth's molten iron core around 10 times per second (10 Hz) where relaxed but alert human thought/brainwaves occur between 8 and 14 Hz.

In addition to the Earth's natural emanations, vast Schumann Resonances (SR) that constantly circle the globe

*Corresponding author: B. Blake Levitt, P.O. Box 2014, New Preston, CT, 06777, USA, E-mail: blakelevitt2@gmail.com and blakelevit@cs.com
Henry C. Lai, Department of Bioengineering, University of Washington, Seattle, WA, USA, E-mail: hlai@uw.edu
Albert M. Manville II, Advanced Academic Programs, Krieger School of Arts and Sciences, Environmental Sciences and Policy, Johns Hopkins University, Washington DC Campus, USA, E-mail: amanvil1@jhu.edu

were theorized in 1952 by physicist Windfried Otto Schumann and reliably measured in the 1960s [1, 2]. SR are a global electromagnetic phenomenon caused by a complex relationship between lightening at the Earth's surface and the ionosphere. Excited by the 2,000 thunderstorms that occur globally at any given time and approximately 50 flashes of lightening every second, the space between Earth and the ionosphere 60 miles (97 km) above it form a resonant cavity and closed waveguide [3]. Schumann Resonances occur in the ELF bands between 3 and 60 Hz with distinct fundamental peaks around 7.83 Hz. Since the 1960s, scientists have discovered that variations in the resonances correspond to seasonal changes in solar activity, the Earth's magnetic environment, in atmospheric water aerosols and various other earth-bound phenomena, including increased weather activity due to climate change. There are an estimated 1.2 billion lightening flashes globally each year, 25 million in the U.S. alone [4], not all of which are of sufficient length to contribute to the resonances.

Many behavioral aspects in biology are thought to be synchronized with both the Earth's natural fields and the Schumann Resonances. Many species rely on the Earth's natural fields for daily movement, seasonal migration, reproduction, food-finding, and territorial location, as well as diurnal and nocturnal activities. Human circadian rhythms, mainly regulated by light targeting signaling pathways in the hypothalamic suprachiasmatic nucleus, are known to be finely tuned to the Earth's day/night cycles as well as natural seasonal variations, as are most species [5–8]. Artificial ELF-EMF is also known to adversely affect human circadian clocks, possibly through modulation in circadian clock gene expression itself [9].

Nonionizing electromagnetic fields (EMF; 0–300 GHz) include all the frequencies that fall between visible light below the ultraviolet range and the Earth's natural static fields. The nonionizing bands are used in virtually everything involved with communications and energy propagation so useful in modern life, including electric power production/distribution, all wireless technologies and accompanying infrastructure for cell phones, WiFi, baby/home monitoring systems, 'smart'grid/meters, all 'smart' technology/devices, 2-through-5G Internet of Things, AM/FM broadcast radio and television, shortwave and HAM radio, surveillance/security systems, satellites, radar, many military applications, and myriad medical diagnostic tools like MRI's, to name but a few (see Figure 1).

In its natural state, very little radiofrequency radiation (RFR) reaches the Earth's surface. Aside from the Earth's natural extremely low frequency (ELF) direct current (DC) magnetic fields, lightening and sunlight would primarily comprise our normal exposures to the electromagnetic spectrum. Most harmful radiation coming from outer space is blocked by the Earth's magnetosphere. But now, for the first

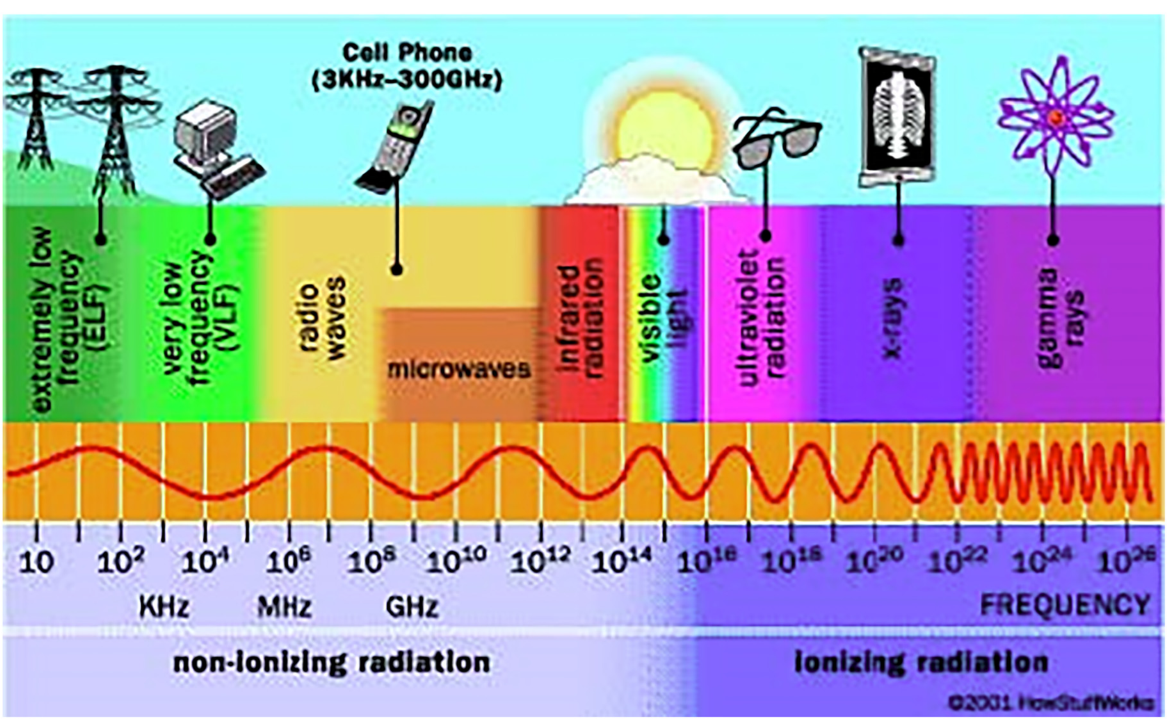

Figure 1: The electromagnetic spectrum.
The electromagnetic spectrum is divided into ionizing and nonionizing radiation. Ionizing radiation falls at and above the ultra violet range in the light frequencies. Examples of ionizing radiation include gamma rays, cosmic rays, X-rays and various military and civilian nuclear activities. It is the nonionzing bands that we have completely filled in with modern technology.

time in evolutionary history, we have infused the Earth's surface with a blanket of artificial energy exposures with no clear understanding of what the consequences may be.

And although "natural," not all energy is alike. Man-made exposures contain propagation characteristics — such as alternating current, modulation, complex signaling characteristics (e.g., pulsed, digital, and phased array), unusual wave forms (e.g., square and sawtooth shapes), and at heightened power intensities at the Earth's surface that simply do not exist in nature. These are all man-made artifacts. In our embrace of technology, we have completely altered the Earth's electromagnetic signature in which all life has evolved, in essence bypassing the magnetosphere's protection. And because so much of wireless technology is satellite based, increasing exposures are no longer just ground-generated. All atmospheric levels are now affected by increasing ambient exposures (see Part 1 and Part 1 Supplement). This is especially true in the lower atmosphere, which is 'habitat' (beyond mere oxygen and clean air standards) for all species that mate, migrate, and feed in the air — including birds, mammals (such as bats), insects and some arachnids.

Species extinctions

There has been an unprecedented rate of biodiversity decline in recent decades according to the International Union for Conservation of Nature [10] which maintains a "Red List of Threatened Species" that is considered the world's most comprehensive source on the global conservation status of animal, fungi and plant species — all critical indicators of planetary health.

IUCN's 2018 list showed that 26,000 species are threatened with extinction, which reflected more than 27% of all species assessed. This was greatly increased from their 2004 report that found at least 15 species had already gone extinct between 1984 and 2004, and another 12 survived only in captivity. Current extinction rates are now at least 100 to 1,000 times higher than natural rates found in the fossil record.

The more recent May 2019 report by the Intergovernmental Science and Policy Platform on Biodiversity and Ecosystem Services, Paris, France [11] projected that at least 1 million plant and animal species worldwide are at imminent threat of extinction if our current human actions and activities are not immediately reversed. A review of 73 reports by Sanchez-Bayo and Wyckhuys [12] found those rates had greatly accelerated. The authors noted that biodiversity of insects in particular is threatened worldwide with dramatic declines that could lead to a 40% extinction of insect species over the next several decades. In terrestrial ecosystems they found *Lepidoptera, Hymenoptera, and Coleoptera* (dung beetles) were most affected, while in aquatic ecosystems *Odonata, Plecoptera, Trichoptera and Ephemeroptera* have already lost a considerable proportion of species. Affected insect groups included niche specialist species, as well as common and generalist species, many of which are critically important for pollination, as well as seed, fruit, nut and honey production, and natural pest control, among others of immeasurable economic and ecological value.

Humans are the primary cause for most declines via habitat destruction/degradation; over-exploitation for food, pets, cattle and medicine; artificially introduced species; pollution/contamination; pesticides; and disease. Climate change is increasingly established as a serious threat, as well as agricultural practices like monoculture crops for cattle feed, biofuels, and timber. New pesticides and weed killers introduced within the last 20 years, using neonicotinoids, glyphosphate, and fipronil, are especially damaging since they are long-lasting and capable of sterilizing soil of beneficial microorganisms, including worms and grubs, which can then extend to areas far beyond applications sites.

One example of multi-factorial damage includes the iconic American Monarch butterfly (*Danaus plexippus)* which is found across America and Southern Canada and generally geographically divided into eastern and western migratory groups by the Rocky Mountains. That species has declined by a full 99.4% in the west since the 1980s — 85% of that being since 2017 [13, 14]. According to the Center for Biological Diversity [15], the eastern monarch population has shrunk by 90% in the past two decades. Massive habitat loss, wildfires, climate change, droughts, enhanced storm ferocity, and the 1990s introduction of Monsanto "Roundup Ready" crops capable of surviving herbicides that kill other weeds — including milkweed, which monarchs need for breeding and as their sole food supply along their migratory routes — are thought to be the primary culprits.

Here, we argue, environmental EMF should be added to this list since many insects and other living species have sensitive receptors for EMF, e.g., monarchs were found to have light sensitive magnetoreceptors in their antennae that serve as an inclination compass when daylight is absent [16]. RFR is also known to alter the time period needed for a butterfly to complete morphogenesis, plus gastrulation and larval growth can be accelerated [17]. And the devastating loss of pollinating insects like honey bees and other wild pollinators may also be related to environmental EMF (see "Insects" below.)

Anecdotally, many people recall when there were significantly more insects and far more abundant wildlife. Since about 1980, there has been a steady, almost imperceptible, biodiversity diminishment among many species globally [18–20]. In 2018, scientists estimated that the largest king penguin colony shrank by 88% in just 35 years [21] due in major part to effects from climate change, while according to the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, over 97% of bluefin tuna have disappeared from the world's oceans, primarily due to industrial overfishing but exacerbated by oil spills, contamination, and climate change. Tree and cave-dwelling bats until recently were common, including in the Eastern United States. Now with the massive impacts from White-nosed Syndrome (a fatal bat fungal disease), annual wind-turbine bat collision mortality estimated at nearly 1 million per year in the U.S. alone [22, 23], and pesticide use, few bats are seen. Bats species are also sensitive to EMF. Impacts from EMF as now seen in extensive reviews add only yet another troubling variable for all wildlife [24–36].

Since all food webs are uniquely tied together, there are negative cascading effects across all ecosystems. Birds that eat insects are hard hit: 8-in-10 partridges have disappeared from French farmlands while there has been a 50–80% reduction in nightingales and turtledoves respectively in the UK. Since 1980 the number of birds that typically inhabit Europe's farmlands has shrunk by 55%, while in the last 17 years, French farmland-bird counts dropped by a full third. Intensified agricultural practices are thought responsible, with loss of insects being the largest contributor [12, 37]. In the United States, of the 1,027 species of migratory birds currently protected under the Migratory Bird Treaty Act of 1918, an estimated 40% are in decline based on breeding bird surveys [38], Christmas Bird Counts [39], and other monitoring tools [22, 23]. This trend is comparable to what is happening globally. What role EMF plays in these declines is unclear but remains a disturbing possibility. Nor do we understand the limits of tolerance any given species has for environmental disturbance — some show high flexibility while others thrive only within the narrowest ranges.

One estimate of Earth's species finds that since 1970, wild animal populations have been reduced on average by 60%. Popularly called the "sixth mass extinction" [40], the term connotes the sixth time in the Earth's history that large numbers of species have rapidly disappeared over a relatively short period, this time due to human activity, not asteroid strikes or volcanic activity. Though not officially so-designated, many now refer to this most recent geologic/ecosystem period as the "Anthropocene" — the Age of Man [41–46].

Insect populations have been especially hard hit with extinctions eight times faster than that of mammals, birds and reptiles [12]. Insect total mass is falling by an estimated 2.5% per year, suggesting they could vanish by the next century. And what affects insect populations affects everything in the food web in one way or another. Loss of insect diversity and abundance can cause devastating effects throughout food webs and endanger entire ecosystems [12]. In Europe, Hallmann et al. [47] found a more than 75% decline over 27 years in total flying insect biomass in 63 protected areas, many throughout Germany. There was an 82% decline in mid-summer flying insect mass. Many European insect species migrate from distances as far away as Africa. The researchers noted that changes in weather, land use, and habitat characteristics alone cannot explain the overall decline and that there may be more than one unrecognized factor involved in evaluating declines in overall species abundance. That unrecognized factor may be the steadily rising ambient EMF that directly parallels these declines (see Part 1, Supplement 1).

Similar alarming invertebrate declines were discovered in the Western Hemisphere in 2017 when American entomologist Bradford Lister, after 40 years, revisited the El Yunque National Forest in Puerto Rico to follow up on a study begun in 1976 [48]. In the ensuing decades, populations of arthropods, including numerous flying insects, centipedes and spiders, had fallen by 98% in El Yunque, a pristine tropical rainforest within the U.S. National Forest System. Insectivores — including birds, lizards, and toads — showed similar declines, with some species vanishing entirely. After controlling for factors like habitat degradation or loss and pesticide use, the researchers concluded that climate change was the primary factor since the average maximum temperature in that rainforest had increased by 4 °F during that period. They did not factor in the large U.S. military VLF installation in Aquada that communicates with submarines all over the world, or the multiple sweeping over-the-horizon phased array radar units aimed at Puerto Rico from coastal sites in the U.S. that irradiate deep into that forest, or the multiple NOAA Doppler weather radar sites scattered all over the small island to track hurricanes, or the many cell towers there too.

These global declines are truly alarming with implications for planetary health as well as human and wildlife integrity. Many who study this say that climate change alone is not the only factor and that something new is going on [47]. The question is: could steadily rising environmental EMF, as one of the most ubiquitous but unrecognized new environmental genotoxins introduced since the 1980s, be contributing to these unprecedented species losses, beginning with insects but now manifesting in other species too? The upper microwave bands couple maximally with some insects the size of fruit flies and are capable of creating devastating resonance and other effects. Historically, radiofrequency radiation (RFR) impacts to insects were among the first biological effects to be studied [49] with the hope of discovering new forms of insect control [50]. All insect metamorphic developments have been studied, including egg, larva, pupa, and adult stages. One hypothesis holds that some adult species are more sensitive than at larval stages because adult appendages act as conducting pathways to the body (see “Insects” below).

It is these exact frequency bands between 30 kHz and 3 GHz used in telecommunications technology that have been on the rise during this period. And 5G is on the horizon which may specifically target insect populations (see Part 1).

Species sensitivity to EMFs

Other species have vastly more complex electromagnetic sensing tools than humans, as well as unique physiologies that evolved to sense weak fields. Many species are highly sensitive to the Earth’s natural electromagnetic fields, as well as geographic and seasonal variations. In fact, it appears that most living things — including many species of mammals, birds, fish, and bacteria — are tuned to the Earth’s electromagnetic background in ways once considered as “superpowers” but are now known to be physiological, even as mechanisms are still imperfectly understood. For example, many animals have been observed sensing earthquakes long before human instruments detect them, including snakes and scorpions that seek shelter; cattle that stampede; birds that sing at the wrong times of day; and female cats that frantically move kittens [7].

This ability is likely due, in part, to numerous species reacting to changes in the Earth’s magnetic field and electrostatic charges in the air detected through a naturally occurring mineral called magnetite found in many species [51, 52]. In fact, honey bees are able to detect static magnetic field fluctuations as weak as 26 nT against background earth-strength magnetic fields that are much higher [53] and to sense weak alternating fields at frequencies of 10 and 60 Hz [54]. Magnetite reacts a million times more strongly to external electromagnetic fields than any other known magnetic material. Authors Kobayshi and Kirchvink [52] and Kirchvink et al. [53, 54] hypothesized results were consistent with biophysical predictions of a magnetite-based magnetoreceptor. Other mechanisms, like radical pair mechanisms and cryptochromes, may also be responsible (see “Mechanisms” below).

Much has been written about magnetoreception — the term used to describe how species sense electromagnetic fields — which is well established but not well understood. Many species use information about the Earth’s natural fields for migration, mating, food-finding, homing, nesting, and numerous other activities. Migratory bird species [55, 56], honey bees [57], fish [58], mammals [59], bats [60], numerous insect species [61], mollusks [62], and even bacteria [63] are known to sense Earth’s magnetic fields in various ways. Magnetoreception may enable some bird species to actually see the Earth’s fields [64].

Some insect and arachnid species (e.g., Trichobothria) can detect natural atmospheric electric fields [65] which trigger ballooning behavior — e.g., climbing to the highest place, letting out silk, and traveling on wind currents using hair-like Trichobothria that detects airborne vibrations, currents, and electrical charge. Some have been found as high as 2.5 mi (4 km) in the sky, dispersing over hundreds of kilometers. Morley and Robert [65] found that the presence of a weak natural vertical e-field elicited ballooning behavior and takeoff in the spiders; their mechano-sensory hairs function as putative sensory receivers which are activated by natural weak electric-fields in response to both e-field and air-flow stimuli. The researchers hypothesized that atmospheric electricity was key to the mass migration patterns of some arthropod fauna.

Even soil nematodes (*Caenorhabditis elegans)* orient to earth-strength magnetic fields in their burrowing behaviors and a recent study by Vidal-Gadea [66] found that weak static fields slightly above Earth’s natural fields determined stem cell regeneration in flatworms (*Planaria*) [67].

Large ruminant mammalian species also orient to the Earth’s fields. Grazing cattle and deer were first observed aligning to geomagnetic field lines by Begall et al. [68]. Using satellite imagery, field observations, and measuring “deerbeds” in snow, they noted that domestic cattle across the globe, as well as grazing and resting red (*Cervus alphas*) and roe (*Capreolus capreolus*) deer, consistently align their body axis in a general north–south direction and that roe deer also orient their heads northward when grazing or resting. Burda et al. [69] discovered, however, that man-made ELF-EMF disrupted the north-south alignment with the geomagnetic field in resting cattle and roe deer when they found body orientation was random on pastures under or near power lines, with the disturbed pattern diminishing with distance from conductors. Cattle exposed to various magnetic field patterns directly beneath or near power lines exhibited distinct patterns of alignment. They concluded there was evidence for magnetic sensation in large mammals, as well as overt behavioral reactions to weak ELF-MF in vertebrates, implying cellular and molecular effects. Slaby et al. [70] also found cattle align along a north-south axis but suggested that such alignment may depend on herd density as the affect disappeared in herds with higher numbers. Fedrowitz [71] expanded this to include bovine sensitivity to other weak ELF-EMF from powerlines but with observed effects due to combined electric and magnetic fields rather than the electric field exposure alone (see “Bovines”below).

Cerveny et al. [72] found red fox (*Vulpes vulpes)* use geomagnetic fields during hunting. Even domestic dogs were found by Hart et al. [73] to be sensitive to small variations in the Earth’s orientation in their excretion habits, preferring a general north-south axis for both defecation and urination depending on geomagnetic field changes. And Nießner et al. [74] found dogs and some other species may actually “see” geomagnetic fields through blue-light sensing photoreceptor proteins in their eyes called cryptochromes.

According to the US/UK World Magnetic Model [75], sensitivity to the geomagnetic field may further complicate issues for migratory species (e.g., some turtles, sea animals, birds, and insects) because the Earth’s magnetic north pole is shifting faster than at any time in human history. Compared to the period between 1900 and 1980, it has greatly accelerated to about 30 mi (50 km) distance per year — moving west from over Canada’s Ellesmere Island, its traditional allocation for most of recorded history — toward Russia [76]. Magnetic north fluctuates according to changes in the Earth’s molten core, unlike true north which aligns according to the Earth’s axis. This trend may indicate a coming pole reversal with north and south trading places, something that occurs approximately every 400,000 years with the last being about 780,000 years ago. Some animals may be capable of recalibrating navigational cues but that remains to be seen. Since some migratory bird species may see geomagnetic fields through special receptor cells in their eyes and via other mechanisms, they could be thrown off course. It is unclear how many other species also see geomagnetic fields but some crustaceans and several insect species, especially those with compound eye structures consisting of thousands of ommatidia — tiny independent photoreception units with a cornea, lens, and photoreceptor cells that orient in different directions and distinguish brightness and many more bands of color than humans — are good candidates. Compared to single-aperture eyes, compound eyes have a very large view angle that can detect fast movement and in some cases light polarization.

In aquatic environments, some lakes have more than 200 species of fish that use some form of electromagnetism to locate food and reproduce. Electric eels can deliver a 500-V zap to kill prey. Sharks have an array of electromagnetic sensors. These include: magnetic field receptors in their mouths, eyes that are 10 times more sensitive than humans, and their perception of tiny electric neuronal discharges from the moving muscles in prey (including humans) guides their attacking/feeding behavior (see “Fish”below). Sharks are often attracted by low-level electromagnetic fields surrounding underwater electric cables and are sometimes electrocuted when they mistake the conduit for living prey and bite into it. Many fish have lateral lines on either side of their bodies that are composed of magnetite, which allows fish to swim in synchronous schools [52].

Many other animals evolved special receptor organs to detect environmental EMF. The duck-billed platypus (*Ornithorhynchus anatinus),* a semi-aquatic primitive egg-laying mammal, has thousands of electric sensors on its bill skin. As noted in Lai [77], using these electroreceptors and interacting with another type of mechanoreceptor, a platypus can detect an electric field of 20 μV/cm [78] — equivalent to that produced by the muscles of a shrimp. The information is processed by the somatosensory cortex of the platypus to fix the location of prey. This type of electroreception is common in the three species of monotremes: platypus, and long (*Zaglossus bruijni)* and short-bill (*Tachyglossus aculeatus*) echidna. Electric fish (elasmobranchs) emit EMF that covers a distance of several centimeters [79, 80]. This allows location of potential prey by comparing its electrical properties with that in its immediate vicinity. Their electroreceptors have been shown to detect a field of 5 nV/cm. Such EMF-sensing systems are highly sensitive and efficient but also highly vulnerable to disruption by unnatural fields. Organisms that use the geomagnetic field for migration have the capability not only to detect the field but also the orientation of the field.

Anthropogenic light frequencies affect wildlife in ways we have only recently grasped. Ecological studies have found that artificial light-at-night is disrupting nocturnal animals in devastating ways, including disorientation and disruption in breeding and migration cycles in turtles, flying insects, birds, butterflies and a host of other wildlife including mammals [81–84]. As much as 30% of nocturnal vertebrates and over 60% of invertebrates may be affected by artificial light [85]. Illumination reflected off of clouds known as “sky glow” can produce unnaturally bright conditions at night from various wavelength spectra that impact different species, with the potential to alter the balance of species interactions [86, 87]. It has been found that changing the color of the light can help some species yet harm another [88]. For instance, low-pressure sodium lights that have more yellow in their spectrum reduce moth deaths around the bulbs, but salamanders cannot navigate from one pond to the next under yellow or red light. Some frogs have been observed to freeze for hours, even after lights have been turned off, and to suspend both feeding and reproduction [83].

One of nature's great mysteries involves "natal homing behavior" — the ability of some animal species to return to their original location of birth in order to reproduce, sometimes over great distances. Natal homing behavior is known in sea turtles [89]; eels [90]; and salmon [91], among other species. The underlying mechanism, though imperfectly understood, involves such species "remembering" the geomagnetic field configurations of their birthplace via a process known as "imprinting," and thus can locate and return to it even if they are thousands of miles/kilometers away at reproduction time. Apparently, newborns of these species are imprinted with the memory of the intensity and the inclination angle of the local geomagnetic field. This information is then later used to locate their place of birth where they return to breed.

The question is whether man-made EMF could distort this imprinting memory in later locating the site. For example, what if RFR-emitting facilities are located near turtle breeding sites? Could that interfere with imprinting? There is some evidence from Landler et al. [92] of adverse effects in turtles. The researchers found that RFR could disrupt a natural orientation, establish its own orientation, and reverse completely a natural orientation, indicating a need for research to further investigate as we simply do not know the full effects to other species from anthropogenic EMF.

Energy conduction in different species: unique physiologies and morphologies

The unique physiology and morphology of non-human species create additional complexities. For instance, quadrapedal species with four feet on the ground have different and potentially more efficient conductivity than bipedal species with two feet. One example is bovine heightened sensitivity to increased ground current near high tension lines [93, 94] and cell towers [95–97]. Also, bodies that are predominately parallel to the ground, which includes most four-legged mammals, rather than a perpendicular upright gait, conduct EMF in different ways than vertical species like humans, apes, and other primates. Species that hug the ground, like snakes, salamanders, and frogs, have unique exposures to ground currents, especially on rainy nights when water, as a conductive medium, can increase exposures [98]. This may make some species more sensitive to artificial ground current caused by electric utility companies using the Earth as their neutral return back to the substation for excess alternating current on their lines instead of running additional neutral lines on utility poles [99].

Hair and whiskers and related appendages in various species are known to detect small variations in electromagnetic fields as well as water and weather alterations [100]. In fact, ants have been observed to use their antennae as "EMF antennas" when subjected by researchers to external electromagnetic fields, aligning themselves to "channel" RFR away from the colony [7]. Species such as birds, as well as some insects with compound eyes structures, can see vastly more colors than humans, while cats, dogs, and owls, for instance, hear many more sound frequencies at incredibly low levels.

Magnetoreception mechanisms: electroreceptor cells, magnetite, cryptochromes/radical pairs

According to Lai [77], "…in order for an environmental entity to affect the functions of an organism, the following criteria have to be met: the organism should be able to detect the entity; the level of the entity should be similar to those in the normal ambient environment which is generally much lower than the level of the entity used in experimental studies; and the organism must have response mechanisms tuned to certain parameters of the entity that allow immediate detection of the presence and changes of the entity. Thus, a variation of the entity would be detected as an aberrant input and trigger a response reaction. In order to understand how man-made EMF affects wildlife, the above criteria must be considered, including multiple sensory mechanisms that vary from species to species."

The questions are: How do diverse species detect weak natural geomagnetic signals, distinguish the subtle internal microcurrent and magnetic fields inherent to all biology from external fields, then get beyond both internal and external background noise to make use of that electromagnetic information?

There are three primary mechanisms used to understand magnetoreception:

(1) Magnetic induction of weak electrical signals in specialized sensory receptors [101].
(2) Magnetomechanical interactions with localized deposits of single-domain magnetite crystals [52, 102, 103].
(3) Radical-pair photoreceptors, which may be the most plausible [104–111].

In the induction model (mechanism 1), according to Lin [102], the first category of electrodynamic interactions with weak magnetic fields is epitomized by elasmobranchs, including sharks, rays, and skates, with heads that contain long jelly-filled canals with high electrical conductivity known as the Ampullae of Lorenzini. As these fish swim through the Earth's geomagnetic lines of flux, small voltage gradients are induced in these canals with electric field detections as low as 0.5 μV/m [101] The polarity of the induced field in relation to the geomagnetic field provides directional cues for the fish. However, in birds, insects, and land-based animals, such cells have not been found, indicating this may not be a universal mechanism but rather are environment/species-specific factors [111].

The magnetomechanical model (mechanism 2) involves the naturally occurring iron-based crystalline mineral called magnetite found in most species [52]. Its function is most simply demonstrated in magnetotactic bacteria [63] with high iron content where biogenic magnetite is manufactured in 20–30 single domain crystal chains [112]. Orientation is patterned according to the geomagnetic field. Blakemore et al. [113] found that magnetotactic bacteria in the northern hemisphere migrate toward the north pole of the geomagnetic field whereas the same strains migrate toward the South Pole in the southern hemisphere. At the equator, they are nearly equally divided in north- and- south seeking orientations [114]. And they all migrate downward in response to the geomagnetic field's vertical component, which, in aqueous environments may be essential for their survival in bottom sediments.

Among the many species where magnetite has been found include the cranium and neck muscles of pigeons [115, 116]; denticles of mollusks [117, 118]; and the abdominal area of bees [119]. Tenforde [103] delineated other species with localized magnetite, including dolphins, tuna, salmon, butterflies, turtles, mice, and humans.

The third mechanistic model (mechanism 3) getting research attention today involves a complex free-radical-pair reaction and conversion of the forms of electrons (singlet-triplet inter-conversion) in a group of protein compounds known as cryptochromes. Cryptochromes have been found in the retinas of nocturnal migratory songbirds by Heyers et al. [55] and Moller et al. [56], showing complex communication with the brain for orientation when relying on magnetoreception. Gegear et al. [61] found cryptochromes to be a critical magnetoreception component in fruit flies (*Drosophila melanogaster)*. As noted in Lai [77], cryptochrones are also present in the retinas of some animals [120]. RFR [121] and oscillating magnetic fields [122] have been reported to disrupt the migratory compass orientation in migratory birds. There are also reports that indicate the presence of cryptochromes in plants, which may be responsible for the effect of EMF on plant growth [123]. Cryptochromes are also known to be involved with circadian rhythms [56, 124]. For an excellent review on plausibility, theories, and complexities of cryptochrome/radical pairs, see Ritz et al. [111].

Many species likely use a combination of these mechanisms as well as more subtle influences as yet undetected. The vector of the geomagnetic field may provide the directional information, while intensity and/or inclination provide the positional information needed for orientation. In behavioral studies [125, 126], Wiltschko et al. found that birds used both magnetite and cryptochrome mechanisms when they responded to a short, strong magnetic pulse capable of changing magnetization of magnetite particles, while their orientation was light-dependent and easily disrupted by high-frequency magnetic fields in the MHz range indicating radical pair processes. These findings suggest that along with electrophysiological and histological studies, birds have a radical pair mechanism located in the right eye that provides compass-like directional information while magnetite in the upper beak senses magnetic intensity, thus providing positional information. However, Pakhomov et al. [122] pointed out that the songbird magnetic compass can be disrupted by an oscillating 1.403-MHz magnetic field of 2–3 nT, at a level that cannot be explained by the radical-pair mechanism.

Light plays a significant role [127], which is of environmental concern today as more technology moves toward using the infrared bands for communications and the increase of satellites create artificial/unfamiliar star-like lights in the night sky that are potentially capable of impacting night migration patterns. There is other evidence that species use a combination of photoreceptors and magnetite-based magnetoreception. As mentioned above, in birds the two mechanisms exist side by side, mediating different types of magnetic information as needed, such as flight on sunny vs. cloudy days or nocturnal flights, and they can be easily disrupted [106, 128–130]. Birds may co-process visual information with magnetic information and be able to distinguish between the two [131, 132]. This function likely occurs in the eye or higher avian brain areas via light-dependent information processing and radical pair cryptochromes [131, 133]. Birds' magnetic compass is an inclination compass and RFR fields in the Larmor frequencies near 1.33 MHz were found to disrupt birds' orientation in an extremely sensitive resonance relationship. Blue-light absorbing photopigment cryptochromes have been found in the retinas of birds. RFR appears to directly interfere with the primary processes of magnetoreception and disable the avian compass as long as the exposure is present [126, 128].

Mammals have also demonstrated magnetoreception indicating radical-pair mechanisms. Malkemper et al. [134] found that the surface-dwelling wood mouse (*Apodemus sylvaticus*) built nests in the northern and southern sectors of a visually symmetrical, circular arena, using the ambient magnetic field, or in a field rotated by 90°, indicating the animals used magnetic cues. When the mice were also tested in the ambient magnetic field with a superimposed radio frequency magnetic field (100 nT, 0.9 to 5 MHz frequency sweep), they changed preference from north-south to east-west nest building. But unlike birds that have been found sensitive to a constant Larmor frequency exposure at 1.33 MHz, that range had no effect on mice orientation. Individual animal physiology clearly plays a role in how various species respond. Malewski et al. [135] also found that the Earth's magnetic field acts as a common directional indicator in five species of subterranean digging rodents. And for the first time, research also found that human brain waves exhibit a strong response to ecologically-relevant rotations of Earth-strength magnetic fields [136].

We need far better understanding of magnetoreception's neural, cellular, and molecular processes because the ultimate question is, given our constant rising background levels of EMF, is this ambient noise reaching a tipping point beyond which species simply cannot "hear?" Are we artificially overwhelming living species' ability to function with innate natural biological sensors that evolved over eons in a far more "electro-silent" world? The electroreception mechanisms described above — electroreceptors, magnetite, and cryptochrone/radical-pairs — enable living organisms to detect the presence and immediate changes in environmental fields of very low intensity. And thus they can be easily disturbed by the presence of unfamiliar low-intensity man-made fields.

Electrohypersensitivity in humans has also shown instantaneous response to EMF at low intensity [137]. According to Lai [77], one wonders whether the underlying mechanisms of electrohypersensivity are similar to those described above. Electrohypersensitivity may be a remnant of the evolutionary responses of living organisms to electromagnetic fields — particularly magnetic fields — in the environment. Similarities include responsiveness to very low-field intensity; the response is persistent and built into the physiology of an organism; and the response is immediate and reacts quickly to the fields. Cryptochrome-free radical mechanisms may be involved. Some people are more sensitive than others. Perhaps non-sensitive people can tolerate and compensate for effects, and/or have lost responsiveness to natural magnetic fields and thus have become evolutionarily aberrant. Electrosensitivity is an issue in need of more careful and systematic study and has yet to be broadly highlighted as a health or public welfare concern.

One recent theory by Johnsen et al. [138] postulates that magnetoreception in animal species may be "noisy" — meaning that the magnetic signal is small compared to thermal and other receptor noise, for instance. They speculate that magnetoreception may serve as a redundant "as-needed" source of information, otherwise animal species would use it as their primary source of information. Many species, they note, preferentially exploit non-magnetic cues first if they are available despite the fact that the Earth's geomagnetic field is pervasive and ever-present. They speculate that magnetic receptors may thus be unable to instantaneously attain highly precise magnetic information, and therefore more extensive time-averaging and/or other higher-order neural processing of magnetic information is required. This may render "…the magnetic sense inefficient relative to alternative cues that can be detected faster and with less effort." Magnetoreception may have been maintained, however, they said by natural selection because the geomagnetic field may sometimes be the only available source of directional and/or positional information.

We already know that some species use various mechanisms to detect EMFs as noted throughout this paper. With new environmental factors from anthropogenic causes, such as artificial light-at-night, air/water pollution, climate change impacting visibility as environmental cues, and rising background RFR — all of which can obscure natural information — magnetoreception may, in fact, become *more* necessary as an evolutionary survival tool as time goes on, not less.

Other mechanisms of biological significance: DNA — direct and indirect effects (See Part 2, Supplements 1 and 2, for tables of ELF and RFR genetics studies)

A significant biological effect in any toxicology research involves the basic genetics of an exposed organism. Genetic effects consist mainly of gene expression, chromatin conformational changes, and genotoxicity. All such effects can influence normal physiological functions. Relevant to this paper is the fact that genetic effects are found at EMF levels similar to those in ambient environments, far below levels from communication devices and infrastructure (see Part 1, Supplement 1).

DNA, the fundamental building block of all life, is a molecular double helix that is coiled, twisted and folded within the nucleus of each living cell. It is essentially identical among species with variations only in number and specific genes along chromosomes on DNA's twisted chains that distinguish various species and their characteristics from one another. DNA damage repeatedly seen in one species can therefore be extrapolated to other species, although not all species react the same to external stimuli.

Many factors, both endogenous and exogenous, damage DNA which is then normally repaired by DNA enzymes. But an absence of adequate repair can result in the accumulation of damaged DNA, which will eventually lead to aging, cell death (apotosis) and/or cancer. DNA breaks occur as both single and double strand events; double strand breaks are difficult to repair correctly and can lead to mutations. DNA damage from endogenous factors can include free radical formation from mitochondrial respiration and metabolism; exogenous factors include chemicals, ionizing and nonionizing radiation, and ultra violet light among others [139]

In several early studies, Lai and Singh [140, 141] found both double and single strand DNA breaks in the brain cells of rats exposed to RFR for 2 h at 2,450 MHz, and whole body SAR levels of 0.6 and 1.2 W/kg. The effects were interestingly blocked by antioxidants [142] suggesting free radical involvement, which could indicate an indirect cause for DNA damage (see below). The low-intensity genetic effects listed in Part 2 Supplements 1 and 2 are at 0.1 W/kg and less. Therefore, the Lai and Singh [140, 141] RFR studies are not included in those Supplements. Very similar effects have also been found by Lai and Singh [143, 144] with 60-Hz magnetic field exposure.

There has also been much study of ELF genetic effects. As discussed in Phillips et al. [139], numerous studies found that ELF-EMF leads to DNA damage [143–158]. Two studies [159, 160] showed that ELF also affects DNA repair mechanisms. Sarimov et al. [161] found chromatin conformational changes in human lymphocytes exposed to a 50-Hz magnetic field at 5–20 μT. EMF-induced changes in cellular free radicals are also well studied [77, 162].

Others investigated DNA damage early on but without the availability of today's more sensitive assays. Sarkar et al. [163] exposed mice to 2,450-MHz microwaves at a power density of 1 mW/cm^2 for 2 h/day over 120, 150, and 200 days. They found DNA rearrangement in the testis and brain of exposed animals that suggested DNA strand breakage. Phillips et al. [164] were the first to use the comet assay to study two different forms of cell phone signals — multi-frequency time division multiple access (TDMA) and integrated digital enhanced network (iDEN) — on DNA damage in Molt-4 human lymphoblastoid cells using relatively low intensities of 2.4–26 W/g for 2–21 h. The authors reported seeming conflicting increases *and* decreases in DNA damage, depending on the type of signal studied, as well as the intensity and duration of exposure. They speculated the fields could affect DNA repair mechanisms in cells, accounting for the conflicting results.

In a recent literature review of EMF genetic effects by Lai [165], analysis found more research papers reporting effects than no effects. For RFR, 224 studies (65%) showed genetic effects while 122 publications (35%) found no effects. For ELF and static-EMF studies, 160 studies (77%) found effects while in 43 studies (23%) no effects were seen.

Research now points to the duration, signaling characteristics, and type of exposure as the determining factors in potential damage [164, 166], not the traditional demarcation between ionizing and nonionzing radiation. Long-term, low-level nonionizing radiation exposures common today are thought to be as detrimental to living cells as are short-term, high-intensity exposures from ionizing radiation. Effects may just take longer to manifest [167]. Nonionizing EMF at environmental levels does cause genetic damage. These have also been shown in humans exposed to environmental levels of EMF in both ELF and RFR ranges [168–171]. Conceivably, similar genetic effects could happen in other species living in similar environments.

This body of genetics work goes against the pervasive myth that low-level, low-intensity nonionizing radiation cannot cause detrimental genetic effects. That premise is in fact the bedrock belief upon which vested interests and government agencies rely in support of current exposure standards. But in fact, biological systems are far more complex than physics models can ever predict [6, 8, 172]. A new biological model is needed because today's exposures no longer fit that framework [173] for humans and wildlife. Enough research now indicates a reassessment is needed, perhaps including the very physics model used to back those traditional approaches (see Part 1).

Direct mechanisms: DNA as fractal antennas, cell membranes, ion channels

DNA as fractal antennas

There are several likely mechanisms for DNA damage from nonionizing radiation far below heating thresholds, both direct and indirect, intracellular, intercellular, and extracellular. Such mechanisms potentially apply to all wildlife. One direct mechanism theorizes that DNA itself acts as a fractal antenna for EMF/RFR [174], capable of receiving information from exogenous exposures.

According to Blank and Goodman [174], DNA has interesting electrical characteristics due to its unique structure of intertwined strands connected by rungs of molecules called nucleotides (also called bases), with each rung composed of two nucleotides (one from each strand) in bonded pairs. The nucleotides are held together by hydrogen bonds in close proximity that results in a strong attraction between the two strands. There are electrons on both molecular surfaces making the symmetrical nucleotides capable of conducting electron current along the entire DNA chain, a phenomenon called electron transfer. This makes DNA a most efficient electrical conductor, something not lost on nanotechnology researchers.

DNA may also act as an efficient fractal antenna due to its tightly packed shape within the cell nucleus. Blank and Goodman [174] characterized DNA properties in different frequency ranges, and considered electronic conduction within DNA's compact construction in the nucleus. They concluded that the wide frequency range of observed interactions seen with EMF is the functional characteristic of a fractal antenna, and that DNA itself possesses the two structural characteristics of fractal antennas — electronic conduction and self symmetry. They noted that these properties contribute to greater reactivity of DNA with EMF in the environment, and that direct DNA damage could account for cancer increases, as well as the many other biological effects seen with EMF exposures.

A fractal is a self-repetitive pattern of sometimes geometric shapes, marked by a larger originating design progressing to small identical designs with a potentially unlimited periphery. Each part of the shape looks like the whole shape. Fractal designs are quite common in nature, e.g., in snail/mollusk shells, some deciduous tree leaves and conifer needles, pine cones, many flowering plants, some reptile scales, bird feathers and animal fur patterns, snowflakes, and crystals forming on cold winter glass windows. Minerals — both inert and biological — can also be fractals.

The varying sizes within fractals are what make them inherently multi-frequency. By mimicking nature, repetitive fractal patterns are also designed into mechanical transceiver antennas that radiate in multiband frequencies with more or less efficiency [175]. Cell phones, WiFi, digital TV, and many other transceivers use fractal antennas to operate.

The complex twisted shape and coiled structure of DNA — small coils coiled into larger coils, or *coiled coils*, which Blank and Goodman [174] note that no matter how far you zoom in or out, the shape looks the same — is the exact structure of a fractal that maximizes the length of an antenna within a compact space while boosting multi-frequency signals. As such, DNA may be acting as a hidden intracellular biological fractal capable of interacting with exogenous EMF across a range of frequencies. In fact, one of DNA's fundamental functions may be specifically to interact with exogenous natural energy and as such may be more sensitive to EMF than other larger protein molecules within any living system. Once thought safely tucked away and protected within the nucleus, DNA may be acting as a most efficient electrical conductor at the nexus of all life. This interesting theory, unfortunately, has not been followed up by others to test its biological validity although fractals have been mimicked widely in technology.

Cell membranes/ion channels

Another direct effect from EMF is at the cell membrane itself. While DNA is life's fundamental building block, cells are DNA's complex electron-coherent architectural expression. The cell's membrane is far more than just a boundary. It is rather the most important ordering tool in the biological space between intracellular and extracellular activities, "… a window through which a unitary biological element can sense its chemical and electrical environment" [176]. And it is replete with microcurrent.

The cell's outer surface contains molecules that receive innumerable electrochemical signals from extracellular activities. Specific binding portals on the cell membrane set in motion a sequence leading to phosphorylation of specific enzymes that activate proteins for cellular 'work.' That includes everything from information processing in the central nervous system, mechanical functions such as muscle movements, nutrient metabolism, and the defense work of the immune system, among many others including the production of enzymes, hormones, antibodies, and neurotransmitters [177]. Complex microcurrent signaling pathways exist from the cell's outside to the inside via protein intramembraneous particles in the phospholipid plasma membrane. These convey information on external stimuli to the cell's interior to allow cellular function.

The cell membrane also has electrical properties. Microcurrent constantly moves from the interior to the exterior and vice versa of the cell membrane. According to Adey and Sheppard [176], some of these properties influence proteins that form voltage gated membrane channels, which is one way that cells control ion flow and membrane electromagnetic potential essential to life. There are specific windows that react according to frequency, amplitude, and duration differences, indicating a nonlinear and non-equilibrium character to exogenous exposures on cells [177–185].

Some pulsed fields are more biologically active than non-pulsed fields and different forms of pulsing also create different effects. As far back as 1983, Goodman et al. [186] found pulsed weak electromagnetic fields modified biological processes via DNA transcription when a repetitive single pulse and the repetitive pulse train were used. The single pulse increased the specific activity of messenger RNA after 15 and 45 min while the pulse train increased specific activity only after 45 min of exposure. Digital technology simulates pulsing and is the most common form of environmental exposure today.

Cellular calcium ion channels have long been of interest and may be particularly sensitive targets for EMFs due to possible increased calcium flux through the channels which can lead to secondary responses mediated through Ca^{2+}/calmodulin stimulation of nitric oxide synthesis, calcium signaling, elevated nitric oxide (NO), NO signaling, peroxynitrite, free radical formation, and oxidative stress — many with implications to DNA as hypothesized by Pall [187]. Calcium is essential to signal transduction between cells and is significant to everything from metabolism, bone/cell/blood regeneration, hormone production and neurotransmissions among many others. These cellular calcium responses to EMF indicate an artificial change in the signaling processes at the cell membrane — considered a switchboard for information between the exterior environment and intracellular activities that guide cell differentiation and control growth [188].

Pall [187] cited 23 studies of effects to voltage gated calcium channels (VGCC) and noted nonthermal mechanisms were the most likely since many studies showed effects were blocked by calcium channel blockers (widely prescribed for heart irregularities having nothing to do with thermal issues). Pall [189] noted that many other studies showed EMF changes in calcium fluxes and intracellular calcium signaling. He hypothesized that alterations in intracellular calcium activity may explain some of the myriad biological effects seen with EMF exposure, including oxidative stress, DNA breaks, some cancers, infertility, hormonal alterations, cardiac irregularities, and diverse neuropsychiatric effects. These end points need further study and verification.

There is much to be learned about calcium effects as studies are contradictory. Changes in free radicals (see below) also affect calcium metabolism. There are more studies showing EMF effects on free radicals than calcium changes. Calcium activates the nitric oxide free radical pathway but there are only a few studies of this pathway following EMF exposure — less than 5% of EMF-oxidative change studies are on nitric oxide mechanisms. Also of interest is the fact that power density and frequency windows were seen in early research at rising harmonic increments along the electromagnetic spectrum beginning in the ELF bands [190–195]. Observed effects were quite dramatic in what researchers described as calcium efflux or 'dumping' from cells. The most dramatic effects were seen at 180 Hz in the ELF range. This appears to contradict Pall's work [189] cited above as increased calcium efflux is the opposite of what Pall's hypothesis would predict, e.g., calcium *influx*. With more research both calcium influx and efflux effects may be found to be caused by different variables and/or EMF exposures.

In addition, exogenous signaling characteristics are also important to how cells react to both ELF and RFR ranges. Building on the work that demonstrated carrier waves of 50 and 147 MHz, when sinusoidally amplitude modulated at 16 Hz ELF in *in vitro* chick brain tissue [190, 191] and in live awake cat brain models [196] that created frequency windows for calcium efflux, Blackman et al. [194] additionally found that signaling *characteristics* were also significant. Research showed that calcium efflux occurred only when tissue samples are exposed to specific intensity ranges of an ELF-modulated carrier wave; unmodulated carrier waves did not affect ion efflux. Blackman et al. [194] further wrote that cells may be capable of demodulating signals. The authors reported that 16-Hz sinusoidal fields, in the absence of a carrier wave, altered the efflux rate of calcium ions and showed a frequency-dependent, field-induced enhancement of calcium-ion efflux within the ranges 5–7.5 V/m and 35–50 V/m (peak-to-peak incident field in air) with no enhancement within the ranges 1–2, 10–30, and 60–70 V/m. This body of work indicates that living cells interact with, and are capable of taking direction from, exogenous fields in far more complex ways than ever imagined, at intensities barely above background levels. This work may be particularly important to new technology that turns previously wired ELF frequencies into wireless applications, such as "wireless electricity" to charge electric cars.

Blackman et al. [197] found for the first time a link between the ELF/EMF being studied and the density of the natural local geomagnetic field (LGF) in the production of a biological response. Calcium efflux changes could be manipulated by controlling the LGF along with ELF and RF-EMF exposures. In a local geomagnetic field at a density of 38 μT, 15- and 45-Hz electromagnetic signals had been shown to induce calcium ion efflux from the exposed tissues, whereas 1- and- 30-Hz signals did not. Bawin and

Adey [190] found a reduction in efflux when using an electric field; Blackman et al. [194] found an increase when using an electromagnetic field, thus identifying/isolating for the first time the significance of the magnetic field component in exposure parameters. Building on the window ranges noted above, Blackman et al. [197] demonstrated that the enhanced calcium efflux field-induced 15-Hz signal could be rendered ineffective when the LGF is reduced to 19 μT with Helmholtz coils. In addition, the ineffective 30-Hz signal became effective when the LGF was altered to k25.3 μT or to +76 μT. *The results demonstrated that the net intensity of the local geomagnetic field is an important cofactor in biological response and a potentially hidden variable in research.* The results, they noted, appear to describe a resonance-like relationship in which the frequency of the electromagnetic field can induce a change in calcium efflux proportional to LGF density (see Liboff [198, 199] below for more detail).

The bottom line is that changes of this magnitude at the cellular level — be it directly to DNA within the nucleus or via voltage gated channels at the cell's membrane — can lead to direct effects on DNA within and across species. The evidence cited above illustrates the degree, likelihood, and variety of impacts from EMF directly on cellular physiology that are capable of affecting DNA in all living systems in myriad ways.

Indirect mechanisms: free radicals, stress proteins, resonance, Earth's geomagnetic fields

Free radicals

An indirect, or secondary, mechanism for DNA damage would be through free radical formation within cells, which is the most consistently reported with both ELF and RFR exposures under many different conditions in biological systems. According to Phillips et al. [139], free radicals may also interact with metals like iron [142, 151, 152, 158] and play a role in genotoxic effects from something called the Fenton effect — a process "…catalyzed by iron in which hydrogen peroxide, a product of oxidative respiration in the mitochondria, is converted into hydroxyl free radicals, which are very potent and cytotoxic molecules" [139].

The significance of free radical processes may eventually answer some questions regarding how EMF interacts with biological systems. There are about 200–300 papers showing EMF effects on free radicals [77, 168, 200]. Free radicals are important compounds involved in numerous biological functions that affect many species. Increases in free radicals explain effects from damage to macromolecules such as DNA, protein, and membrane lipids; increased heat shock proteins; neurodegenerative diseases; and many more.

Yakymenko et al. [168] published a review on oxidative stress from low-level RFR and found induced molecular effects in living cells, including significant activation of key pathways generating reactive oxygen species (ROS), activation of peroxidation, oxidative damage in DNA, and changes in the activity of antioxidant enzymes. In 100 peer-reviewed studies, 93 confirmed that RFR induced oxidative effects in biological systems and that their involvement in cell signaling pathways could explain a high pathogenic range of biological/health effects. They concluded that low-intensity RFR should be recognized as one of the primary mechanisms of biological activity of nonionizing radiation. In a follow-up study, Yakymenko et al. [200] investigated the oxidative and mutagenic effects of low intensity GSM 1,800 MHz RFR on developing quail embryos exposed *in ovo* (0.32 $\mu W/cm^2$, 48 s On, 12 s Off) during 5 days before and 14 days through the incubation period. They found statistically significant oxidative effects in embryonic cells that included a 2-fold increase in superoxide generation rate, an 85% increase in nitrogen oxide generation, and oxidative damage to DNA up to twice the increased levels of 8-oxo-dG in cells of 1-day old chicks. RFR exposure almost doubled embryo mortality and was statistically significant. They concluded that such exposures should be recognized as a risk factor for living cells, including embryonic integrity.

Lai [77] focused a review on static magnetic field ELF-EMF and found that changes in free radical activities are one of the most consistent effects. Such changes can affect numerous physiological functions including DNA damage, immune system and inflammatory response, cell proliferation and differentiation, wound healing, neural electrical activities, and behavior. Given that many species have proven sensitive to natural static geomagnetic fields and use such information in critical survival skills, some wildlife species may also be adversely affected via free radical alterations from anthropogenic exposures. But Lai [77] noted the inherent contradictions from EMF-induced changes in free radicals, particularly on cell proliferation and differentiation since those processes can affect cancer development as well as growth and development. Induced free-radical changes may therefore have therapeutic applications in killing cancer cells via the generation of the highly cytotoxic hydroxyl free radical by the Fenton Reaction (noted above), thereby creating a non-invasive low-side-effect cancer therapy.

Stress proteins

Another potentially indirect effect to DNA is via protein synthesis required by all cells to function. A living animal converts animal and plant proteins that it ingests into other proteins needed for life's activities — antibodies, for instance, are a self-manufactured protein. DNA is critical to protein synthesis and can create in humans about 25,000 different kinds of proteins with which the body can then create 2,000,000 types in order to fully function.

There are many different classes of proteins. These include stress proteins stimulated by potentially harmful environmental factors to help cells cope and repair damage due to factors like acute temperatures, changes in oxygen levels, chemicals/heavy metals exposure, viral/bacterial infections, ultraviolet light and other ionizing and nonionizing radiation exposures [124].

The presence of stress proteins indicates healthy repair action by an organism and is considered beneficial up to a point as a protective mechanism. According to Blank and Goodman [201], "The 20 different stress protein families are evolutionarily conserved and act as 'chaperones' in the cell when they 'help' repair and refold damaged proteins and transport them across cell membranes. Induction of the stress response involves activation of DNA." Stress proteins are also considered a yardstick to determine what living cells experience as stress that requires remediation in the first place — something not always obvious, especially with subtle environmental exposures like low-level EMF barely above natural background levels.

Whether an effect is thermal or nonthermal, adverse or simply observed biologically, has been subject to fierce debate for decades; thus tissue-heating DNA pathways are also central to this paper. Heat as a cellular stressor was first observed in the 1960s by Italian researcher Ferruccio Ritossa in fruit flies (*D. melanogaster*) when experimental temperatures were accidentally raised by a few degrees and he observed enlarged chromosomes at particular sites. (*Drosophilae* are often used in research because they only have four pairs of chromosomes, are relatively easy to work with, have a fast breeding cycle, and lay numerous eggs.) As cited in Blank [124], as Ritossa's observation became better understood, with effects subsequently seen over decades in animals, plants and yeast cells, it came to be called the "heat shock response." Extensive research established that the heat shock response lead to the formation of a unique protein class — heat shock proteins (HSP) that repair other proteins from potentially fatal temperature damage, as well as assist cells to be more thermo-tolerant. Research has gone on to prove that cells produce other similar proteins to various stressors, now generally called stress proteins but most are still categorized as "HSP" from the original demarcation.

Goodman and Blank [202, 203] found that EMF is a cellular stressor even at low intensities in the absence of elevated temperatures. They found the protein distribution patterns synthesized in response to ELF-EMF resembled those of heat shock with the same sequence of changes even though the energy of the two stimuli differed by many orders of magnitude. Their results indicated that ELF-EMF stimulates a similar gene expression pathway as that of thermal shock and is itself a cellular stressor. Of particular significance is the fact that over-expression of stress genes is found in a number of human tumors and is characteristic of a variety of neoplasia [202]. Increased stress proteins are seen in numerous animal model studies pertinent to wildlife.

Blank and Goodman [201] further noted that both ELF and RFR activate the cellular stress response despite the large energy difference between them; that the same cellular pathways respond in both frequency ranges; and that models suggest that EMF can interact directly with electrons in DNA. They note that low energy EMF interacts with DNA to induce the stress response while the increased energy in RFR can lead to DNA strand breaks. *As such, this makes the stress response a frequency-dependent direct and indirect cause of DNA damage — a significant finding.* They concluded that exposure standards should not be based on exposure intensity alone but on biological responses long before thermal thresholds are met or crossed.

Resonance and geomagnetic fields

There are other important direct and indirect ways that EMFs interact with and effect biological systems, including various forms of resonance — cyclotron, electron paramagnetic, nuclear, and stochastic — as well as through inherently produced biological materials such as magnetite found in bird brains and many other species (see below).

Resonance is the phenomenon that occurs when a certain aspect of a force (like a frequency wave) matches a physical characteristic (like a cell or whole living organism) and the power inherent in the force is transferred to the physical object causing it to resonate or vibrate. Within the object, the resonance is self-perpetuating. The classic example is of an opera singer hitting high C in the presence of a crystal goblet for a sustained period until it shatters.

Following the work of Blackman et al. [197] who found the Earth's local geomagnetic fields (LGF) could influence calcium ions moving through membrane channels (see above), Liboff [198, 199] proposed that cyclotron resonance was a plausible mechanism for coupling interactions between the LGM and living cells. Liboff found cyclotron resonance consistent with other indications that showed many membrane channels have helical configurations; that the model could apply to other circulating charged components within the cell; and that cyclotron resonance could lead to direct resonant electromagnetic energy transfer to selected cell compartments.

All resonance is based on a *relationship*. Cyclotron resonance is based on the relationship between a constant magnetic field and an oscillating (time-varying) electric or magnetic field that can affect the motion of charged particles such as ions, some molecules, electrons, atomic nuclei, or DNA in living tissue. Living systems are filled with charged particles necessary for life, including calcium, sodium, lithium, and potassium ions that all pass through the cell membrane and are capable of affecting DNA. Cyclotron resonance occurs when an ion is exposed to a steady magnetic field (such as the Earth's) which causes the ion to move in a circular orbit at a right angle to the field. The speed of the orbit is determined by the charge and mass of the ion and the strength of the magnetic field. If an electric field is added that oscillates at exactly the same frequency and that is also at a right angle to the magnetic field, energy will be transferred from the electric field to the ion causing it to move faster. The same effect can be created by applying an additional magnetic field parallel to the constant magnetic field. This is important because it provides a plausible mechanism for how living cells interact with both natural and artificial fields, and explains how vanishingly low levels of EMFs can create major biological activity when concentrated on ion particles. It also points to living systems' ability to demodulate — or take direction from — certain aspects of electromagnetic information from both natural and artificial exposures [7]. Resonance should not be underestimated. It applies to all frequencies and is not based on power density alone.

Another subtle energy relationship in biology is called stochastic resonance that has been determined to be significant in how various species interact with their natural environments, in some instances for their survival. Stochastic resonance is a phenomenon where a signal below normal sensing can be boosted by adding wide-spectrum white noise signals. The frequencies in the white noise that match the original signal's frequencies will resonate with each other and amplify the original signal while not amplifying the rest of the white noise. This increase in what is called the signal-to-noise ratio makes the original signal more prominent. Some fish, for instance, can "hear" predators better in the noise of running water than in still water due to stochastic resonance (see "Fish" below.).

The signal-to-noise ratio has been a prominent aspect of EMF research with some scientists long holding that energy exposures below the body's natural signal-to-noise ratio could not possibly damage living tissue. But the most recent research that finds effects to DNA from low intensity EMF indicates that many variables affect biological processes, often in nonlinear patterns far below the signal-to-noise ratio. Some of the most cutting edge research — with an eye toward treating human *in utero* birth defects and adult limb regeneration — is being done by manipulating the electric charge across cell membranes (called membrane potential) via intentional manipulation of genes that form ion channels. Pai et al. [204] found that by putting ion channels into cells to raise the voltage up or down, they could control the size and location of the brain in embryonic African clawed frogs (*Xenopus laevis*), thus demonstrating the importance of microcurrents on membrane potential in growth and development. The research group also studied endogenous bioelectricity on clawed frog brain patterning during embryogenesis, noting that early frog embryos exhibit a characteristic hyperpolarization of cells lining the neural tube. Disruption of this spatial gradient of the transmembrane potential (V_{mem}) diminished or eliminated the expression of early brain markers in frogs, causing anatomical mispatterning, including absent or malformed regions of the brain. This effect was mediated by voltage-gated calcium signaling and gap-junctional communication. The authors hypothesized that voltage modulation is a tractable strategy for intervention in certain classes of birth defects in humans but they did not make the leap to potential environmental damage to other species from such ambient exposures.

In general, whether direct, indirect, or synergistic, to understand ambient effects to wildlife, one also needs to know if effects are cumulative, what compensatory mechanisms a species may have, and when or if homeostasis will deteriorate to the point of no return [205]. In looking at environmental contaminants, we have historically focused on chemicals for both direct and indirect effects such as endocrine disruption. But primary biological manifestation is more physical than chemical since the only thing that distinguishes one chemical from another on the Periodic Table is the amount of electrons being traded up and down on the scale. Chemicals are actually secondary manifestations of initial atomic principles, not the other way around. Plus, the synergistic effects of the Earth's natural fields can no longer be dismissed as an interesting artifact that is not biologically active or relevant. All living systems are first and foremost expressions of biological energy in various states of relationship.

For a Table of more low-level effects studies on DNA, see Part 2, Supplements 1 and 2.

What the studies show

The literature is voluminous on EMF effects to nonhuman species, going back at least to the 1930s using modern methods of inquiry. We have, after all, been using animal, plant, and microbial models in experiments for decades. We may in fact know *less* about effects to humans than to other species.

In this paper, we focused on exposures common in today's environment. In Part 1, Rising Background Levels, we defined low level RFR as power density of 0.001 mW/cm^2 (1 µW/cm^2), or a SAR of 0.001 W/kg. Part 2 Supplements 3 and 4 contain extensive tables with pertinent studies that apply to fauna and flora, respectively. The sections that follow in Part 2 on individual species include selected studies of particular interest to how EMF couples with, and potentially affects, wildlife. In most studies, as illustrated in Part 2, Supplement 3, the intensity of the incident EMF was provided in µW/cm^2 or V/m. To be consistent throughout the paper, we converted intensity in the studies to µW/cm^2. However, such conversion (i.e. V/m to µW/cm^2) tends to overestimate the exposure level and does not represent the full picture. Therefore where studies provided the amount of energy absorbed, e.g., the specific absorption rate (SAR), they were also included in Supplement 3 (in W/kg). Very low levels of energy absorption have shown effects in all living organisms studied.

Levitt and Lai [167] reported numerous biological effects from RFR at very low intensities and SARs comparable to far-field exposures within 197–492 ft (60–150 m) from cell towers. Included were *in vivo* and *in vitro* low-intensity RFR studies. Effects included genetic, growth and reproductive changes; increased permeability of the blood brain barrier; changes in stress proteins; behavioral responses; and molecular, cellular, genetic, and metabolic alterations. All are applicable to migratory birds, mammals, reptiles, and other wildlife and to plant communities, and to far-field exposures in general. (An update of that table appears in Part 2 Supplement 3.) It is apparent that environmental levels of RFR can elicit biological/health effects in living organisms. Although there are not enough data on low-intensity effects of static ELF-EMF to formulate a separate table, some effects of low-intensity static ELF-EMF are also described throughout this paper. ELF genotoxic effects can be found in Part 2, Supplement 2 and ELF in flora are also listed separately in Part 2, Supplement 4.

Effects, however, do not easily translate from the laboratory to the field. Cucurachi et al. [31] reported on 113 studies with a limited number of ecological studies. The majority were conducted in laboratory settings using bird embryos or eggs, small rodents, and plants. In 65% of the studies, effects from EMF (50% of the animal studies and about 75% of the plant studies) were found at both high and low intensities, indicating broad potential effects. But lack of standardization among the studies and limited sampling size made generalizing results from organism to ecosystem difficult. The researchers concluded that due to the number of variables, no clear dose–response relationship could be determined. Nevertheless, effects from some studies were well documented and can serve as predictors for effects to wild migratory birds and other wildlife.

As noted elsewhere throughout this paper, living organisms can sense and react to very low-intensity electromagnetic fields necessary for their survival as seen, for instance, in studies by Nicholls and Racey [206, 207] on bats and many others. Bats are already in serious trouble in North America from white-nosed syndrome and commercial wind turbine blade collisions. Due to the increased use of tracking radars for bird and bat studies, impacts will likely only increase [22, 23]. Presence of low levels of RFR from tracking radars could adversely affect bat foraging activity, which in turn could affect the composition of insect populations in the vicinity. Many insects, including honey bees (*Apis mellifera* var) and butterflies also depend on the Earth's electromagnetic fields for orientation and foraging. Presence of exogenous RFR can disturb these functions. This is particularly relevant for pollinator insects, such as bees and butterflies. Pollinators are essential in producing commercial crops for human consumption, including almonds, apples, pears, cherries, numerous berry crops, citrus fruits, melons, tomatoes, sunflowers, soybeans, and much more. The strongest disruptive effect to insect pollinators occurs at 1.2 MHz known as the Larmor frequency [208] which is related to radical pair resonance and superoxide radical formation. This is an important indication that effects from RFR are frequency-dependent.

Lai [77], citing Shepherd et al. [209], noted that EMF can disrupt the directional sense in insects. The fact that many animals are able to differentiate the north and south poles of a magnetic field known as the polarity compass [68, 73, 134, 210, 211] indicates they are susceptible to having that important sense impaired. These polarity compass traits confer survival competitiveness to organisms but are of particular concern since directional cues can be easily disturbed by man-made EMF [69, 134, 212].

Bird migration also depends on proper sensing and orientation to natural electromagnetic fields. A study by Engels et al. [213] showed that magnetic noise at 2 kHz–9 MHz (within the range of AM radio transmission) could disrupt magnetic compass orientation in migratory European Robins (*Erithacus rubecula*). The disruption can occur at a vanishingly low level of 0.01 V/m, or 0.0000265 μW/cm^2. Similar effects of RFR interference on magnetoreception have also been reported in a night-migratory songbird [214] and the European Robin [126]. Migration is already a taxing and dangerous activity for birds; adding another potential negative impact to bird survival is troubling.

Lai [77] also noted that another consideration is the "natal homing behavior" exhibited in some animals that return to their natal birth places to reproduce. These include sea turtles [89] eels [90]; and salmon [91]. Newborns of these animals are imprinted with the memory of the intensity and the inclination angle of the local geomagnetic field, later used to locate their place of birth when they return to breed. There are indications that man-made EMF can distort this imprinting memory to locate the site (see "Fish" and "Turtles"below). This has important consequences to the survival of particular species since it interrupts their reproductive processes.

It is clear that biological effects can occur at levels of man-made RFR in our present environment, thereby conceivably altering delicate ecosystems from a largely unrecognized danger.

Mammals

The majority of EMF laboratory research, some going back to the 1800s, has been conducted on a variety of mammal species using mice, rats, rabbits, monkeys, pigs, dogs, and others. (The second and third most used models are on insects and yeast respectively.) Thus, with varying degrees of confidence, we know a significant amount about how energy couples with, and affects, laboratory mammalian species across a range of frequencies. However, this evidence does not automatically transfer at the same confidence level regarding how this vast body of research applies to wildlife, including mammalian species.

There is unfortunately a dearth of field research on EMF effects to wildlife. Referenced below, however, are many potential indicator studies. The effects seen include reproductive, behavioral, mating, growth, hormonal, cellular, and others.

Rodents

Rodents are the most frequently used mammalian species in laboratory research across a range of frequencies and intensities. While studies are inconsistent, there are enough troubling indications regarding potential EMF implications for wildlife.

In the RFR range, there have been several reviews of fertility and other issues in rodent models with citations too numerous to mention here — see La Vignera e al. [215] and Merhi [216] — but some stand out as potentially pertinent to wildlife.

Magras and Xenos [217] investigated effects of RFR on prenatal development in mice, using RFR measurements and *in vivo* experiments at several locations near an "antenna park," with measured RFR power densities between 0.168 and 1.053 μW/cm^2. Divided into two groups were 12 pairs of mice, placed in locations of different power densities, and mated five times. One hundred eighteen newborns were collected, measured, weighed, and examined macro- and microscopically. With each generation, researchers found a progressive decrease in the number of newborns per dam ending in irreversible infertility. However, the crown-rump length, body weight, and number of lumbar, sacral, and coccygeal vertebrae, was improved in prenatal development of some newborns. RFR was below exposure standards and comparable to far-field exposures that mice could experience in the wild.

Aldad et al. [218], in a laboratory setting, investigated cell phone RFR (800–1,900 MHz, SAR of 1.6 W/kg) exposures in *in-utero* mouse models and effects on neurodevelopment and behavior. They found significant adult behavioral effects in prenatally exposed mice vs. controls. Mice exposed *in-utero* were hyperactive, had decreased memory and anxiety, and altered neuronal developmental programming. Exposed mice had dose-response impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex. This was the first evidence of neuropathology in mice from *in-utero* RFR at cell phone frequencies, now the most prevalent in the environment. Effects persisted into adulthood and were transmissible to next generations. Such changes can affect survival in wild populations.

Meral et al. [219] looked at effects in guinea pigs (*Cavia parcels*) from 900 MHz cell phone frequency exposures on brain tissue and blood malondialdehyde (MDA), glutathione (GSH), retinol (vitamin A), vitamin D(3) and tocopherol (vitamin E) levels, as well as catalase (CAT) enzyme activity. Fourteen male guinea pigs were randomly divided into control and RFR-exposed groups containing seven animals each. Animals were exposed to 890- to-915 MHz RFR (217 Hz pulse rate, 2 W maximum peak power, SAR 0.95 W/kg) from a cellular phone for 12 h/day (11 h 45 min stand-by and 15 min spiking mode) for 30 days. Controls were housed in a separate room without cell phone radiation. Blood samples were collected through cardiac puncture; biochemical analysis of brain tissue was done after decapitation at the end of the 30-day period. Results found MDA levels increased (p<0.05), and GSH levels and CAT enzyme activity decreased, while vitamins A, E and D(3) levels did not change significantly in the brain tissue of exposed animals. In blood samples of the exposed group, MDA, vitamins A, D(3) and E levels, and CAT enzyme activity increased (p<0.05), while GSH levels decreased (p<0.05). They concluded that cell phone radiation could cause oxidative stress in brain tissue of guinea pigs but more studies were needed to determine if effects are harmful and/or affect neural functions.

Lai et al. [220] found that Sprague-Dawley rats exposed to RFR during water maze testing showed spatial working memory deficits compared to controls. But similar studies [221–223] did not find performance effects in spatial tasks or alterations in brain development after similar exposures. However, subsequent studies in the last two decades have shown memory and learning effects in animals and humans after RFR exposure [224].

Several studies also investigated RFR behavioral effects in rodent models on learning, memory, mood disturbances, and anxiety behaviors with contradictory results. Daniels et al. [225] found decreased locomotor activity, increased grooming and increased basal corticosterone levels in rats exposed to RFR for 3 h per day at 840 MHz, but no significant differences were seen between controls and test animals in spatial memory testing or morphological brain assessment. The researchers concluded that RFR exposure may lead to abnormal brain functioning.

Lee et al. [226, 227] looked specifically at effects on pregnant mice and rat testicular function from combined RFR mobile network signal characteristics used in wideband code division multiple access (W-CDMA) or CDMA used in 3G mobile communications. Experiments showed no observable adverse effects on development, reproduction, or mutation in tested subjects. And no significant effects were seen by Poulletier de Gannes et al. [228] in *in-utero* and post-natal development of rats with wireless fidelity (WiFi) at 2,450 MHz. Also, Imai et al. [229] found no testicular toxicity from 1.95 GHz W-CDMA.

One extremely high frequency (EHF) study comparable to 5G on a mouse model by Kolomytseva et al. [230] looked at leukocyte numbers and the functional activity of peripheral blood neutrophils. In healthy mice, under whole-body exposures to low-intensity extremely-high-frequency electromagnetic radiation (EHF, 42.0 GHz, 0.15 mW/cm^2, 20 min daily) found that the phagocytic activity of peripheral blood neutrophils was suppressed by about 50% (p<0.01 as compared with the sham-exposed control) in 2–3 h after the single exposure. Effects persisted for 1 day and thereafter returned to normal within 3 days. But a significant modification of the leukocyte blood profile was observed in mice exposed to EHF for 5 days after exposure cessation. Leukocytes increased by 44% (p<0.05 as compared with sham-exposed animals). They concluded that EHF effects can be mediated via metabolic systems and further said results indicated whole-body low-intenstiy EHF exposure of healthy mice had a profound effect on the indices of nonspecific immunity. These low levels will be common near 5G infrastructure.

In well-designed non-rodent mammal field studies, Nicholls and Racey [206, 207], found that foraging bats showed aversive behavioral responses near large air traffic control and weather radars. Four civil air traffic control (ATC) radar stations, three military ATC radars and three weather radars were selected, each surrounded by heterogeneous habitat. Three sampling points were carefully selected for matched habitats, type, structure, altitude and surrounding land class at increasing distances from each station. Radar field strengths were taken at three distances from the source: close proximity (<656 ft/200 m) with a high EMF strength >2 V/m (1.06 μW/cm^2), an intermediate line-of sight point (656–1,312 ft/200–400 m) with EMF strength <2 V/m, and a control location out of radar sight (>1,312 ft/400 m) registering 0 V/m. Bat activity was recorded three times for a total of 90 samples, 30 within each field strength category. Measured from sunset to sunrise, they found that bat activity was significantly reduced in habitats exposed to an EMF greater than 2 V/m compared to 0 EMF sites, but such reduced activity was not significantly different at lower EMF levels within 400 m of the radar. They concluded that the reduced bat activity was likely due to thermal induction and an increased risk of hyperthermia. This was a large field study near commercial radar installations with mostly high intensity exposures but low-level effects cannot be excluded given known magneto-sensitivity in bats.

In another field study using a small portable marine radar unit significantly less powerful than their earlier measured field study, Nicholls and Racey [207] found the smaller signal could also deter bats' foraging behaviors. First, in summer 2007, bat activity was compared at 20 foraging sites in northeast Scotland during experimental trials with radar switched on, and in controls with no radar signal. After sunset, bat activity was recorded for a period of 30 min with the order of the trials alternating between nights. Then in summer 2008, aerial insects were sampled at 16 of the sites using two small light-suction traps, one with a radar signal, the other a control. Bat activity and foraging were found significantly reduced when the radar signal was unidirectional, creating a maximized exposure of 17.67–26.24 V/m (83–183 μW/cm^2). The radar had no significant effect on the abundance of insects captured by the traps despite reduced bat activity.

Balmori [231] also noted significantly reduced bat activity in a free-tailed bat colony (*Tadarida teniotis*) where the number of bats decreased when several cell towers were placed 262 ft (80 m) from the colony.

In the ELF range, Janać et al. [232] investigated ELF/MF effects — comparable to powerline and stray voltage ground current — on motor behavior patterns in Mongolian gerbils (*Meriones unguiculatus)* and found age-dependent changes in locomotion, stereotypy, and immobility in 3- and 10-month-old males. Animals were continuously exposed to ELF-MF (50 Hz; 0.1, 0.25 and 0.5 mT) for seven days with behavior monitored for 60 min in the open field after the 1st, 2nd, 4th, and 7th day (to capture immediate effects), as well as three days after exposure (to capture delayed effects). They found that exposure to 3-month-old gerbils increased motor behavior (locomotion and stereotypy), and therefore decreased immobility. In the 3-month old gerbils, ELF/MF also showed a delayed effect (except at 0.25 mT) on stereotypy and immobility. In 10-month-old gerbils, ELF/MF of 0.1, 0.25 and 0.5 mT induced decreased locomotion, a slight increase in stereotypy, and pronounced stimulation of motor behavior. Increased motor behavior was observed three days after exposure, indicating long lasting effects. Researchers concluded that in 3- and 10-month-old gerbils, specific temporal patterns of motor behavior changes were induced by ELF/MF due to age-dependent morpho-functional differences in brain areas that control motor behavior.

The above is a very small sample of rodent studies. See Part 2 Supplements 1 and 2 for more genetic effects to rodents, and Supplement 3 for additional studies.

Bovines

Due to domestication and easy accessibility, there are numerous studies of dairy cows (*Bos taurus*) which appear particularly sensitive to both natural and man-made EMFs. Fedrowitz [71] published a thorough review with citations too numerous to mention here. Noted in the review is the fact that bovines, although easily accessible, are difficult to study with precision due to their size, which creates handling and dosimetric complexities. Also noted are that bovines today are at their milk- and beef-production physiological limits, and that the addition of even a weak stressor may be capable of altering a fragile bovine physiological balance. It is clear in the Fedrowitz review that cows respond to environmental exposures from a broad range of frequencies and properties, even as some studies lack good exposure assessment. RFR exposure created avoidance behavior, reduced ruminating and lying times, and alterations in oxidative stress enzymes among other problems, while ELF-EMF found contradictory evidence affecting milk production, fat content, hormone imbalances and important changes in other physiological parameters. Cows have also been found sensitive to stray voltage and transient harmonics with problematic milk production, health, reproduction and behavioral effects.

The question is how much of this body of work could translate to other ruminants and large mammals on-field or in the wild such as deer/cervids — behaviorally, reproductively, and physiologically. Stray voltage and ELF-EMF near powerlines, and rural area RFR from both ground-based and satellite transmitters, for instance, may affect wild migratory herds and large ungulates in remote areas that go undetected.

Bovines and RFR

Loscher and Kas [233] observed abnormal behavior in a dairy herd kept in close proximity to a TV and radio transmitter. They found reduction in milk yield, health problems, and behavioral abnormalities. After evaluating other factors, they concluded the high levels of RFR were possibly responsible. They removed one cow with abnormal behavior to another stable 20 km away from the antenna, resulting in normalization of behavior within five days. Symptoms reappeared when the cow was returned to the stable near the antennas. In a later survey, Loscher [234] also found effects of RFR on the production, health and behavior of farm animals, including avoidance behavior, alterations in oxidative stress parameters, and ruminating duration.

Balode [59] obtained blood samples from female brown cows from a farm close to, and in front of, the Skrunda Radar – located in Latvia at an early warning radar system operating in the 156–162 MHz frequency range — and samples from cows in a control area. They found micronuclei in peripheral erythrocytes were significantly higher in the exposed cows, indicating DNA damage.

Stärk et al. [235] investigated short-wave (3–30 MHz) RFR on salivary melatonin levels in dairy cattle, with one herd at a farm located at 1,640 ft/500 m (considered higher exposure) and a second control herd located 13,123 ft/4,000 m from the transmitter (considered unexposed). The average nightly magnetic field strength readings were 21-fold greater on the exposed farm (1.59 mA/m) than on the control farm (0.076 mA/m). At both farms, after initially monitoring five cows' salivary melatonin concentrations at 2-h intervals during night dark phase for 10 consecutive days, and with the short-wave transmitter switched off during three of the 10 days (off phase), samples were analyzed using a radioimmunoassay. They reported that mean values of the two initial nights did not show a statistically significant difference between exposed and unexposed cows and concluded that chronic melatonin reduction was unlikely. But on the first night of re-exposure after the transmitter had been off for three days, the difference in salivary melatonin concentration between the two farms (3.89 pg/ml, CI: 2.04, 7.41) was statistically significant, indicating a two-to-sevenfold increase of melatonin concentration. They concluded that a delayed acute effect of EMF on melatonin concentration could not be excluded and called for further trials to confirm results.

Hässig et al. [95] conducted a cohort study to evaluate the prevalence of nuclear cataracts in veal calves near mobile phone base stations with follow-up of each dam and its calf from conception through fetal development and up to slaughter. Particular emphasis was focused on the first trimester of gestation (organogenesis). Selected protective antioxidants (superoxide dismutase, catalase, glutathione peroxidase [GPx]) were assessed in the aqueous humor of the eye to evaluate redox status. They found that of 253 calves, 79 (32%) had various degrees of nuclear cataracts, but only 9 (3.6%) of calves had severe nuclear cataracts. They concluded that a relationship between the location of veal calves with nuclear cataracts in the first trimester of gestation and the strength of antennas was demonstrated. The number of antennas within 328–653 ft (100–199 m) was associated with oxidative stress and there was an association between oxidative stress and the distance to the nearest base station. Oxidative stress was increased in eyes with cataract (OR per kilometer: 0.80, confidence interval 95 % 0.62, 0.93). But the researchers further concluded that it had not been shown that the antennas actually affected stress. Hosmer-Lemeshow statistics showed an accuracy of 100% in negative cases with low radiation, and only 11.11% accuracy in positive cases with high radiation. This reflected, in their opinion, that there are a lot of other likely causes for nuclear cataracts beside base stations and called for additional studies on EMF during embryonic development.

Hässig et al. [96] further examined a dairy farm in Switzerland where a large number of calves were born with nuclear cataracts after a mobile phone base station was erected near the barn. Calves showed a 3.5 times higher risk for heavy cataracts if born there compared to the Swiss average. All usual causes for cataracts could be excluded but they nevertheless concluded that the incidence remained unknown.

Bovines and swine: ELF-EMF, stray electric current

Bovines appear unusually sensitive to ELF-EMF from stray current caused by both normal industrial and faulty grounding methods near high tension transmission lines close to dairy farms. Stray current can cover large areas and occurs when current flows between the grounded circuit conductor (neutral) of a farm and the Earth through dairy housing equipment like metal grates. It typically involves small, steady power frequency currents [99], not high transient shocks, although that also can sometimes occur under wet weather conditions. According to Hultgren [236], dairy cattle can perceive alternating currents exceeding 1 mA between the mouth and all four hooves with behavioral effects in cows usually occurring above 3 mA. Stray current can act as a major physical stressor in cows and other animals [237]. This may also be happening in wild migratory species moving through such areas.

At the request of dairymen, veterinarians, and county extension agents in Michigan, U.S., Kirk et al. [238] investigated stray current on 59 Michigan dairy farms. On 32 farms, stray current sources were detected. Where voltage exceeded 1 V alternating current, increased numbers of dairy cows showed abnormal behavior in the milking facility and increased prevalence of clinical mastitis. Recovery from the stray current-induced abnormalities was related to the type of abnormality and the magnitude of the exposure voltage.

Burchard et al. [239] in a small but well-controlled alternating exposure study of non-pregnant lactating Holstein cows found a longer estrous cycle in cows exposed to a vertical electric field of 10 kV/m and a uniform horizontal magnetic field of 30 μT at 60 Hz, compared to when they were not exposed. Rodriguez et al. [240] also found that exposure to EMF may increase the duration of the bovine estrous cycle. Burchard et al. [241] evaluated effects on milk production in Holsteins exposed to a vertical electric field of 10 kV/m and a uniform horizontal MF of 30 μT at 60 Hz and found an average decrease of 4.97, 13.78, and 16.39% in milk yield, fat corrected milk yield, and milk fat, respectively in exposed groups, and an increase of 4.75% in dry matter food intake. And Buchard et al. [242] in two experiments investigated blood thyroxine (T4) levels in lactating pregnant and non-lactating non-pregnant Holstein cows exposed to 10 kV/m, 30 μT EMF and found a significant change depending on the time of blood sampling in exposed groups. They concluded that exposure of dairy cattle to ELF-EMF could moderately affect the blood levels of thyroxine.

Hillman et al. [93, 94] reported that harmonic distortion and power quality itself could be another variable in bovine sensitivity to stray current. They found behavior, health, and milk production were adversely affected by transients at the 3rd, 5th, 7th, and triplen harmonic currents on utility power lines after a cell tower was found charging the ground neutral with 10+ V, causing the distortion. After installing a shielded neutral isolation transformer between the utility and the dairy, the distortion was reduced to near zero. Animal behavior improved immediately and milk production, which had been suppressed for three years, gradually returned to normal within 18 months.

Swine (*Sus scrofa domesticus*) — like rats and mice — have demonstrated aversive behavior to ELF-EMF electric fields. Hjeresen et al. [243] found miniature pigs, exposed to 60-Hz electric fields (30 kV/m for 20 h/day, 7 days/week up to 6 months) preferred an absence of the field during a 23.5-h period by spending more time out of the electric field than in it during sleep periods. And Sikov et al. [244], as part of a broad study of Hanford Miniature swine on reproductive and developmental toxicology (including teratology) over three breeding cycles found a strong association between chronic exposure to a vertical uniform electric field (60-Hz, 30-kV/m, for 20 h/day, 7 days/week) and adverse developmental effects vs. control. They concluded that an association exists between chronic exposure to strong electric fields and adverse developmental effects in swine (75% malformations in exposed vs. 29% sham) in first generation with consistent results in two subsequent generations.

Avian

Birds are important indicators of ecosystem well-being and overall condition. Even subtle effects can be apparent due to their frequent presence in RFR areas. Their hollow feathers have dielectric and piezoelectric properties, meaning they are conductive and capable of acting as a waveguide directing external RFR energy directly and deeply into avian body cavities [245–249]. Their thin skulls have both magnetite and radical pair receptors (see "Mechanisms" above) and they are highly mobile — often traveling across great migratory distances of tens to as much as a hundred thousand kilometers round-trip per year, resulting in potential multi-frequency cumulative effects from chronic near, middle, and far-field exposures. Avian populations are declining worldwide, especially among migratory species. This means that birds may be uniquely sensitive to adverse effects from environmental RFR since their natural habitat is air and they often fly at lateral levels with infrastructure emissions, bringing them that much closer to generating sources.

Tower and building construction, as direct obstacles, are known hazards to birds. One tower at 150 feet (46 m) above ground level is thought to account for as many as 3,000 songbird deaths per month in migratory pathways during peak migration [250] and communication tower collisions have been documented to kill more than 10,000 migratory birds in one night at a TV tower in Wisconsin [251, 252]. It has been known for years that the songbird populations of North America and Europe are plummeting. Only recently were towers considered a significant factor. But is the problem solely due to obstacles in direct migratory pathways or is something else involved?

RFR from towers may be acting as an attractant to birds due to their singular physiology. Avian eyes and beaks are uniquely magnetoreceptive with both magnetite and cryptchrome radical pair receptors. One definitive study by Beason and Semm [253] demonstrated that the common cell phone frequency (900-MHz carrier frequency, modulated at 217 Hz) at nonthermal intensities, produced firing in several types of nervous system neurons in Zebra Finches (*Taeniopygia guttate*). Brain neurons of irradiated anesthetized birds showed changes in neural activity in 76% of responding cells, which increased their firing rates by an average 3.5-fold vs. controls. Other responding cells exhibited a decrease in rates of spontaneous activity. The Beason and Semm study [253] could explain why birds may be attracted to cell towers, a theoretical premise they previously observed with Bobolinks (*Dolichonyx oryzivorus*; [254]).

RFR may also act as an avian stressor/irritant. Early work by Wasserman et al. [255] in field studies on 12 flocks of migratory birds subjected to various combinations of microwave power density and duration under winter conditions at Monomet, MA, using birds from two additional flocks as controls, showed increased levels of aggression in some of the irradiated birds.

Other research indicated a range of effects capable of broad adverse environmental outcomes. Laboratory studies by Di Carlo et al. [256] found decreases in heat shock protein production in chick embryos. The researchers used 915-MHz RFR on domestic chicken embryos and found that exposure typical of some cell phone emissions reduced heat shock proteins (HSP-70) and caused heart attacks and death in some embryos. Controls were unaffected. In replicated experiments, similar results were found by Grigor'ev [257] and Xenos and Magras [258]. Batellier et al. [259] found significantly elevated embryo mortality in exposed vs. sham groups of eggs incubated with a nearby cell phone repeatedly calling a 10-digit number at 3-min intervals over the entire incubation period. Heat shock proteins help maintain the conformation of cellular proteins during periods of stress. A decrease in their production diminishes cellular protection, possibly leading to cancer, other diseases, heart failure, and reduction in protection against hypoxia and ultraviolet light.

Not all results are adverse. Tysbulin et al. [260, 261] investigated both short and prolonged GSM 900 MHz cell phone signal exposure on embryo development in Quail (*Coturnix coturnix japonica),* irradiating fresh fertilized eggs during the first 38 h and 14 days of incubation using a cell phone in connecting mode continuously activated through a computer system. Maximum intensity of incident radiation on the egg's surface was 0.2 mW/cm^2. Results found a significant ($p<0.001$) increase in differentiated somites in 38-h exposed embryos and a significant ($p<0.05$) increase in total survival of embryos in eggs after 14 days exposure. They also found the level of thiobarbituric acid (TBA) reactive substances was significantly (p 0.05–0.001) higher in the brains and livers of hatchlings from exposed embryos and hypothesized that a facilitating effect exists due to enhanced metabolism in exposed embryos via peroxidation mechanisms. They concluded low-level nonthermal effects from GSM 900 MHz to quail embryogenesis is possible and that effects can be explained via a hormesis effect induced by reactive oxygen species (ROS).

Signaling characteristics such as pulsing vs. continuous wave are also important. Berman et al. [262], in a multi-lab study of pulsed ELF magnetic fields found a highly significant incidence of abnormalities in exposed chick eggs vs. controls. And Ubeda et al. [263] found irreversible damage to chick embryos from weak pulsed ELF-EMF magnetic fields that are common in the environment today. Initial studies on freshly fertilized chicken eggs were exposed during the first 48 h of post-laying incubation to pulsed magnetic fields (PMFs) with 100 Hz repetition rate, 1.0 μT peak-to-peak amplitude, and 500 μs pulse duration. Two different pulse waveforms were used, with rise and fall times of 85 μs or 2.1 μs. A two-day exposure found significant increased developmental abnormalities. In follow-up research, after exposure, eggs were incubated for an additional nine days without PMFs. Embryos removed from eggs showed an excess of developmental anomalies in the PMF-exposed groups compared with the sham-exposed samples. There was a high rate of embryonic death in the 2.1 μs rise/fall time. Results indicate PMFs can cause irreversible developmental changes, confirming that a pulse waveform can determine embryonic response to ELF magnetic fields common today.

Between 1999 and 2005, Fernie et al. for the first time investigated various potential reproductive effects on a captive raptor species — the American Kestrel (*Falco sparverius*) — from ELF-EMF equivalent to that of wild nesting pairs on power transmission lines. In a series of studies, captive pairs were typically bred under control or EMF exposure over 1–3 breeding cycles. In 1999, Fernie et al. [264] investigated photo phasic plasma melatonin in reproducing adult and fledgling kestrels, finding that EMFs affected plasma melatonin in adult male kestrels, suppressing it midway through, but elevating it at the end of the breeding season. In long-term, but not short-term EMF exposure of adults, plasma melatonin was supressed in their fledglings too which could affect migratory success. Molt happened earlier in adult EMF-exposed males than in controls. EMF exposure had no effect on plasma melatonin in adult females. In avian species, melatonin is involved in body temperature regulation, seasonal metabolism, locomotor activity, feeding patterns, migration, and plumage color changes important for mate selection. Melatonin also plays a key role in the growth and development of young birds. The researchers concluded it is likely that the results are relevant to wild raptors nesting within EMF exposures.

In 2000 Fernie et al. [265] focused on reproductive success in captive American Kestrels exposed to ELF-EMF, again equivalent to that experienced by wild reproducing kestrels. Kestrels were bred one season per year for two years under EMF or controlled conditions. In some years but not others, EMF-exposed birds showed a weak association with reduced egg laying, higher fertility, larger eggs with more yolk, albumen, and water, but thinner egg shells than control eggs. Hatching success was lower in EMF pairs than control pairs but fledging success was higher than control pairs in one year. They concluded that EMF exposure such as what kestrels would experience in the wild was biologically active in a number of ways leading to reduced hatching success.

Also in 2000, Fernie et al. [266] further investigated behavioral changes in American Kestrels to ELF-EMF, again in captive birds comparable to nesting pairs that commonly use electrical transmission structures for nesting, perching, hunting, and roosting. The amount of EMF exposure time of wild reproducing American Kestrels was first determined at between 25 and 75% of the observed time. On a 24-h basis, estimated EMF exposure in wild species ranged from 71% during courtship, to 90% during incubation. Then effects of EMFs on the behavior of captive reproducing kestrels were examined at comparable exposures of 88% of a 24-h period. Additionally, captive kestrels were exposed to EMF levels experienced by wild kestrels nesting under 735-kV power lines. There appeared to be a stimulatory/stress effect. Captive EMF females were more active, more alert, and perched on the pen roof more frequently than control females during courtship. EMF females preened and rested less often during brood rearing. EMF-exposed male kestrels were more active than control males during courtship and more alert during incubation. The researchers concluded that the increased activity of kestrels during courtship may be linked to changes in corticosterone, but not to melatonin as found in earlier work [264], but said the behavioral changes observed were unlikely to result in previously reported effects in EMF-exposed birds as noted above. They added that behavioral changes of captive EMF-exposed kestrels may also be observed in wild kestrels, with uncertain results.

In 2001 Fernie and Bird [267] looked at ELF-EMF oxidative stress levels in captive American Kestrels using the same test parameters described above to see if ELF-EMF exposure elicited an immune system response. In captive male kestrels bred under control or EMF conditions equivalent to those experienced by wild kestrels, short-term EMF exposure (one breeding season) suppressed plasma total proteins, hematocrits, and carotenoids in the first half of the breeding season. It also suppressed erythrocyte cells and lymphocyte proportions, but elevated granulosa proportions at the end of the breeding season. Long-term EMF exposure (two breeding seasons) also suppressed hematocrits in the first half of the reproductive period. But results found that only short-term EMF-exposed birds experienced an immune response, particularly during the early half of the breeding season. The elevation of granulocytes and the suppression of carotenoids, total proteins, and melatonin [264] in the same kestrel species indicated that the short-term EMF-exposed male kestrels had higher levels of oxidative stress due to an immune response and/or EMF exposure. The researchers noted that long-term EMF exposure may be linked to higher levels of oxidative stress solely through EMF exposure. Oxidative stress contributes to cancer, neurodegenerative diseases, and immune disorders. And in 2005, Fernie and Reynolds [268] noted most studies of birds and EMF indicate changes on behavior, reproductive success, growth and development, physiology and endocrinology, and oxidative stress — with effects not always consistent or in the same direction under EMF conditions. The entire body of work by this research group has implications for all wild species that encounter a wide range of EMFs on a regular basis.

In field studies on wild birds in Spain, Balmori [269] found strong negative correlations between low levels of microwave radiation and bird breeding, nesting, roosting and survival in the vicinity of communication towers. He documented nest and site abandonment, plumage deterioration, locomotion problems, and death in Wood Storks (*Mycteria americana*), House Sparrows (*Passer domesticus*), Rock Doves (*Columba livia*), Magpies (*Pica pica*), Collared Doves (*Streptopelia decaocto)*, and other species. While these species had historically been documented to roost and nest in these areas, Balmori [269] did not observe these symptoms prior to construction and operation of the cell phone towers. Results were most strongly negatively correlated with proximity to antennas and Stork nesting and survival. Twelve nests (40% of his study sample) were located within 656 ft (200 m) of the antennas and never successfully raised any chicks, while only one nest (3.3%), located further than 984 ft (300 m) never had chicks. Strange behaviors were observed at Stork nesting sites within 328 ft (100 m) of one or several cell tower antennas. Birds impacted directly by the main transmission lobe (i.e., electric field intensity > 2 V/m) included young that died from unknown causes. Within 100 m, paired adults frequently fought over nest construction sticks and failed to advance nest construction (sticks fell to the ground). Balmori further reported that some nests were never completed and that Storks remained passively in front of cell site antennas. The electric field intensity was higher on nests within 200 m (2.36 ± 0.82 V/m; 1.48 $\mu W/cm^2$) than on nests further than 300 m (0.53 ± 0.82 V/m, 0.074 $\mu W/cm^2$). RF-EMF levels, including for nests <100 m from the antennas, were not intense enough to be classified as thermal exposures. Power densities need to be at least 10 mW/cm^2 to produce tissue heating of even 0.5 °C [270]. Balmori's results indicated that RFR could potentially affect one or more reproductive stages, including nest construction, number of eggs produced, embryonic development, hatching and mortality of chicks and young in first-growth stages.

Balmori and Hallberg [271] and Everaert and Bauwens [272] found similar strong negative correlations among male House Sparrows (*Passer domestics)* throughout multiple sites in Spain and Belgium associated with ambient RFR between 1 MHz and 3 GHz at various proximities to GSM cell base stations. House Sparrow declines in Europe have been gradual but cumulative for this species once historically well adapted to urban environments. The sharpest bird density declines were in male House Sparrows in relatively high electric fields near base stations, indicating that long-term exposure at higher RFR levels negatively affected both abundance and/or behavior of wild House Sparrows. In another review, Balmori [25] reported health effects to birds that were continuously irradiated. They suffered long-term effects that included reduced territorial defense posturing, deterioration of bird health, problems with reproduction, and reduction of useful territories due to habitat deterioration.

Birds have been observed avoiding areas with high and low-intensity EMF, in daylight as well as nocturnally. An early study by Southern in 1975 [273] observed that gull chicks reacted to the U.S. military's Project Sanguin ELF transmitter. Tested on clear days in the normal geomagnetic field, birds showed significant clustering with predicted bearing corresponding with migration direction, but when the large antenna was energized they dispersed randomly. He concluded that magnetic fields associated with such conductors were sufficient to disorient birds. Larkin and Sutherland [274] observed that radar tracking of individual nocturnal migrating birds flying over a large alternating-current antenna system caused birds to turn or change altitude more frequently when the antenna system was operating than when it was not. The results suggested that birds sense low-intensity alternating-current EMF during nocturnal migratory flight.

In a well-designed, multi-year avian study of magneto-disruption, Engels et al. [213] investigated environmental broadband electromagnetic 'noise' emitted everywhere humans use electronics, including devices and infrastructure. They found migratory birds were unable to use their magnetic compass in the presence of a typical urban environment today. European Robins (*E. rubecula),* exposed to the background electromagnetic 'noise' present in unscreened wooden huts at the University of Oldenburg campus, could not orient using their magnetic compass. But when placed in electrically grounded aluminum-screened huts, creating Faraday cages that attenuated electromagnetic 'noise' by approximately two orders of magnitude, their magnetic orientation returned. The researchers were able to determine the frequency range from 50 kHz to 5 MHz was the most disruptive. When grounding was removed, or additional broadband electromagnetic 'noise' was deliberately generated inside the screened and grounded huts, birds again lost magnetic orientation abilities. They concluded that RFR's magneto-disruption effects are not confined to a narrow frequency band. Birds tested far from sources of EMFs required no screening to orient with their magnetic compass. This work documented a reproducible effect of anthropogenic electromagnetic ambient 'noise' on the behavior of an intact vertebrate. The magnetic compass is integral to bird movement and migration. The findings clearly demonstrated a nonthermal effect on European Robins and serves as a predictor for effects to other migratory birds, especially those flying over urban areas. Such fields are much weaker than minimum levels expected to produce any effects and far below any exposure standards.

Intensity windows in different species have also been found where effects can be more extreme at lower intensities than at higher ones due to compensatory mechanisms such as cell apotosis. Panagopoulos and Margaritas [34] found an unexpected intensity window at thermal levels around 10 mW/cm^2 RFR — not uncommon near cell towers — where effects were more severe than at intensities higher than 200 mW/cm^2. This window appeared at a distance of 8–12 in (20–30 cm) from a cell phone antenna, corresponding to a distance of about 66–98 ft (20–30 m) from a base station antenna. This could be considered a classic nonlinear effect and would apply to far-field exposures. Since cell base station antennas are frequently located within residential areas where birds nest, often at distances 20–30 m from such antennas, migratory birds, non-migratory avifauna, and other wildlife may be exposed up to 24-h per day.

Concerns also apply to impacts from commercial radio signals on migratory birds. The human anatomy is resonant with the FM bands so exposure standards are most stringent in that range. High intensity (>6,000 W) commercial FM transmitters are typically located on the highest ground available to blanket a wider area. Low powered FM transmitters (<1,000 W) can be placed closer to the human population. High intensity locations, which can be multi-transmitter sites (colloquially called "antenna farms") for other services, also provide convenient perches and nest sites for migratory birds. FM digital signals, which simulate pulsed waves, pose additional health concerns to migratory birds. This creates a dangerous frequency potential for protected migratory birds such as Bald Eagles with wingspans that extend to about 6 ft (1.83 m) — a resonant match with the length of the FM signal — creating a potential full-body resonant effect for both humans and Bald Eagles. Birds could experience both thermal and non-thermal effects.

All migratory birds are potentially at risk, including Bald Eagles, Golden Eagles, birds of conservation concern [275], federal and/or state-listed bird species, birds nationally or regionally in peril, as well as birds whose populations are stable. Sadly, addressing these concerns — beginning with independent research conducted by scientists with no vested interest in the outcomes — has not been a priority for government agencies or the communications industry.

Insects and arachnids

Insects are the most abundant and diverse of all animal groups, with more than one million described species representing more than half of all known living species, and potentially millions more yet to be discovered and identified. They may represent as much as 90% of all life forms on Earth. Though some are considered pests to farm crops and others as disease vectors, insects remain essential to life and planetary health. Found in nearly all environments, they are the only invertebrates that fly, but adults of most insect species walk, while some swim.

Because of these different environmental adaptations, different species will encounter different EMF exposures in varying degrees. For instance, ground-based walking insects may be more susceptible to effects from 60 Hz stray current while flying insects may be more susceptible to wireless exposures. However, all species tested have been affected across a range of the nonionizing electromagnetic bands.

Most insects have an exoskeleton, three-part body consisting of a head, thorax, and abdomen, three pairs of jointed legs, compound eye structures capable to seeing many more colors, widths, and images than humans, and one pair of antennae capable of sensing subtle meteorological changes and Earth's geomagnetic fields. They live in close harmony with the natural environment for survival and mating purposes. The most diverse insect groups co-evolved with flowering plants, many of which would not survive without them. Most insect species are highly sensitive to temperature variations and climate alterations as they do not dissipate heat efficiently.

Nearly all insects hatch from eggs that are laid in myriad ways and habitats. Growth involves a series of molts and stages (called instars) with immature stages greatly differing from mature insects in appearance, behavior, and preferred habitat. Some undergo a four-stage metamorphosis (with a pupal stage) and others a three-stage metamorphosis through a series of nyphal stages.

While most insects are solitary, some — like bees, termites and ants — evolved into social networks, living in "cooperative" organized colonies that can function as one unit as evidenced in swarming behaviors. Some even show maternal care over eggs and young. They communicate through various sounds, pheromones, light signals, and through their antennae such as during the bees' "waggle dance" (see below).

As far back as the 1800s, even though testing methods were primitive by today's standards, researchers were curious about electromagnetism's effect on insect development, particularly teratogenicity [276]. Research on EMF across frequencies and insect populations has been ongoing since at least the 1930s with an eye toward using energy as an insecticide and anti-contaminant in grain, typically at high intensity thermal exposures that would not exist in the natural environment. Mckinley and Charles [277] found that wasps die within seconds of high frequency exposure. But not all early work was strictly high intensity, or all effects observed due to thermal factors.

There were interesting theories introduced by early researchers regarding how energy couples with various insect species. Frings [278] found larval stages are more tolerant to heat than adult insects with appendages that can act as conducting pathways to the body, and that the more specialized the insect species, the more susceptible they appear to microwave exposure. Carpenter and Livingstone [279] studied effects of 10 GHz continuous-wave microwaves at 80 mW/cm^2 for 20 or 30 min, or at 20 mW/cm^2 for 120 min on pupae of mealworm beetles (*Tenebrio molitor*) — clearly within thermal ranges. In control groups, 90% metamorphosed into normal adult beetles whereas only 24% of exposed groups developed normally, 25% died, and 51% developed abnormally. Effects were assumed to be thermally induced abnormalities until they simulated the same temperature exposure using radiant heat and found 80% of pupae developed normally. They concluded that microwaves were capable of inducing abnormal effects other than through thermal damage.

Fruit flies

Insects at all metamorphic stages of development have been studied using RFR including egg, larva, pupa and adult stages. Much work has been done on genetic and other effects with fruit flies (*D. melanogaster*) because of their well-described genetic system, ease of exposure, large brood size, minimal laboratory space needed, and fast reproductive rates. Over several decades Goodman and Blank, using ELF-EMF on *Drosophila* models, found effects to heat shock proteins and several other effects ([201]; and see "Mechanisms" above). It is considered a model comparable to other insects in the wild approximating that size. *D. melanogaster* may be the most lab-studied insect on Earth, although honey and related bee species, due to their devastating losses over the last decade and significance to agriculture, are quickly catching up.

Michaelson and Lin [50] noted that RFR-exposed insects first react by attempting to escape, followed by disturbance of motor coordination, stiffening, immobility and eventually death, depending on duration of exposure and insect type. For example, *D. melanogaster* survived longer than 30 min while certain tropical insects live only a few seconds at the same field intensity. Also noted were concentration changes in many metabolic products and effects to embryogenesis — the period needed for a butterfly to complete metamorphosis — with accelerated gastrulation and larval growth [17]. Michaelson and Lin [50] cited several negative studies with *D. melanogaster* exposed with continuous-wave RFR between 25 and 2,450 MHz on larval growth [280, 281] and mutagenicity [282]. This was after Heller and Mickey [283] found a tenfold rise in sex-linked recessive mutations with pulsed RFR between 30 and 60 MHz. It was among the earliest studies that found pulsing alone to be a biologically active exposure.

As reported in Michaelson and Lin [50], Tell [284] looked at *D. melanogaster*'s physiological absorption properties and found that a group of 6-day old male wild-type flies, exposed to 2,450 MHz for 55 min at an intense field caused a dramatic 65% reduction in body weight. This was thought to be from dehydration. They then sought to calculate the fruit fly's absorption properties in relation to plane electromagnetic waves and found that a fly has only a 1/1,000th effective area of its geometric cross section and thus is an inefficient test species for absorbed microwave radiation. However, they concluded that fruit flies were responsive to absorbed energy at thermal levels as a black body resonator at a power density of 1.044×10^4 mW/cm^2, corresponding to a thermal flux density of 0.562×10^{-3} cal. These are levels found in close proximity to broadcast facilities and cell phone towers today.

More recent investigations of RFR by Weisbrot et al. [285] using GSM multiband mobile phones (900/ 1,900 MHz; SAR approximately 1.4 W/kg) on *D. melanogaster* during the 10-day developmental period from egg laying through pupation found that non-thermal radiation increased numbers of offspring, elevated heat shock protein-70 levels, increased serum response element (SRE) DNA-binding and induced the phosphorylation of the nuclear transcription factor, ELK-1. Within minutes, there was a rapid increase of hsp70, which was apparently not a thermal effect. Taken together with the identified components of signal transduction pathways, the researchers concluded the study provided sensitive and reliable biomarkers for realistic RFR safety guidelines.

Panagopoulos et al. [286] found severe effects in early and mid-stage oogenesis in *D. melanogaster* when flies were exposed *in vivo* to either GSM 900-MHz or DCS 1,800-MHz radiation from a common digital cell phone, at non-thermal levels, for a few minutes per day during the first 6 days of adult life. Results suggested that the decrease in oviposition previously reported [287–289] was due to degeneration of large numbers of egg chambers after DNA fragmentation of their constituent cells which was induced by both types of mobile phone radiation. Induced cell death was recorded for the first time in all types of cells constituting an egg chamber (follicle cells, nurse cells and the oocyte) and in all stages of early and mid-oogenesis, from germarium to stage 10, during which programmed cell death does not physiologically occur. Germarium and stages 7–8 were found to also be the most sensitive developmental stages in response to electromagnetic stress induced by the GSM and DCS fields. Germarium was also found to be more sensitive than stages 7–8. These papers, taken collectively, indicate serious potential effects to all insect species of similar size to fruit flies from cell phone technology, including from infrastructure and transmitting devices.

Fruit flies have also been found sensitive to ELF-EMF. Gonet et al. [290] found 50 Hz ELF-EMF exposure affected all developmental stages of oviposition and development of *D. melanogaster* females, and weakened oviposition in subsequent generations.

Savić et al. [291] found static magnetic fields influenced both development and viability in two species of *Drosophila* (*D. melanogaster and D. hydei*). Both species completed development (egg-to-adult), in and out of the static magnetic field induced by a double horseshoe magnet. Treated vials with eggs were placed in the gap between magnetic poles (47 mm) and exposed to the average magnetic induction of 60 mT, while control groups were kept far from the magnetic field source. They found that exposure to the static magnetic field reduced development time in both species, but only results for *D. hydei* were statistically significant. In addition, the average viability of both species was significantly weaker compared to controls. They concluded a 60 mT static magnetic field could be a potential stressor, influencing on different levels both embryonic and post-embryonic fruit fly development.

Beetles

Other insect species also react to both ELF-EMF and RF-EMF. Newland et al. [292] found behavioral avoidance in cockroaches (*Periplaneta americana*) to static electric fields pervasive in the environment from both natural and man-made sources. Such fields could exist near powerlines or where utilities ground neutral lines into the Earth. They found insect behavioral changes in response to electric fields as tested with a Y-choice chamber with an electric field generated in one arm of the chamber. Locomotor behavior and avoidance were affected by the magnitude of the electric fields with up to 85% of individuals avoiding the charged arm when the static e-field at the entrance to the arm was above 8–10 kV/m. Seeking to determine mechanisms of perception and interaction, they then surgically ablated the antennae and cockroaches were unable to avoid electric fields. They concluded that antennae are crucial in cockroach detection of electric fields that thereby helps them avoid such fields. They also noted that cockroach ability to detect e-fields is due to long antennae which are easily charged and displaced by such fields, not because of a specialized detection system. This leads to the possibility that other insects may also respond to electric fields via antennae alone.

Vácha et al. [208] found that cockroaches (*P. americana*) were sensitive to weak RFR fields and that the Larmor frequency at 1.2 MHz in particular had a "deafening effect" on magnetoreception. The parameter they studied was the increase in locomotor activity of cockroaches induced by periodic changes in geomagnetic North positions by 60°. The onset of the disruptive effect of a 1.2 MHz field was found between 12 and 18 nT whereas the threshold of a field twice the frequency (2.4 MHz) fell between 18 and 44 nT. A 7 MHz field showed no significant effect even at maximal of 44 nT. The results suggested resonance effects and that insects may be equipped with the same magnetoreception system as birds.

Prolić et al. [293] investigated changes in behavior via the nervous system of cerambycid beetles (*Morimus funereus*) in an open field before and after exposure to a 50 Hz ELF-MF at 2 mT. Experimental groups were divided into several activity categories. Results showed activity increased in the groups with medium and low motor activity, but decreased in highly active individuals. High individual variability was found in the experimental groups, as well as differences in motor activities between the sexes both before and after exposure to ELF-MF. They assumed activity changes in both sexes were due to exposure to ELF-MF. Only a detailed analysis of the locomotor activity at 1-min intervals showed some statistically significant differences in behavior between the sexes.

Ants

Ants are another taxa found sensitive to EMF. Ants comprise between 15 and 25% of the terrestrial animal biomass and thrive in most ecosystems on almost every landmass on Earth. By comparison, the total estimated biomass (weight) of all ants worldwide equates to the total estimated biomass of all humans. Their complex social organization in colonies, with problem-solving abilities, division of labor, and both individual and whole colony communication via complex behavioral and pheromone signaling may account for their success in so many environments. Some ant species (e.g., *Formica rufa*-group) are known to build colonies on active earthquake faults and have been found to change behavior hours in advance of earthquakes [294], thus demonstrating predictive possibilities. Ants can modify habitats, influence broad nutrient cycling, spread seeds, tap resources, and defend themselves. Ants co-evolved with other species which led to many different kinds of mutual beneficial and antagonistic relationships.

Ants (e.g., *Solenopsis invictus*) are long known to be sensitive to magnetic fields both natural and manmade [295]. Ants (e.g., *Atta colombica*), like birds, have been found to be sensitive to the Earth's natural fields and to use both a solar compass on sunny days as well as a magnetic compass when there is cloud cover [296]. Jander and Jander [297] similarly found that the weaver ant (*Oecophylla* spp*)* had a more efficient light compass orientation with a much less efficient magnetic compass orientation, suggesting that they switch from the former to the latter when visual celestial compass cues become unavailable. There is evidence from Esquivel et al. [298] that such magnetoreception is due to the presence of varying sized magnetite particles and paramagnetic resonance in fire ants (*Solenopsis* spp). But Riveros and Srygley [299] found a more complex relationship toward a magnetic compass rather than the presence of magnetite alone when leafcutter ants (*Atta columbica)* were subjected to a brief but strong magnetic pulse which caused complete disorientation regarding nest-finding. They found external exposures could interfere with ants' natural magnetic compass in home path integration, which indicated evidence of a compass based on multi-domain and/or super-paramagnetic particles rather than on single-domain particles like magnetite.

Acosta-Avalos et al. [300] found that fire ants are sensitive to 60 Hz alternating magnetic fields as well as constant magnetic fields, changing their magnetic orientation and magnetosensitivity depending on the relation between both types of magnetic fields. Alternating current had the ability to disrupt ant orientation, raising the question of effects to wild species from underground wiring and the common practice of powerline utility companies using the Earth as a neutral return pathway to substations, creating stray current along the way [99].

Camelitepe et al. [301] tested black-meadow ants' (*Formica pratensis*) response under both natural geomagnetic and artificial earth-strength static EMFs (24.5 μT). They found that under the natural geomagnetic field, when all other orientational cues were eliminated, there was significant heterogeneity of ant distribution with the majority seeking geomagnetic north in darkness while under light conditions ants did not discriminate geomagnetic north. Under artificial EMF exposure, however, ant orientation was predominantly on the artificial magnetic N/S axis with significant preference for artificial north in both light and dark conditions. This indicated EMF abilities to alter ant orientation.

Ants are also shown to react to RFR [302, 303]. Cammaerts et al. [304] found that exposures to GSM 900 MHz at 0.0795 $\mu W/cm^2$ significantly inhibited memory and association between food sites and visual and olfactory cues in ants (*Myrmica sabuleti*) and eventually wiped out memory altogether. Subsequent exposure, after a brief recovery period, accelerated memory/olfactory loss within a few hours vs. a few days, indicating a cumulative effect even at very low intensity. The overall state of the exposed ant colonies eventually appeared similar to that exhibited by honey bee (*Apis mellifera*) colony collapse disorder. Although the impact of GSM 900 MHz radiation was greater on the visual memory than on the olfactory memory, the researchers concluded that such exposures — common to cell phones/towers — were capable of a disastrous impact on a wide range of insects using olfactory and/or visual memory, including bees. Many ant species (e.g., *Lasius neglectus, Nylanderia fulva, Camponotus* spp, *Hymenoptera formicidae, Solenopsis invicta,* among others*)* are attracted to electricity, electronic devices, and powerlines, thereby causing short circuits and fires. One hypothesis [305] is that the accumulation of ants in electrical equipment may be due to a few foraging "worker ants" seeking warmth and finding their way into small spaces, completing electrical contacts which then causes a release of alarm exocrine gland pheromones that attract other ants, which then go through the same cycle. In their study, they found that workers subjected to a 120 V alternating-current released venom alkaloids, alarm pheromones and recruitment pheromones that elicited both attraction and orientation in ants as well as some other unknown behavior-modifying substances. But given how ants are affected by EMFs in general it is likely that an attractant factor is also involved, not just warmth and small spaces.

There is evidence that ants use their antennae as "antennas" in two-way electrochemical communications. Over 100 hundred years ago, Swiss researcher Auguste Forel [306] removed the antennae of different species of ants and put them together in one place. What would have normally evoked aggressive behaviors among the different species did not occur and they got along as if belonging to the same colony. To Forel this indicated an ability of ant antennae to help different ant species identify each other.

Two mechanisms in ants have long been known for chemical receptivity as well as electromagnetic sensitivity. Recently Wang et al. [307] found evidence that chemical signals located specific to antennae vs. other body areas drew more attention from non-nest mates. When cuticular hydrocarbons (CHCs) were removed by a solvent from antennae, non-nest mates responded less aggressively than to other areas of the body, indicating that antennae reveal nest-mate identity, conveying and receiving social signals. Regarding magnetoreception, magnetic measurements [308–310] found the presence of biogenic magnetite was concentrated in antennae and other body parts of the ant *Pachycondyla marginata*. De Oliveira et al. [311] also found evidence of magnetite and other magnetic materials imbedded in various locations of antennae tissue in *P. marginata* indicating that antennae function as magnetoreceptors. The amount of magnetic material appeared sufficient to produce a magnetic-field-modulated mechanosensory output and therefore demonstrated a magnetoreception/transduction sense in migratory ants.

Ticks

Ticks are members of the order Arachnida, shared with scorpions and spiders. Recent papers in a tick species (*Dermacentor reticulates*) mirrors an attraction to some frequencies but not others. Vargová et al. [312, 313] found that exposure to RFR may be a potential factor altering both presence and distribution of ticks in the environment. Studies were conducted to determine potential affinity of ticks for RFR using radiation-shielded tubes (RST) under controlled conditions in an electromagnetic compatibility laboratory in an anechoic chamber. Ticks were irradiated using a Double-Ridged Waveguide Horn Antenna to RF-EMF at 900 and 5,000 MHz; 0 MHz served as control. Results found that 900 MHz RFR induced a higher concentration of ticks on the irradiated arm of RST whereas at 5,000 MHz ticks escaped to the shielded arm. In addition, 900 MHz RFR had been shown to cause unusual specific sudden tick movements during exposure manifested as body or leg jerking [312]. These studies are the first experimental evidence of RFR preference and behavioral changes in *D. reticulates* with implications for RFR introduced into the natural environment by devices and infrastructure. In a further study, Frątczak et al. [314] reported that *Ixodes ricinus* ticks were attracted to 900 MHz RFR at 0.1 $\mu W/cm^2$, particularly those infected with Rickettsia (spotted fever).

RFR may be a new factor in tick distribution, along with known factors like humidity, temperature and host presence, causing concentrated non-homogenous or mosaic tick distribution in natural habitats. Tick preference for 900 MHz frequencies common to most cell phones has possibly important ecological and epidemiological consequences. Increasing exposures from use of personal devices and infrastructure in natural habitats where ticks occur may increase both tick infestation and disease transmission. Further studies need to investigate this work, given the ubiquity of ticks today, their northward spread due to climate change in the Northern Hemisphere, and the increasing and sometimes life-threatening illnesses they transmit to humans, pets, and wildlife alike.

Monarch butterflies

The American Monarch butterfly (*D. plexippus)* has fascinated researchers for over 100 years as it is the only insect known to migrate in multi-generational stages [315–319], with the ability to find their exact birthplace on specific milkweed plants (*Asclepias* spp.) at great distances across land and oceans.

Monarchs (*D. plexippus*), found across Southern Canada, the United States, and South America, are generally divided by the Rocky Mountains into eastern and western migratory groups. Their population has precipitously declined by 99.4% since the 1980s (85% of that since 2017) and by 90% in the past two decades in both western and eastern populations [13, 15]. These steep declines are from numerous anthropogenic causes and may have already crossed extinction thresholds, thereby leaving us bereft not only of their beauty and inspiration, but also the perfect model for long-distance animal migration study in general.

Monarch butterflies are among North America's most beloved invertebrates. They have for centuries navigated thousands of miles/kilometers in an iconic fall migration from southern Canada and the mid- and northeastern U.S. to a small area of about 800 square miles (2,072 square kilometers) in Central Mexico where they once wintered over in the millions in small remote oyamel fir forests. By the time they reach their final destination, some will have traveled distances exceeded only by some migratory seabird species. The monarch is the only insect known to migrate annually over 3,000 miles (4,828 km) at ~ 250 miles (402 km) per day in the fall from the Canadian border to Mexico, and in the springtime back again. Similar to some bird species, it is the only butterfly known to have a two-way migration pattern. Monarchs are only followed by army cutworm moths (*Euxoa auxiliaris*) which may migrate several thousand kilometers to high elevation sites in the Rocky Mountains to escape lowland heat and drought.

But monarchs are more interesting than for this one amazing migrational feat alone. How they do this is a long-standing mystery since their entire lifecycle, including their two-stage spring return migration, is multi-generational indicating genetic factors in directional mapping since the final return fall migration south cannot be considered "learned." Several multifaceted mechanisms must come into play, as well as little understood complexities in how those mechanisms cooperate and trade off with each other under different environmental circumstances. Monarchs also go from solitary insects during early developmental stages confined to specific locations, then exhibit social insect behaviors after the third generation has reached northern latitudes and turned south during the final fall migration. And all of this happens in a brain the size of a grain of sand.

Reppert et al. [320] published an excellent review in 2010 on the complexities of monarch migration, noting "… recent studies of the fall migration have illuminated the mechanisms behind the navigation south, using a time-compensated sun compass. Skylight cues, such as the sun itself and polarized light, are processed through both eyes and likely integrated in the brain's central complex, the presumed site of the sun compass. Time compensation is provided by circadian clocks that have a distinctive molecular mechanism and that reside in the antennae. Monarchs may also use a magnetic compass, because they possess two cryptochromes that have the molecular capability for light-dependent magnetoreception. Multiple genomic approaches are being utilized to ultimately identify navigation genes. Monarch butterflies are thus emerging as an excellent model organism to study the molecular and neural basis of long-distance migration." Reppert and de Roode [321] updated that information in 2018.

Although it has been known for some time that monarchs use a circadian rhythm time-compensated directional sun compass [316, 322–338], many questions remain about its dynamics and concerns regarding effects from radiation.

Monarch antennae are known to contain magnetite [339, 340] and cryptochromes [335, 336, 341, 342] — both understood to play a role in magnetoreception (see "Mechanisms"above). One early study by Jones and MacFadden [343] found magnetic materials located primarily in the head and thorax areas of dissected monarchs. More recently, Guerra et al. [16] found convincing evidence that monarchs use a magnetic compass to aid their longest fall migration back to Mexico. Those researchers used flight simulator studies to show that migrants possess an inclination magnetic compass to assist fall migration toward the equator. They found this inclination compass is light-dependent, utilizing ultraviolet-A/blue light between 380 and 420 nm and noted that the significance of light (<420 nm) for an inclination compass function had not been considered in previous monarch studies. They also noted that antennae are important for an inclination compass since they contain light-sensitive magneto-sensors. Like some migratory birds, the presence of an inclination compass would serve as an orientation mechanism when directional daylight cues are impeded by cloudy or inclement weather or during nighttime flight. It may also augment time-compensated sun compass orientation for appropriate directionality throughout migration. The inclination compass was found to function at earth-strength magnetic fields, an important metric.

The question remains: Can the magnetic compass in monarchs be disrupted by anthropogenic EMF like it does with geomagnetic orientation in migratory birds [213]. There is some indication this is possible. Perez et al. [330] found monarchs completely disorient after exposure to a strong magnetic field (0.4-T MF for 10 s, or approximately 15,000 times the Earth's magnetic field) immediately before release vs. controls. This is a high exposure but within range of man-made exposures today very close to powerlines.

Bees, wasps, and others

Pollinators, bees in particular, are keystone species without which adverse effects would occur throughout food webs and the Earth's entire biome were pollinators to disappear. Because of their central role and accessibility for research, bee studies have created a wealth of information, including regarding anthropogenic EMFs.

Bees — especially honey and bumble bees — are another iconic insect species beloved for their role in pollination; honey, propolis, royal jelly and beeswax production; their critical importance to our food supply; and their crucial role in global ecological health and stability. Found on every continent except Anarctica wherever there are flowering plants requiring insect pollination, there are over 16,000 known species of bees in seven different biological families, consisting of four main branches. Some species live socially in colonies while others are solitary. The western honey bee (*Apis mellifera*) is the best known and most studied due in part to its central role in agriculture. Bees feed on nectar for energy and pollen for protein/nutrients, and have co-evolved with many plant species in astoundingly complex ways. They are also highly sensitive to both natural and anthropogenic EMFs. Beeswax itself has electrical properties [50].

Human apiculture has been practiced since the time of ancient Egyptian and Greek cultures and bees have been closely studied since the 1800s. Almost all bee species, including commercially raised and wild species, are under decades-long multiple assaults. These include from pesticides, herbicides, climate change, various bacterial/viral diseases, infestations from parasitic mite species — particularly *Apis cerana*, *Varroa destructor* and *Varroa jacobsoni* beginning in the mid-1980s — and predation from introduced species that attack bees directly (e.g., the invasive giant bee-eating hornet *Vespa mandarinia*), as well as alter plant ecology over time to adversely affect bee food supply. Some have suggested that vanishing bees may also have to do with premature aging due to environmentally caused shortened telomeres [344].

Whole colony collapse disorder (CCD) is the most dramatic manifestation of domesticated bee demise in which worker bees abruptly disappear from a hive without a trace, resulting in an empty hive with perhaps a remaining queen and a few worker bees despite ample resources left behind. Few, if any, dead bees are ever found near the hive. CCD was first described in the U.S. in 2006 in Florida in commercial western honey bee colonies. Van Englesdorp et al. [345] quantified bee losses across all beekeeping operations and estimated that between 0.75 and 1.00 million honey bee colonies died in the United States over the winter of 2007–2008. Up until that survey, estimates of honey bee population decline had not included losses occurring during the wintering period, thus underestimating actual colony mortality.

The same phenomenon had been described by beekeepers in France in 1994 [346] — later attributed to the timing of sunflower blooming and the use of imidacloprid (IMD), a chlorinated nicotine-based insecticide or "neonicotinoid" being applied to sunflowers for the first time there [347]. Similar to DDT but considered safer for mammals including humans, neonicotinoids are a slow-release class of neurotoxins that block insect nervous systems via acetylcholine receptors, interfering with neuronal signaling across synapses. Sublethal doses can interfere with bee navigation.

Since then similar phenomena have been seen throughout Europe [348] and some Asian countries. Causal hypotheses included all of the above factors with varying foci on pesticide classes like neonicotinoids and genetically modified crops, but no single agent adequately explains CCD. Bromenshenk et al. [349] however, identified pathogen pairing/co-infection with two previously unreported RNA viruses — *V. destructor*-1, and Kakugo viruses, and a new irridescent virus (IIV) (*Iridoviridae*) along with *Nosema ceranae* — in North American honey bees that were associated with all sampled CCD colonies. The pathogen pairing was not seen in non-CCD colonies. Later cage trials with IIV type-6 and *N. ceranae* confirmed that co-infection with those two pathogens was more lethal to bees than either pathogen alone. Still many questions remain.

There are two national surveying groups in the U.S. — the U.S. Department of Agriculture (USDA) which began surveying managed bee populations in 2015 but funding was cut in late 2019; and the Bee Informed Partnership (BIP), a non-profit that coordinates with research facilities and universities. Prior to USDA's funding cuts, managed colonies decreased from CCD by 40% [350] with an additional 26% over the same quarter in 2019 [351]. BIP's survey period for April 1, 2018 through April 1, 2019 found U.S. beekeepers lost an estimated 40.7% of their managed honey bee colonies. The previous year had similar annual losses of 40.1%. The average annual rate of loss reported by beekeepers since 2010–11 was 37.8% [352].

Also in the U.S., for the first time in 2016, seven species of Hawaiian yellow-faced bees (*Hylaeus anthracinus*, *Hylaeus longiceps*, *Hylaeus assimulans*, *Hylaeus facilis*, *Hylaeus hilaris*, *Hylaeus kuakea*, and *Hylaeus mana*) were added to the federal endangered species list, as well as the rusty patched bumble bee (*Bombus affinis*) which, prior to the late 1990s, had been widely dispersed across 31 U.S. states [353]. Mathiasson and Rehan [354] examined 119 species in museum specimens in New Hampshire going back 125 years and concluded that 14 species found across New England were on the decline by as much as 90%, including the lesser studied leafcutter and mining bees that nest in the ground, unlike honeybees that nest in commercial hives or in trees, shrubs, and rock crevices in the wild.

Worldwide, many bee and other pollinator populations have also declined over the last two decades. Managed honey bee (*Apis mellifera*) colonies decreased by 25% over 20 years in Europe and 59% over 58 years in North America, with many wild bumble bee populations in Europe and North America having gone locally extinct [355–358]. But while dramatic range contractions have been seen, not all bees in all places are declining; some populations are growing depending on opportunistic and species-adaptability factors. For many species data are still insufficient, of poor quality, or nonexistent [359]. In addition, bee declines can affect flora survival. Miller-Struttmann et al. [360] recorded flower declines of 60% with 40 years of climate warming in alpine meadows — areas largely protected from land-use changes. Insects are highly sensitive to temperature changes.

A comprehensive UK survey of pollinator species [361] found that of 353 wild bee and hoverfly species across Britain from 1980 to 2013, 25% had disappeared from the places they had inhabited in 1980. Further estimates found a net loss of over 2.7 million in 0.6 mi (1 km) grid cells across all species. Declining pollinator evenness suggested losses were concentrated in rare species. Losses linked to specific habitats were also identified, with a 55% decline among wild upland species while dominant crop pollinators increased by 12%, possibly due to agricultural business interventions. The general declines found a fundamental deterioration in both wider biodiversity and non-crop pollination services.

There is no question that the huge diversity of pollinator species across the planet is suffering and that losses could be catastrophic with an estimated 90% of wild plants and 30% of world crops in jeopardy [362].

There is a likelihood that rising EMF background levels play a role. Bees have been known for decades to have an astute sense of the Earth's DC magnetic fields [363, 364] and rely on that perception for survival. For centuries beekeepers had noticed curious movements in bee hives but Austrian ethologist Karl von Frisch finally interpreted that activity in the 1940s, winning the Nobel Prize in 1973 for what came to be known as the honey bee "waggle dance." Through complex circles and waggle patterns, bees communicate the location of food sources to other members of the hive, using the orientation of the sun and the Earth's magnetic fields as a gravity vector, "dancing" out a map for hive members to follow like nature's own imbedded GPS. Bees also detect the sun's direction through polarized light and on overcast days use the Earth's magnetic fields, likely through the presence of magnetite in their abdominal area, and employ complex associative learning and memory [365].

Building on the earlier work of Gould et al. [119], Kobayashi and Kirschvink [52] noted that biogenic magnetite in honey bees is located primarily in the anterior dorsal abdomen. When small magnetized bits of wire were glued over those areas, it interfered with bees' ability to learn to discriminate magnetic anomalies in conditioning experiments, while nonmagnetized wire used in controls did not interfere [366]. Kirschvink and Kobayashi [367] found that when pulse-remagnetization techniques were used on bees trained to exit from a T-maze, that north-exiting bees could be converted to a south-exiting direction similar to what was observed in magnetobacteria and artificial reorientation by Blakemore [113]. Honeybees could also be trained to respond to very small changes in the geomagnetic field intensity [368]. Valkova and Vacha [369] discussed the possibility that honey bees use a combination of both radical pair/cryptochromes and magnetite to detect the geomagnetic field and use it for direction like many birds.

Given these sensitivities, bees may be reacting negatively through muti-sensory mechanisms to numerous sources of anthropogenic multi-frequency interference. Bumble bees (*Bombus terrestris*), a solitary species, and honey bees (*Apis mellifera*), a social hive species, are known to detect weak electric fields in different behavioral contexts, using different sensory mechanisms. Bumble bee e-field detection is likely through mechanosensory hairs [370–372] while honey bees reportedly use their antennae [373] that are electro-mechanically coupled to the surrounding e-field, taking place in the antennal Johnston's organ. Greggers et al. [373] found that honey bee antennae oscillate under electric field stimulation that can then stimulate activity in the antennal nerve. The latter occurs due to bees being electrically charged, and thus subject to electrostatic forces. Erickson [374] found different surface potentials in bees when leaving or entering hives, and Colin et al. [375] found seasonal variability between positive and negative charges in resting bees. It has also been shown that honey bees with removed or fixed antennae are less able to associate food reward with electric field stimuli and that bees emanate modulated electric fields when moving their wings (at about 230 Hz) and body (at about 16.5 Hz) during the waggle dance [373].

Electro-ecological interplay between flowers and pollinators has also been known since the 1960s and is critical to pollen transfer from flowers to bees [376–378]. It is known that as bees fly through the air, they accumulate a positive charge. Flowers, on the other hand, which are electrically grounded through their root systems, tend to have a negative charge in their petals created by surrounding air that carries around 100 V for every meter above ground. The accumulating positive charge around the flower induces a negative charge in its petals which then interacts with the positive charge in bees. In fact, bees do not even need to land on flowers for pollen transfer to occur; pollen can "jump" from the flower to the bee as the bee approaches due to charge differentials between the two. Thus, it appears that bees and flowers have been "communicating" via electric fields all along [379]. Bees can also learn color discrimination tasks faster when color cues are paired with artificial electric field cues similar to those surrounding natural flowers, but did not learn as readily in an electrically neutral environment [370].

This evidence points to floral e-fields being used in a co-evolutionary symbiotic relationship with bees. Clarke et al. [370, 371] even found that bumblebees can distinguish between flowers that give off different electric fields as floral cues to attract pollinators. Like visual cues, floral electric fields exhibit complex variations in pattern and structure that bumblebees can distinguish, contributing to the myriad complex cues that create a pollinator's memory of floral food sources. And because floral electric fields can — and do — change within seconds of being visited by pollinators, this sensory ability likely facilitates rapid and dynamic "information exchange" between flowers and their pollinators. Bumblebees can even amazingly use electric field information to discriminate between nectar-rewarding and unrewarding flowers [370].

Bees, locusts: ELF-EMF

Bees are also known to be sensitive to anthropogenic ELF-EMF. In 1973,Wellenstein [380] found that high tension powerlines adversely affected honey bees in wooden hives. This in part prompted the Bonneville Power Administration, an American federal agency operating in the Pacific Northwest under the U.S. Department of Energy (U.S. DOE), to investigate in 1974 [381–384] the effects of transmission lines on people, plants, and animals, including honey bees. The industry group, Electric Power Research Institute, also followed up on bee research [385, 386]. Both of those studies confirmed that transmission line electric fields can affect honey bees inside wooden hives as wood is a poor insulator and current can be induced when hives are placed in electric fields whether metal is present or not. The strength of the current inside the hive was influenced by the electric field strength, hive height, and moisture conditions with effects noticeable when induced current exceeded 0.02–0.04 mA. Depending on hive height, this occurred in field strengths between 2 and 4 kV/m. Effects included increased motor activity with transient increase in hive temperature, excessive propolis production (a resinous material used by bees as a hive sealer), decreased colony weight gains, increased irritability and mortality, abnormal production of queen cells, queen loss, decreased seal brood, and poor over-winter colony survival [387]. Impacts were most likely caused by electric shocks inside the hives [386, 388]. Effects were mitigated with grounded metal screen/shielding of hives [385]; however, bees appeared unaffected by magnetic fields which permeate metal shielding. The authors concluded that the shielding results indicated that bees were unaffected by flying through an external electric field up to 11 kV/m but noted that the study design could not reveal if subtle effects were occurring.

A more recent study of electric fields by Migdał [389] focused on honey bee behavioral effects on walking, grooming, flight, stillness, contact between individuals, and wing movement. They found that the selected frequency, intensity, and duration of exposure effects bees' behavioral patterns. Bees were exposed for 1, 3 and 6 h to E-fields at 5.0 kV/m, 11.5 kV/m, 23.0 kV/m, or 34.5 kV/m (with controls under E-field <2.0 kV/m). Within the exposed groups, results showed that exposure for 3 h caused decreased time that bees spent on select behaviors as well as the frequency of behaviors, whereas after both 1 and 6 h, the behavioral parameters increased within the groups. The researchers concluded that a barrier allowing behavioral patterns to normalize for some periods was indicated although none of the exposed groups returned to reference values in controls which adhered to normal behavioral patterns. Bees may have compensatory windows that appear to be both time and intensity dependent for E-fields. The significance of this study is that bees must accomplish certain activities — like flight frequency and the honey bee 'waggle dance' noted above — that are critical for life expectancy and survival. Even slight sequential disturbances may have cascading effects.

In an early-1988 study, Korall et al. [390] also found effects to bees from magnetic fields (MF). Bursts comparable to some of today's pulsed exposures of artificial MF at 250 Hz — the frequency of buzzing during the waggle dance — were applied parallel to natural EMF field lines and induced unequivocal 'jumps' of misdirection by up to +10° in bees during the waggle dance. This alone could cause directional confusion in hives. Continuous fields of 250 Hz with bursts perpendicular to the static MF however caused no effects. They concluded that a resonance relationship other than classic resonance models was indicated (see "Mechanisms" above). This early work has implications for subsequent digital pulsing and all wireless broadband technology.

More recent work on honey bees and ELF-EMF by Shepherd et al. [209] in 2018 found that acute exposure to 50 Hz fields at levels from 20–100 μT (at ground level underneath powerline conductors), to 1,000–7,000 μT (within 1 m of the conductors), reduced olfactory learning, foraging flight success toward food sources and feeding, as well as altered flight dynamics. Their results indicated that 50 Hz ELF-EMFs from powerlines is an important environmental honey bee stressor with potential impacts on cognitive and motor abilities.

Some wasp species have also been found sensitive to ELF-EMF. Pereira-Bomfim et al. [391] investigated the magnetic sensitivity of the social paper wasp (*Polybia paulista*) by analyzing wasp behavior in normal geomagnetic fields and in the presence of external magnetic fields altered by either permanent magnets (DC fields) or by Helmholtz coils (AC fields). They evaluated the change in foraging rhythm and colony behavior, as well as the frequency of departing/homeward flights and the behavioral responses of worker wasps located on the outer nest surface. They found that the altered magnetic field from the DC permanent magnet produced an increase in the frequency of departing foraging flights, and also that wasps grouped together on the nest surface in front of the magnet with their heads and antennae pointing toward the perturbation source, possibly indicating a response to a potential threat as a defense strategy. Controls showed no such grouping behavior. The AC fields created by the Helmholtz coils also increased foraging flights, but individuals did not show grouping behavior. The AC fields, however, induced wasp workers to perform "learning flights." They concluded that for the first time, *P. paulista* demonstrated sensitivity to an artificial modification of the local geomagnetic field and that mechanisms may be due to both cryptochrone/radical pairs and magnetite.

Another flying insect model — desert locust (*Schistocerca gregaria*) — was found susceptible to entrainment by ELF-EMF. In a complex study, Shepherd et al. [392] analyzed acute exposure to sinusoidal AC 50 Hz EMF (field strength range: 10 to 10,000 μT) vs. controls on flights of individual locusts tethered between copper wire coils generating EMFs at various frequencies and recorded on high-speed video. Results found that acute exposure to 50 Hz EMFs significantly increased absolute change in wingbeats in a field-strength-dependent manner. Applying a range of ELF-EMF close to normal wingbeat occurance, they found that locusts entrained to the exact frequency of the applied EMF. They concluded that ELF exposure can lead to small but significant changes in locust wingbeats, likely due to direct acute effects on insect physiology (vs. cryptochrome or magnetite-based magnetoreception) and/or behavioral avoidance responses to molecular/physiological stress. Wyszkowska et al. [393] also found effects on locusts — exposure to ELF-EMF above 4 mT led to dramatic effects on behaviour, physiology and increased Hsp70 protein expression. Such higher exposures may be found near high tension lines.

Bees: RF-EMF

The effects of RF-EMF on bees is of increasing interest since that is the fastest rising EMF environmental exposure of the past 30 years [369]. Beginning in the early 2000s, studies of cell phones placed in the bottom of hives began to appear. Honey bees showed disturbed behavior when returning to hives after foraging and under various RFR exposures [394–396]. Early methodologies, however, were not well designed or controlled. For instance, Favre [397] found increased piping — a distress signal that honey bees give off to alert hive mates of threats and/or to announce the swarming process. Both active and inactive mobile phone handsets were placed in close proximity to honey bees with sounds recorded and analyzed. Audiograms and spectrograms showed that active phone handsets had a dramatic effect on bee behavior in induced worker piping. This study was criticized by Darney et al. [398] for using music in the active RFR exposure which may have introduced a variable capable of affecting bee piping in response to the added sound alone.

In a complex study, Darney et al. [398] tested high frequency (HF) and ultra high frequency (UHF) used in RFID technology in order to develop a method to automatically record honey bees going in and out of hives. They glued RFID tags onto individual bee dorsal surfaces that were detected at the hive entrance by readers emitting HF radio waves. They then looked for possible HF adverse effects on honey bees' survival. Eight-day-old honey bees were exposed to HF 13.56 MHz or UHF 868 MHz RFR for 2 h split into ON and OFF periods of different durations. Dead bees were counted daily with cumulative mortality rates of exposed and non-exposed honey bees compared seven days after exposure. Two out of five experimental conditions found increased mortality, once after HF and once after UHF exposure, with OFF duration of 5 min or more, after which they recommended limiting honey bee exposure to RFR to less than 2 h per day. They also curiously concluded that the RFID parameters they used for monitoring hive activity presented no adverse effects but the multifrequency peak exposures and RFID attachments need further study in light of other works on RFID effects (see Part 1 for discussion of RFID.)

In another study using an active cell phone attached to hive frames, Odemer and Odemer [399] investigated RFR effects on honey bee queen development and mating success. Control hives had an inactive cell phone attached. After exposing honey bee queen larvae to GSM 900 MHz RFR during all stages of pre-adult development (including pupation), hatching of adult queens was assessed 14 days after exposure and mating success after an additional 11 days. They found that chronic RFR exposure significantly reduced honey bee queen hatching; that mortalities occurred during pupation but not at the larval stages; that mating success was not adversely affected by the irradiation; and that after exposure, surviving queens were able to establish intact colonies. They therefore determined that mobile phone radiation had significantly reduced the hatching ratio but not mating success if queens survived, and if treated queens successfully mated, colony development was not adversely affected. Even though they found strong evidence of mobile phone RFR damage to pupal development, they cautioned its interpretation, noting that the study's worst-case exposure scenario was the equivalent of a cell phone held to a user's head, not at a level found in typical urban or rural hive settings. They concluded that while no acute negative effects on bee health were seen in the mid-term, they also could not rule out effects on bee health at lower chronic doses such as found in ambient environments, and urgently called for long term research on sublethal exposures present in major city environments.

Sharma and Kumar [400] found similar abnormalities in honey bee behavior when they compared the performance of honey bees in RFR exposed and unexposed colonies. Two of four test colonies were designated and each equipped with two functional cell phones — a high exposure — placed on two different hive side walls in call mode at GSM 900 MHz. The average RFR power density was measured at 8.549 μW/cm^2 (56.8 V/m, electric field). One control colony had a dummy phone; the other had no phone. Exposure was delivered in 15 min intervals, twice per day during the period of peak bee activity. The experiment was performed twice a week during February to April. It covered two brood cycles with all aspects of hive behavior observed, including brood area comprising eggs, larvae and sealed brood; queen proficiency in egg-laying rate; foraging, flight behavior, returning ability; colony strength including pollen storage; and other variables. Results included a significant decline in colony strength and egg laying and reduced foraging to the point where there was no pollen, honey, brood, or bees by the end of the experiment. One notable difference in this study was that the number of bees leaving the hive decreased following exposure. There was no immediate exodus of bees as a result of exposure — instead bees became quiet, still, and/or confused "…as if unable to decide what to do…" the researchers said. Such a response had not been reported before. The authors concluded that colony collapse disorder is related to cell phone radiation exposures.

Vilić et al. [401] investigated RFR and oxidative stress and genotoxicity in honey bees, specifically on the activity of catalase, superoxide dismutase, glutathione *S*-transferase, lipid peroxidation levels and DNA damage. Larvae were exposed to 900 MHz RFR at field levels of 10, 23, 41 and 120 V m^{-1} for 2 h. At a field level of 23 V m^{-1} the effect of 80% AM 1 kHz sinusoidal and 217 Hz modulation were also investigated. They found that catalase activity and the lipid peroxidation levels significantly decreased in larvae exposed to the unmodulated field at 10 V m^{-1} (27 μW/cm^2) compared to the control. Superoxide dismutase and glutathione *S*-transferase activity in honey bee larvae exposed to unmodulated fields were not statistically different compared to the control. DNA damage increased significantly in larvae exposed to modulated (80% AM at 1 kHz) field at 23 V m^{-1} (140 μW/cm^2) compared to control and all other exposure groups. Their results suggested that RFR effects in honey bee larvae manifested only after certain EMF exposure conditions. Interestingly, they found that increased field levels did not cause a linear dose-response in any of the measured parameters, while modulated RFR produced more negative effects than the corresponding unmodulated field. They concluded that while honey bees in natural environments would not be exposed to the high exposures in their experiments, the results indicated additional intensive research is needed in all stages of honey bee development since the cellular effects seen could affect critical aspects of bee health and survival.

Kumar et al. [402] also found biochemical changes in worker honey bees exposed to RFR. A wooden box was designed with glass on the front and back and wire gauze for ventilation on two sides for both exposed bees and controls. Cell phones (same make, model, and network connection) were kept in listen-talk mode for 40 min. At intervals of 10, 20 and 40 min, 10 exposed and 10 control bees were collected at the same times. Hemolymph was then extracted from the inter-segmental region of bee abdomens and analyzed. Results included increased concentration of total carbohydrates in exposed bees in the 10 min exposure period compared to unexposed bees. Increasing the exposure time to 20 min resulted in a further increase in the concentration, but exposure at 40 min had a reverse effect with declines in carbohydrate concentration although it was still higher than controls. Hemolymph glycogen and glucose content also showed the same exposure pattern — increase in content up to 20 min after which a slight decline that was still higher than controls. Changes in total lipids/cholesterol — the major energy reserves in insects — can affect numerous biological processes. Some lipids are crucial membrane structure components while others act as raw materials in hormones and pheromones. Changes in these parameters are significant to every biological activity, including reproduction. Also of interest in this study was that as exposure time increased, the bees appeared to have identified the source of disturbance. There was a large scale movement of workers toward the talk-mode (with higher RFR exposure during transmission function) but not the listening mode. Bees also showed slight aggression and agitation with wing beating. The researchers hypothesized that this increased activity could be responsible for increased energy use thereby accounting for the decrease in concentration of carbohydrates and lipids in the 40 min exposed sample. The researchers concluded that cell phone radiation influences honey bee behavior and physiology. Sharma [403] had also reported increased glycogen and glucose levels in exposed honey bee pupa.

It must be pointed out that the cell phone emission conditions used in some experiments are questionable, in particular where there was no detail regarding how the phones were activated to achieve emission.

Not all studies demonstrated adverse effects. Mall and Kumar [404] found no apparent RFR effects on brood rearing, honey production or foraging behavior in honey bees in hives with cell phones inside or near a cell tower; and Mixon et al. [405] also found no effects of GSM-signal RFR on increased honey bee aggression. They concluded that RFR did not impact foraging behavior or honey bee navigation and therefore was unlikely to impact colony health.

Although there are several anectodal reports of insect losses near communication towers, there are only a handful of ambient RFR field studies conducted on invertebrates thus far. In the first large survey of wild pollinating species at varying distances from cell towers, Lázaro et al. [406] found both positive and negative effects from RFR in a broad range of insects on two islands (Lesvos and Limnos) in the northeastern Aegean Sea near Greece. Measured ambient RFR levels included all frequency ranges used in cell communications; broadcast RFR is absent on the islands. RFR values did not significantly differ between islands (Lesvos: 0.27 ± 0.05 V/m; Limnos: 0.21 ± 0.04 V/m; v3 2 = 0.08, p=0.779) and did not decrease with the distance to the antenna, possibly, they hypothesized, because some sampling points near the antenna may have been outside or at the edge of the emission lobes. They measured RFR at four distances of 50, 100, 200 and 400 m (164, 328, 656, and 1,312 ft, respectively) from 10 antennas (5 on Lesvos Island and 5 on Limnos Island) and correlated RFR values with insect abundance (numbers of insects) and richness (general health and vitality) — the latter only for wild bees and hoverflies. The researchers conducted careful flowering plant/tree- and- insect inventories in several low-lying grassland areas, including for wild bees, hoverflies, bee flies, other remaining flies, beetles, butterflies, and of various types. Honey bees were not included in this study as they are a managed species subject to beekeeper decisions and therefore not a wild species. On Lesvos 11,547 insects were collected and on Limnos 5,544. Varied colored pan traps for both nocturnal and diurnal samples were used. Results found all pollinator groups except butterflies were affected by RFR (both positively and negatively) and for most pollinator groups effects were consistent on both islands. Abundance for beetles, wasps, and hoverflies significantly decreased with RFR but overall abundance of wild bees and bee flies significantly increased with exposure. Further analysis showed that only abundance of underground-nesting wild bees was positively related to RFR while wild bees nesting above ground were not affected. RFR effects between islands differed only on abundance of remaining flies. On species richness, RFR tended to only have a negative effect on hoverflies in Limnos. Regarding the absence of effects seen in butterflies, they hypothesized that the pan trap collection method is not efficient for collecting butterflies (butterflies accounted for only 1.3 % of total specimens), and that a different sampling method might produce a different result. They concluded that with RFR's negative effects on insect abundance in several groups leading to an altered composition of wild pollinators in natural habitats, it was possible this could affect wild plant diversity and crop production. They further said the negative relationship between RFR on the abundance of wasps, beetles and hoverflies could indicate higher sensitivity of these insects to EMFs. Potentially more EMF-tolerant pollinators, such as underground-nesting wild bees and bee flies, may fill the vacant niches left by less tolerant species, thus resulting in their population increases. Another possible explanation is that EMFs may have particularly detrimental effects on more sensitive larval stages, and if so, larvae developing above ground (many beetles, wasps, hoverflies) may be more vulnerable than those developing underground since the former could be exposed to higher radiation levels.

In another field study, Taye et al. [407] placed five hives from December to May at varying distances of 1,000, 500, 300, 200 and 100 m (3,280, 1,640, 984, 656 and 328 ft, respectively) from a cell tower in India to measure flight activity, returning ability, and pollen foraging efficiency in honey bees (*Apis cerana* F). They found most effects closest to towers with the least returning bees at 100 m distance from the tower. Maximum foraging and return ability to the colonies was seen at 500 m, followed by 1,000 m and in descending order at 300 and 200 m, with the fewest returning bees at 100 m from the tower. The study also found that if bees returned, the pollen load per minute was not significantly affected.

Vijver et al. [408] however challenged the accuracy of distance from towers that is often used as a proxy for EMF gradients such as the study above. In a field study in The Netherlands, the researchers tested exposure to RFR from a cell base station (GSM 900 MHz) on the reproductive capacity of small virgin invertebrates during the most sensitive developmental periods spanning preadolescent to mating stages when reproductive effects would most likely be seen. Careful RFR field measurements were taken to determine null points in order to see if distance from emitters is a reliable RFR exposure model in field studies. They exposed four different invertebrate hexapod species. Springtails (*Folsomia candida*), predatory 'bugs' (*Orius laevigatus)*, parasitic wasps (*Asobara japonica)*, and fruitflies (*D. melanogaster*) were placed in covered pedestal containers within the radius of approximately 150 m of a 900 MHz mobile phone base station for a 48-h period. Six control groups were placed within 6.6 ft (2 m) of the treatment groups and covered in Farady cages. After exposure, all groups were brought to the laboratory to facilitate reproduction with resulting fecundity and number of offspring then analyzed. Results showed that distance was not an adequate proxy to explain dose-response regressions. After complex data synthesis, no significant impact from the exposure conditions, measures of central tendency, or temporal variability of EMF on reproductive endpoints were found although there was some variability between insect groups. As seen in other studies, distance is often used to create a gradient in energy exposures in studies but this study found the intensity of the transmitter and the direction of transmission to be more relevant, as did Bolte and Eikelboom [409, 410]. The direction and tilt of the transmitter determines whether the location of interest in field studies is in the main beam. In some instances, the closer promixity to the transmitter provided lower readings than further away, which they found between two locations. They also noted that the organisms selected in the study were small in size; springtails have a body length on average of 2 mm; wasps are about 3 mm, insect sizes from 1.4 to 2.4 mm, with the largest organisms tested being female fruit flies at about 2.5 mm length and males slightly smaller. Due to size, limited absorption and little energy uptake capacity, none of these insects are efficient whole-body receptors for 900 MHz waves with a wavelength of approximately 13 in (33 cm). But they further noted that this was a linear regression study and that biological effects are often non-linear. However, finding no distinct effects did not exclude physiological changes. They concluded that because of RFR exposure's increasing ubiquity, urgent attention to potential effects on biodiversity is needed.

The issue of insect size, nonlinearity, and antenna tilt/ direction are factors of critical importance with 5G radiation which will create extremely complex near- and- far-field ambient exposures to species in urban and rural environments alike, not only from a densification of small cell antennas close to the ground but also from increased satellite networks circling in low Earth orbits (see Part 1). The range of frequencies used for wireless telecommunication systems will increase from below 6 GHz (2G, 3G, 4G, and WiFi) to frequencies up to 120 GHz for 5G which, due to smaller wavelengths, is therefore a better resonant match for small insects. An alarming study by Thielens et al. [411], drawing on numerous robust studies of RFR's decades-long use as a thermal insecticide, modeled absorbed RFR in four different types of insects as a function of frequency alone from 2 to 120 GHz. A set of insect models was obtained using novel Micro-CT (computer tomography) imaging and used for the first time in finite-difference time-domain electromagnetic simulations. All insects showed frequency-dependent absorbed power and a general increase in absorbed RFR at and above 6 GHz, in comparison to the absorbed RFR power below 6 GHz. Their simulations showed that a shift of 10% of the incident power density to frequencies above 6 GHz would lead to an increase in absorbed power between 3–370% — a large differential of serious potential consequence to numerous insect species.

Using a similar approach, Thielens et al. [412] focused on the western honey bee (*Apis mellifera*) with RF-EMF, using a combination of *in-situ* exposure measurements near bee hives in Belgium and numerical simulations. Around five honey bee models were exposed to plane waves at frequencies from 0.6 to 120 GHz — frequencies carved out for 5G. Simulations quantified whole-body averaged RFR absorbed as a function of frequency and found that the average increased by factors of 16–121 (depending on the specimen) when frequency increased from 0.6 to 6 GHz for a fixed incident electric field strength. A relatively small decrease in absorption was observed for all studied honey bees between 12 and 120 GHz due to interior attenuation. RFR measurements were taken at 10 bee hive sites near five different locations. Results found average total incident RFR field strength of 0.06 V/m; those values were then used to assess absorption and a realistic rate was estimated between 0.1 and 0.7 nW. They concluded that with an assumed 10% incident power density shift to frequencies higher than 3 GHz, this would lead to an RFR absorption increase in honey bees between 390 and 570% — a frequency shift expected with the buildout of 5G.

The two previous studies alone should give pause regarding environmental effects to invertebrates in these higher 5G frequency ranges.

Kumar [413] noted that RFR should be included as causal agents of bee CCD and that test protocols need to be standardized and established. Standardization is critical since many studies conducted with cell phones in hives are of very uneven quality and only indicative of potential effects. Placing cell phones in hives and assuming that RFR is the only exposure is inaccurate and misleading. ELF-EMFs are always present in all telecommunications technology, using pulsed and modulated signals [414]. All of these characteristics have been found to be highly biologically active apart from frequency alone. Such studies are likely capturing ELF effects without identifying them. All aspects of transmission, including transmission engineering itself from towers, need to be considered to determine accurate exposures and delineate causative agents. Vibration and heat must also be considered — cell phones in transmission mode could raise hive temperature quickly and bees are highly temperature sensitive. Due to "waggle dance" specifics in creating foraging "roadmaps," bees should not be artificially relocated from hives to determine return ability after EMF exposure. They may be confused by relocation alone, adversely affecting their return abilities. Such tests also involve only one stressor when there are multiple stressors on insect species today. Understanding such cofactors is critical in determining accurate data and outcomes [415, 416]. Translating laboratory studies to field relevance has always been problematic but understanding EMF effects to insects has become urgent with ever increasing low-level ambient exposure from devices and infrastructure, especially in light of the new 5G networks being built. There are numerous variables that studies have yet to factor in. All of the above indicates a critical need to standardize experimental protocols and to take electroecology far more seriously, especially regarding aerial species in light of 5G.

Aquatic environments

There are fundamental electrical differences in conductivity (how well a material allows electric current to flow) and resistivity (how strongly a material opposes the flow of electric current) between air and water. Through water, EMF propagation is very different than through air because water has higher permittivity (ability to form dipoles) and electrical conductivity. Plane wave attenuation (dissipation) is higher in water than air, and increases rapidly with frequency. This is one reason that RFR has not traditionally been used in underwater communication while ELF has been. Conductivity of seawater is typically around 4 S/m, while fresh water varies but typically is in the mS/m range, thus making attenuation significantly lower in fresh water than in seawater. Fresh water, however, has similar permittivity as sea water. There is little direct effect on the magnetic field component in water mediums; propagation loss is mostly caused by conduction on the electric field component. Energy propagation continually cycles between electric and magnetic fields and higher conduction leads to strong attenuation/dissipation of EMF [98].

Because of these essential medium differences, electroreceptor mechanisms in aquatic species may be very different than those previously described in aerial species since air is a less conductive and resistive medium with less attenuation. That is why RFR travels more easily and directly through air. In aquatic species electroreception may be a result of transmission via water directly to the nervous system through unique receptor channels called Ampullae of Lorenzini [371]. In frogs, amphibians, fish, some worm species and others, receptor channels may be through the skin as well as via mechanisms more common in aerial species such as in the presence of magnetite (see "Mechanisms" above). There can be great variation in electroreceptive sensitivities in species inhabiting the two fundamentally different environments. Some amphibian species, however, have physical characteristics that span both mediums and therefore varied magnetoreception mechanisms.

Amphibians: frogs, salamanders, reptiles: regeneration abilities

Amphibians are the class of animals that include frogs, toads, salamanders, newts, some reptiles, and caecilians. The common term ‘frog’ is used to describe thousands of tailless amphibian species in the Order *Anura*. There are over 6,300 anuran species recorded thus far, with many more likely disappearing today due to climate change and other factors before we even knew they existed. Informal distinctions are made between frogs (thin-skinned species) and toads (thick, warty skins) but such distinctions are not used for taxonomic reasons. While the greatest concentration of diverse frog species is in tropical rainforests, they are widely found all over the world from the tropics to subarctic regions. Most adult frogs live in fresh water and/or on dry land while some species have adapted to living in trees or underground. Their skin varies in all manner of colors and patterns, from gray/green and brown/black to bright reds/yellows.

Frog skin is smooth and glandular — something of concern given nascent 5G technology (see Part 1) — and can secrete toxins to ward off predators. Frog skin is also semi-permeable which makes them highly susceptible to dehydration and pollutants. With radical weather shifts due to climate change and unpredictable swings between abnormal droughts followed by flooding in previously weather-stable regions, environmentally sensitive amphibians like frogs are considered bell-weather species. Frequently, time may be insufficient for some local/regional species to regenerate in between radical weather cycles, leading to population collapse.

Since the 1950s, there has been a significant decline in frog populations with more than one third of species today considered threatened with extinction while over 120 species are already believed to have gone extinct since the 1980s [10, 417, 418]. This amphibian decline is considered part of an ongoing global mass extinction, with population crashes as well as local extinctions creating grave implications for planetary biodiversity [419]. Amphibian extinction results are from climate change [420–422]; habitat loss/destruction [423, 424]; introduced species [425]; pollution [426], parasites [423, 427]; pesticides, herbicides and fungicides [428–430]; disease [431–435]; and increased ultraviolet-B radiation [436–439] among others. Anthropogenic sound pollution may also affect amphibian call rates and therefore impact reproduction [440] and artificial night lights affect male green frog (*Rana clamitaus melanota*) breeding [441]. Nonionizing electromagnetic fields may also play a role [442].

McCallum [443] calculated that the current extinction rate of amphibians could be 211 times greater than their pre-anthropogenic natural “background extinction” rate with the estimate rising 25,000–45,000 times if endangered species are also included in the computation. Today, declining amphibian populations are seen in thousands of species across numerous ecosystems, including pristine forested areas [418] and declines are now recognized among the most severe impacts of the anthropocene era [417, 442].

In addition, the number of frogs with severe malformations often incompatible with survival has risen sharply. Deformities are a complex issue related to physiology, anatomy, reproduction, development, water quality, changing environmental conditions, and ecology in general. Any time deformities are observed in large segments of wildlife populations there are indications of serious environmental problems [442]. Amphibian malformations are presumed due to an aggressive infectious fungal disease called Chytridiomycosisy, caused by the chytrid fungi *Batrachochytrium dendrobatodis* and *Batrachochytrium salamandrivorans* [432–435], and by parasites like *Ribeiroia ondatrae* [427]. Chytridiomycosis has been linked to dramatic amphibian declines and extinctions in North, Central, and South America, across sections of Australia and Africa and on Caribbean islands like Dominica and Montserrat. First identified in the 1970s in Colorado, U.S., it continues to spread globally at an alarming rate. Some populations witness sporadic deaths while others experience 100% mortality. There is no effective measure to control the disease in wild populations. Herbicides like glyphosate used in Roundup™ and atrazine, an endocrine disruptor, have also been found to cause severe malformations in both aquatic and land amphibian species from farmland pesticide/herbicide/fungicide runoff [428–430].

Frogs are known to be highly sensitive to natural and manmade EMF. Much research into the electrophysiology of frogs has been conducted because they are good lab models for human nervous system research, readily available, and easily handled. As far back as 1780, the Italian physicist Luigi Galvani discovered what we now understand to be the electrical basis of nerve impulses while studying static electricity (the only kind then known) when he accidentally made frog leg muscles contract while connected to the spinal cord by two different metal wires [444]. Galvani thought he had discovered "animal magnetism” but had actually discovered direct current and what later became known as a natural “current of injury”—the process by which an injured limb, for instance, produces a negative charge at the injury site that will later turn to a positive charge at the same site in some species as discovered in the 1960s by Robert O. Becker [444–451]. The earliest curiosity about natural current continued throughout the 1800s on various aspects of EMF and later throughout the 1920s to 1940s in pioneering researchers Elmer J. Lund [452–454] and Harold Saxon Burr [455–457] who worked to establish the first unified electrodynamic field theory of life, using hydra, frog, and salamander models among several others because of their morphogenic properties [458]. While frogs do not regenerate limbs the way salamanders do, both are so similar in taxonomy that curiosity was high in the early pioneers cited above throughout the 1960s to 1990s about what fundamentally allowed limb regeneration in one species, by not the other. Much was learned in the process about amphibian electrophysiology and cellular microcurrent in wound healing, as well as the electrophysiological properties of cellular differentiation, and eventually dedifferentiation pertinent to all contemporary stem cell research. Today the implications of this early work have gained new interest and targeted research regarding endogenous microcurrent and limb regeneration potential in humans, as well as dediffentiation/stem cell/morphogenesis in general for cancer treatment and other healing modalities. For a thorough review of studies on morphogenesis see Levin [459].

Ubiquitous low-level ambient EMFs today match some of the natural low-level microcurrent found critical to the fundamental processes of amphibian growth, reproduction, morphogenesis, and regeneration, lending new meaning to the early research that defined amphibian electrophysiology. We just need to make far better use of it to understand what role, if any, today's ambient exposures may be contributing to amphibian losses. (To compare tables between rising ambient EMF levels and low level effects in wildlife, see Part 1, Supplement 1; and Part 2, Supplement 3.)

Amphibian and reptile magnetoreception

How amphibians perceive natural and manmade EMF is similar to other species reviewed above and for amphibian mechanism reviews see Phillips et al. [460, 461]. Like many bird and insect species, evidence indicates that amphibians perceive the Earth's geomagnetic fields by at least two different biophysical magnetoreception mechanisms: naturally occurring ferromagnetic crystals (magnetite), and light-induced reactions via specialized photo-receptor cells (cryptochromes) that form spin-correlated radical pairs. Like birds, both mechanisms are present in some amphibians. Cryptochromes provide a directional 'compass' and the non-light-dependent magnetite provides the geographical 'map.'

In a thorough discussion of many magnetoreception studies in anura and urodela species, Diego-Rasilla et al. [462] found evidence that Iberian green frog tadpoles (*Pelophylax perezi*) had a light-dependent magnetic compass, and Diego-Rasilla et al. [463] also found that tadpoles of the European common frog (*Rana temporaria*) are capable of using the Earth's magnetic field for orienting along a learned y-axis. In these studies, they investigated if this orientation is accomplished using a light-dependent magnetic compass similar to that found in the earlier experiments with other species of frogs and newts [460, 462–470] or from some other factor. They concluded that the magnetic compass provided a reliable source of directional information under a wide range of natural lighting conditions. They also compared their findings to studies [470] that showed the pineal organ of newts to be the site of the light-dependent magnetic compass, as well as to recent neurophysiological evidence showing magnetic field sensitivity located in the frog frontal organ which is an outgrowth of the pineal gland. They hypothesized this work could indicate a common ancestor as long ago as 294 million years.

To determine if orientation using Earth's magnetic fields changed according to seasonal migration patterns, Shakhparonov and Ogurtsov [471] tested marsh frogs (*Pelophylax ridibundus*) in the laboratory to see if frogs could determine migratory direction between the breeding pond and their wintering site according to magnetic cues. Adult frogs (n=32) were tested individually in a T-maze 127 cm long inside a three-axis Helmholtz coil system (diameter 3 m). Maze arms were positioned parallel to the natural migratory route and measured in accordance with the magnetic field. Frogs were tested in the breeding migratory state and the wintering state, mediated by a temperature/light regime. Frog choice in a T-maze was evident when analyzed according to the magnetic field direction. They moved along the migratory route to the breeding pond and followed the reversion of the horizontal component of the magnetic field. The preference was seen in both sexes but only during the breeding migratory state. They concluded that adult frogs obtained directional information from the Earth's magnetic field.

Diego-Rasilla et al. [472] found similar evidence in two species of lacertid lizards (*Podarcismuralis and Podarcis lilfordi*) that exhibited spontaneous longitudinal body axis alignment relative to the Earth's magnetic field during sun basking periods. Both species exhibited a highly significant bimodal orientation along the north-northeast and south-southwest magnetic axis. Lizard orientations were significantly correlated over a five-year period with geomagnetic field values at the time of each observation. This suggested the behavior provides lizards with a constant directional reference, possibly creating a spacial mental map to facilitate escape. This was the first study to provide spontaneous magnetic alignment behavior in free-living reptiles although studies of terrapins have also found such spontaneous magnetic alignment [92, 323, 473]. Nishimura et al. [474, 475] also found sensitivity to ELF-EMF (sinusoidal 6 and 8 Hz, peak magnetic field 2.6 μT, peak electric field (10 V/m) in a lizard species (*Pogona vitticeps*) as demonstrated by significant increased tail lifting — a reproductive behavior. Interestingly, this tail-lifting response to ELF-EMF disappeared when the parietal eye was covered, suggesting that the parietal eye contributes to light-dependent magnetoreception and that exposure to ELF-EMFs may increase magnetic-field sensitivity in the lizards. A further experiment [476] showed that light at a wavelength lower than 580 nm was needed to activate the light-dependent magnetoreception of the parietal eye.

Amphibians: RF-EMF

Most frogs spend significant time on land but lay eggs in water where they hatch into tadpoles with tails and internal gills. However, some species bypass the tadpole stage and/or deposit eggs on land. Frogs are thus subject to exposures from both land-based and aquatic environments. A frog's life cycle is complete when metamorphosis into an adult form occurs. Many adverse effects do not appear until after metamorphosis is completed but problems have been found throughout the entire life cycle after exposures to both ELF-EMF and RFR.

Most early research on frogs (other than the Becker et al. regeneration inquiries noted above) was conducted at high thermal levels rarely encountered in the environment but some are included here because they helped delineate amphibian electrophysiology with effects later supported in low-level research. Some early work did use frog models to investigate cardiac effects with lower intensity exposures. Levitina [477] found that intact frog whole-body exposure caused a decrease in heart rate, while irradiation of just the head caused an increase. Using VHF frequency RFR at a power density of 60 μW/cm^2, A=12.5 cm, Levitina attributed the cardiac changes to peripheral nervous system effects but according to Frey and Siefert [478], because of the wavelengths used in that study, little energetic body penetration would be expected. They said a skin receptor hypothesis was therefore reasonable.

Following on Levitina's work, Frey and Seifert [478] — using isolated frog hearts, UHF frequencies that penetrate tissue more efficiently and low intensity pulse modulation — found that pulsed microwaves at 1,425 GHz could alter frog heart rates depending on the timing of exposure between the phase of heart action and the moment of pulse action. Twenty-two isolated frog hearts were irradiated with pulses synchronized with the P-wave of the ECGs; pulses were of 10 s duration triggered at the peak of the P-wave. Two control groups were used without RFR exposures with no effects noted. They found heart rate acceleration occurred with pulsing at about 200 ms after the P-wave. But if the pulse occurred simultaneously with the P-wave, no increases were induced. Arrhythmias occurred in half the samples, some resulting in cardiac cessation. Clearly from this study, RFR affected frog heart rhythm and could cause death.

A more recent work by Miura and Okada [479] found severe vasodilation in frog foot webs from RFR. In a series of three experiments using 44 anesthetized frogs (*X. laevis*) at thermal and non-thermal intensities, researchers exposed foot webs to pulsed RFR in three parameters with the monitor coil set at 1 V peak-to-peak: 100 kHz 582-3 mG and 174.76 V cm^{-1}; 10 MHz 7.3 mG and 2.19 V cm^{-1}; 1 MHz 539 mG and 16.11 V cm^{-1}. They found not only dilated arterioles of the web which had already been re-constricted with noradrenaline, but also dilated arterioles under non-stimulated conditions. Vasodilatation increased slowly and reached a plateau 60 min after radiation's onset. After radiation ceased, vasodilation remained for 10–20 min before slowly subsiding. Vasodilation was optimum when pulsation was applied 50% of the total time at a 10 kHz burst rate at 10 MHz. Effects were non-thermal. The pattern of vasodilation induced by warm Ringer solution was different from the vasodilatory effect of weak RFR, involving the level of intracellular Ca^{2+}. They hypothesized that since Ca^{2+} ATPase is activated by cyclic GMP which is produced by the enzymatic action of guanylate cyclase, RF-EMF may activate guanylate cyclase to facilitate cyclic GMP production. They concluded the study indicates for the first time that RFR dilates peripheral resistance vessels by neither pharmacological vasodilator agents nor physical thermal radiation, but that the precise mechanisms of activation of guanylate cyclase by RFR at the molecular level required further study. Vasodilation and constriction affects every part of the body and can affect all organ systems.

Prior to this, Schwartz et al. [480] found changes in calcium ions in frog hearts in response to a weak VHF field that was modulated at 16 Hz. This would be an exposure common in the environment. Calcium ions are critical to heart function.

Balmori [24–30, 442] and Balmori and Hallberg [271] have focused widely on EMF effects to wildlife, with two papers on amphibians. Balmori [442], in a review, noted that RFR in the microwave range is a possible cause for deformations and decline of some amphibian populations, and Balmori [481] in 2010 found increased mortality in tadpoles exposed to RFR in an urban environment. In the 2010 study, tadpoles of the common frog (*Rana temporaria*) were exposed to RFR from several mobile phone towers at a distance of 459 ft (140 m). Two month exposures lasted through egg phase to advanced tadpole growth prior to metamorphosis. RF and MW field intensity between 1.8 and 3.5 V/m (0.86–3.2 μW/cm^2) were measured with three different devices. Results determined that the exposed group (n=70) had low coordination of movements and asynchronous growth that resulted in both large and small tadpoles, as well as a disturbing 90% high mortality rate. In the control group (n=70) a Faraday cage was used under the same conditions. Controls found movement coordination to be normal and development synchronous with mortality rate at a low 4.2%. These results indicated that RFR from cell towers in a field situation could affect both development and mortality of tadpoles. Prior to this study, Grefner et al. [482] also found increased death in tadpoles (*Rana temporaria* L.) exposed to EMF, as well as higher mortality rates, and slower less synchronous development.

Mortazavi et al. [483] found changes in muscle contractions in frogs exposed to 900-MHz cell phone radiation for 30 min; gastrocnemimus muscles were then isolated and exposed to a switched on/off mobile phone radiation for three 10-min intervals. The authors reported RFR-induced effects on pulse height and latency period of muscle contractions. SARs of the nerve-muscle preparation were calculated to be 0.66 (muscle) and 0.407 (nerve) W/kg.

Rafati et al. [484] investigated the effects of RFR on frogs from mobile phone jamming equipment emitting RFR in the same frequencies as mobile phones. (Although illegal in many countries, jammers are nevertheless used to interfere with signals and stop communication.) The study sought to follow up on reports of non-thermal effects of RFR on amphibians regarding alterations of muscle contraction patterns. They focused on three parameters: the pulse height of leg muscle contractions, the time interval between two subsequent contractions, and the latency period of frog's isolated gastrocnemius muscle after stimulation with single square pulses of 1 V (1 Hz). Animals in the jammer group were exposed to RFR at a distance of 1 m from the jammer's antenna for 2 h while the control frogs were sham exposed. All were then sacrificed and isolated gastrocnemius muscles were exposed to on/off jammer radiation for three subsequent 10 min intervals (SAR for nerve and muscle of the different forms of jammer radiation was between 0.01 and 0.052 W/kg). Results showed that neither the pulse height of muscle contractions nor the time interval between two subsequent contractions were affected, but the latency period (time interval between stimulus and response) was statistically significantly altered in the RFR-exposed samples. They concluded the results supported earlier reports of non-thermal effects of EMF on amphibians including the effects on the pattern of muscle contractions. Control sham exposed samples showed no effects.

Amphibians, reptiles: ELF-EMF

Amphibians are highly sensitive to ELF-EMF. An early-1969 study by Levengood [485] using a magnetic field probe found increased high rates of teratogenesis in frogs (*Rana sylvatica*) and salamanders *(Ambystoma maculatum*). Two identical probes using different field strengths were employed — both operated in the kilogauss region with high field gradients. Amphibian eggs and embryos were exposed at various stages of development with gross abnormalities found in developing larvae vs. control. At the hatching stage severe abnormalities were noted in both anuran and urodele larvae from probe-treated eggs. Hatching abnormalities included microcephaly, altered development, and multiple oedematous growths. In probe-treated frogs there was a delay in the appearance of a high percentage of malformations until the climax stage of metamorphosis. Until that stage, the larvae were of the same appearance as control specimens, thus camouflaging the damage after just a brief treatment of early embryos. The frog abnormalities at metamorphosis differed from those in the hatching tadpoles and consisted mainly of severe subepidermal blistering and leg malformations including formation of multiple deformed limbs incompatible with life. Over 90% of the morphological alterations at metamorphosis climax were also found to be associated with deformed kidneys. The gastrula stages of development appeared to be the most sensitive in the delayed-effects category. While this was a high-field exposure experiment, it is an intensity that is found in some environments today especially near high tension lines and in abnormal ground current situations.

Neurath [486] also found strongly inhibited early embryonic growth of the common leopard frog (*Rana pipiens*) by a high static magnetic field with a high gradient (1T) — an exposure sometimes found in the environment — while Ueno and Iwasaka [487] found abnormal growth and increased incidence of malformations in embryos exposed to magnetic fields up to 8T but exposures that high are typically near industrial sites and rarely found in nature.

Severini et al. [488] specifically addressed whether weak ELF magnetic fields could affect tadpole development and found delayed maturation in tadpoles. Two cohorts of *X. laevis laevis* (Daudin) tadpoles were exposed for 60 days during immaturity to a 50 Hz magnetic field of 63.9–76.4 μT rms (root mean square, average values) magnetic flux density in a solenoid. Controls were two comparable cohorts remotely located away from the solenoid. The experiment was replicated three times. Results showed reduced mean developmental rate of exposed cohorts vs. controls (0.43 vs. 0.48 stages/day, $p< 0.001$) beginning from early larval stages; exposure increased the mean metamorphosis period of tadpoles by 2.4 days vs. controls ($p < 0.001$); and during the maturation period, maturation rates of exposed vs. control tadpoles were altered. No increases in mortality, malformations, or teratogenic effects were seen in exposed groups. The researchers concluded that relatively weak 50 Hz magnetic fields can cause sub-lethal effects in tadpoles via slowed larval development and delays in metamorphosis. Such exposures are found in the environment today in some locations and even though the changes were small, coupled with climate change, such sub-lethal effects may impact some wildlife populations in some environments.

In similar followup work, Severini and Bosco [489] found sensitivity to small variations of magnetic flux density (50 Hz, 22-day continuous exposure, magnetic flux densities between 63.9 and 76.4 μT) in tadpoles exposed to a stronger field vs. controls exposed to a weaker field. A significant delay in development of 2.5 days was found in exposed vs. controls. They concluded the delay was caused by the slightly different magnetic flux densities with results suggesting a field threshold around 70 μT in controlling the tadpole developmental rate.

Schlegel in 1997 found European blind cave salamanders (*Proteus anguinus*) and Pyrenean newts (*Euproctus asper)* to be sensitive to low level electric fields in water [490]. And Schlegel and Bulog [491] in followup work found thresholds of overt avoidance behavior to electric fields as a function of frequency of continuous sine-waves in water. Nine salamanders from different Slovenian populations of the urodele (*P. anguinus)* that included three specimens of its 'black' variety (*P. anguinus parkelj*) showed thresholds between 0.3 mV/cm (ca 100 nA/cm^2) and up to 2 mV/cm (670 nA/cm^2), with the most reactive frequencies around 30 Hz. Sensitivity included a total frequency range below 1 Hz (excluding DC) up to 1–2 kHz with up to 40 dB higher thresholds. These are ranges that may be found in the wild near high tension lines and utility grounding practices near water, by some underwater cabling, and by some RFR transmitters.

Landesman and Douglas in 1990 [492] found some newt species showed accelerated abnormal limb growth when pulsed electromagnetic fields were added to the normal limb regeneration process. While normal limb regeneration found normal regrowth patterns in 72% of specimens, 28% were abnormal. Abnormalities included loss of a digit, fused carpals, and long bone defects which occurred singly or in combination with one another. When exposure to a PEMF was added for the first 30 days post-amputation, followed by a 3–4 month postamputation period, a group of forelimbs with unique gross defects increased by an additional 12%. Defects (singly or in combination) included the loss of two or more digits with associated loss of carpals, absence of the entire hand pattern, and abnormalities associated with the radius and ulna. The researchers offered no explanation. Exposure intensities were similar to those used to facilitate non-juncture fracture healing in humans.

Komazaki and Takano in 2007 [493] found accelerated early development growth rates with 50 Hz, 5–30 mT alternating current exposures in the fertilized eggs of Japanese newts (*Cynops pyrrhogaster*). The period of gastrulation was shortened via EMF-promoted morphogenetic cell movements and increased $[Ca^{2+}]_i$. They said their results indicated that EMF specifically increased the $[Ca^2]_i$ of gastrula cells, thereby accelerating growth. This study only observed through the larval stages and they did not see any malformations under EMF exposures, which they attributed to possible differences in the intensity and mode of EMF.

With amphibians and some reptiles demonstrating high sensitivity to natural background EMF for important breeding and orientation needs, amphibians living in aquatic, terrestrial, and aerial environments (i.e. tree frog species) may be affected from multi-frequency anthropogenic EMF in ways we do not fully understand. There are potential effects — especially from 5G MMW that couple maximally with skin — to all aspects of their development and life cycles, including secondary effects.

Fish, marine mammals, lobsters, and crabs

Aquatic animals are exquisitely sensitive to natural EMF and therefore potentially to anthropogenic disturbance. The Earth's dipole geomagnetic field yields a consistent though varying source of directional information in both land and aquatic species for use in homing behavior, orientation during navigation and migration. This information is used both as a 'map' for positional information as well as a 'compass' for direction [494–497]. Aquatic species are known to be sensitive to static geomagnetic fields, atmospheric changes and sunspot activities [498]. For recent comprehensive reviews on magnetic field sensitivity in fish and effects on behavior, see Tricas and Gill [36] and Krylov et al. [33]. Some biological 'magnetic maps' may be inherited [499]. And for a recent extensive discussion of the Earth's natural fields and magnetoreception in marine animals with a focus on effects from electromagnetic surveys that use localized strong EMFs to map petroleum deposits under seabeds, see Nyqvist et al. [498] and below.

As mentioned above, because of the difference in conductivity of water and other factors, the way some aquatic species sense EMF may rely on unique modes of physiological perception, as well as those employed by terrestrial animals. There may also be sensory combinations not yet understood in some aquatic and semi-aquatic species. For instance, what role does the neural conductivity of whiskers (vibrissae) in seals, sea lions and walrus play other than for food finding? Aquatic species' dense network of whiskers is larger with greater blood flow than terrestrial species and can contain 1,500 nerves per follicle vs. cats at 200 per follicle. Seal whiskers also vary geometrically from terrestrial species and the largest part of the seal brain is linked to whisker function. Seals use whiskers to map the size, shape and external structure of objects and can find prey even when blindfolded. Their whiskers are also sensitive to weak changes in water motion [100]. But are they also using them as a location or directional compass in relation to the geomagnetic field? That has yet to be studied.

Unique sensory differences in aquatic species have long been documented. Joshberger et al. [500] noted that in 1,678 Stefano Lorenzini [501] was the first to describe a network of organs in the torpedo ray that became known as the Ampullae of Lorenzini (AoL). Its purpose was unknown for 300 years until Murray [502] measured AoL's electrical properties in elasmobranch fish — sharks, rays and skates. Later work [101, 503–508] confirmed and greatly added to this knowledge. Researchers now know that AoL is likely the primary mechanism that allows elasmobranch fish to detect and map a potential prey's physiology via the very weak changes in electric fields given off by prey's muscle contractions.

Individual ampullae are skin pores that open to the aquatic environment with a jelly-filled canal leading to an alveolus containing a series of electrosensing cells. Within the alveolus, the electrosensitive cells of the ampullae communicate with neurons and this integration of signals from multiple ampullae is what allows elasmobranch fish to detect electric field changes as small as 5 nV/cm [503, 506, 509, 510]. The AoL jelly has been reported as a semiconductor with temperature-dependence conductivity and thermoelectric behavior [500, 509, 510], as well as a simple ionic conductor with the same electrical properties as the surrounding seawater [503, 506]. Josberger et al. [500] attempted to clarify what AoL's role is in electrosensing by measuring AoL's proton conductivity. They found that room-temperature proton conductivity of AoL jelly is very high at 2 ± 1 mS/cm — only 40-fold lower than some current state-of-the-art manmade proton-conducting polymers. That makes AoL the highest conductive biological material reported thus far. They suggested that the polyglycans contained in the AoL jelly may contribute to its high proton conductivity.

Other aquatic magneto-sensory mechanisms more in harmony with terrestrial animals include the presence of ferromagnetic particles in magnetite — tiny naturally produced magnets that align with the Earth's magnetic field, allowing for species' direction and orientation. Magnetite appears to transmit necessary information through a connection with the central nervous system [340, 497, 511]. A magnetite-based system is plausible for cetaceans [512, 513] as magnetite has been found in the meninges dura mater surrounding the brains of whales and dolphins [514, 515]. There is also evidence that local variations/anomalies in the geomagnetic field in certain underwater topographies may play a role in live cetacean strandings [516, 517] which indicates a magnetic compass based on magnetite. And free-ranging cetaceans have shown evidence of magnetoreception-based navigation, e.g., Fin whale migration routes have been correlated with low geomagnetic intensity [513].

Recently, Granger et al. [518] found correlations in data between 31 years of gray whale (*Eschrichtius robustus*) strandings and sunspot activity, especially with RF 'noise' in the 2,800 MHz range. The 11-year sunspot cycle strongly correlates with the intense releases of high-energy particles known as solar storms which can temporarily modify the geomagnetic field, and in turn may modify orientation in magnetoreceptive species. Solar storms also cause an increase in natural broadband RF 'noise'. They examined changes in both geomagnetic fields and RF 'noise' and found RF to be a determinant. Further, they hypothesized that increased strandings during high solar activity is more likely due to radical pair mechanisms which are more reactive with RFR than magnetite, which appears more reactive to ELF-EMF. Two previous studies also found correlations with cetacean strandings and solar activities [519, 520]. Both mechanisms may come into play under different circumstances or act in synergy.

Kremers et al. [512] investigated the spontaneous magnetoreception response in six captive free-swimming bottlenose dolphins (*Tursiops truncates*) to introduced magnetized and demagnetized devices used as controls. They found a shorter latency in dolphins that approached the device containing a strong magnetized neodymium block compared to a control demagnetized block identical in form and density and therefore indistinguishable with echolocation. They concluded that dolphins can discriminate on the basis of magnetic properties — a prerequisite for magnetoreception-based navigation. Stafne and Manger [521] also observed that captive bottlenose dolphins in the northern hemisphere swim predominantly in a counter-clockwise direction while dolphins in the southern hemisphere swim predominantly in clockwise direction. No speculation was offered for this behavior.

How salmon navigate vast distances — from their hatching grounds in freshwater river bottoms to lakes during juvenile growth, then the open ocean during maturity, and with a final return to their neonatal birthing grounds to spawn and die (for most anadromous salmonids) — has fascinated researchers for decades. Research indicates they may use several magneto-senses to accomplish this, including inherited mechanisms [522], imprinting [499, 522], a magnetic compass [499, 522, 523], and biomagnetic materials. Salmon have been found to have crystal chains of magnetite [524]. One recent study found that strong magnetic pulses were capable of disrupting orientation in salmon models [525], indicating a magnetite-based mechanism. In salmon, the migration process is complicated by the fact that the ability to sense geomagnetic fields can be altered by changes in salinity between fresh and salt water, thus pointing to multi-sensory mechanisms [499].

Speculation that salmon use the geomagnetic field in some capacity for their iconic migration goes back decades [526]. Quinn [527] found evidence that sockeye salmon (*Oncorhynchus nerka*) frey use both a celestial and magnetic compass when migrating from river hatching to lakes. Putman et al. [499], who have written extensively on this subject, focused on how salmon navigate to specific oceanic feeding areas — a challenge since juvenile salmon reach feeding habitats thousands of kilometers from natal locations. The researchers experimentally found that juvenile Chinook salmon (*Oncorhynchus tshawytscha*) responded to magnetic fields similar to latitudes of their extreme ocean range by orienting in directions that would lead toward their marine feeding grounds. They further found that fish use the combination of magnetic intensity and inclination angle to assess their geographic location and concluded that the magnetic map of salmon appears to be inherited since the fish had no prior migratory experience. These results, paired with findings in sea turtles (see below), indicate that magnetic maps are widespread in aquatic species and likely explain the extraordinary navigational abilities seen in long-distance underwater migrants [499].

It is less likely that light-sensing radical pair cryptochromes play much of a role in aquatic species though some hypothesize the possibility [528]. Krylov et al. [33], however, noted that there are no anatomical structures or neurophysiological mechanisms presently known for radical pair receptors in the brains of fish and that since light decreases with water depth and fish are capable of orienting in complete darkness using the geomagnetic field, their opinion was that it is too early to say fish have magnetoreception mechanisms based on free radicals, light-dependent or otherwise.

Fish, lobsters, crabs: ELF-EMF

For several reasons having to do with differences in conductivity in water vs. air (see above), RFR is of far less concern in aquatic environments at present than is ELF. With the ever-increasing number of underwater cables used for everything from transcontinental data/communications to power supplies for islands, marine platforms, underwater observatories, off-shore drilling, wind facilities, tidal and wave turbines among others, many new sources of both AC and DC electric current are being created in sea and freshwater environments alike. According to Ardelean and Minnebo writing in 2015 [529], almost 4,971 mi (8,000 km) of high voltage direct current (HVDC) cables were present on the seabed worldwide, 70% of which were in European waters, and this is only expected to grow dramatically as new sources of renewable energy are built to replace fossil fuels globally.

Curiosity about potential adverse effects from cable-generated ELF-EMF on all phases of fish life has also grown, especially in benthic and demersal species that spend significant time near cables in deeper bottom environments for egg laying, larvae growth, and development for most, if not all, of their adult lives.

Fey et al. [494, 495] and Öhman et al. [530] noted that there are two types of anthropogenic exposures created by cables: high voltage direct current (HVDC) that emits static magnetic fields, and three-phase alternating current (AC power transmission) that emit time-varying electromagnetic fields. The density of electric current near underwater cables on the sea floor can vary significantly depending on the type of cable and whether they are positioned on the sea bottom or buried [36, 530]. Noticeable magnetic field changes can occur within meters but generally not more than several meters from the cable. However, Hutchinson et al. [531], in a robust field study and extensive review, found surprisingly stronger and more complex exposures than anticipated (see below).

Since fish are highly sensitive to static magnetic fields (MF), it is important to delineate static fields from anthropogenic alternating current EMF in aquatic studies. In freshwater species under laboratory conditions, Fey et al. [494] found similar results to those of salmon studies (noted above) in northern pike (*Esox lucius*) exposed to a static magnetic field from DC cables (10 mT) during the embryonic phase and in the first six days of post-hatching. No statistically significant MF effect was seen on hatching success, larvae mortality, larvae size at hatching, and growth rate during the first six days of life. However, significant MF effects were seen on hatching time (one day earlier in a magnetic field than in control), yolk-sac size was smaller, and yolk-sac absorption rate was faster. They interpreted the faster yolk-sac absorption in a magnetic field as an indication of increased metabolic rate but added that even if some negative consequences were expected as a result, that the actual risk for increased northern pike larvae mortality seemed negligible. Though higher than 10 mT magnetic field values are hazardous for fish larvae, they added such values do not occur in the natural environment even along underwater cables.

But in follow-up work of longer duration the same general research group reached a different conclusion. Fey et al. [495] studied effects on eggs and larvae of rainbow trout (*Oncorhynchus mykiss*) exposed to a static magnetic field (MF) of 10 mT and a 50 Hz EMF of 1 mT for 36 days (i.e., from eyed egg stage to approximately 26 days post hatching). They found that while neither the static MF nor the 50-Hz EMF had significant effects on embryonic/larval mortality, hatching time, larval growth, or the time of larvae swim-up from the bottom, both fields did however enhance the yolk-sac absorption rates. While they said this was not directly related to a MF effect, it was shown that larvae with absorbed yolk-sacs by the time of swim-up were less efficient in taking advantage of available food at first feeding and gained less weight. They concluded that these exposures could negatively affect the yolk-sac absorption rate thereby hampering fish in important feeding activities needed for fast weight gain and increased survival. In an additional study, Fey et al. [532] observed that rainbow trout reared in a laboratory for 37 days and exposed to a static MF (10 mT) or a 50-Hz EMF (1 mT) showed defects in otolith of the inner ear which is responsible for hearing and balance in fish. The authors concluded that underwater construction and/or cables that emit a MF of 10 mT or higher can affect living organisms within a few meters distance, especially species like trout in settled life stages on the sediment bottom during early development.

Zebrafish (*Danio rerio*) are often used in EMF research in toxicology and developmental biology investigating effects on humans because the genomes are so similar. Li et al. [533] studied ELF-MF on the development of fertilized zebrafish embryos divided into seven groups. Embryos of experimental groups were continuously exposed to 50-Hz sinusoidal MF with intensities of 30, 100, 200, 400, or 800 μT for 96 h. The sham group was identical but without ELF-MF exposure. Results showed that ELF-MF caused delayed hatching and decreased heart rate at early developmental stages but no significant differences were seen in embryo mortality or abnormality. Acridine orange staining assays showed notable signs of apoptosis in the ventral fin and spinal column and transcription of apoptosis-related genes (caspase-3, caspase-9) was significantly up-regulated in ELF-MF-exposed embryos. They concluded that ELF-EMF demonstrated detrimental effects on zebrafish embryonic development, including on hatching, decreased heart rate, and induced apoptosis, although such effects were not a mortal threat. The lower range exposures of this study are found in some aquatic environments.

Sedigh et al. [534] investigated effects on zebrafish exposed to static magnetic fields. Exposures of 1-week acute and 3-week subacute exposures to different static magnetic fields at 2.5, 5, and 7.5 mT were measured on stress indices (cortisol and glucose), sex steroid hormones (17β-estradiol and 17-α hydroxy progesterone) and fecundity. They found a significant change in cortisol, glucose, 17β-estradiol (E_2) and 17-α hydroxy progesterone (17-OHP) levels with increased intensity and duration of exposure and concluded that static magnetic fields at higher intensities showed harmful effects on the reproductive biology of zebrafish during both acute and subacute exposures.

Recent laboratory research by Hunt et al. [535] used the transparent glass catfish (*Kryptopterus vitreolus*) found in slow moving waters in Southeast Asia as a model to investigate magnetoreception. The study used Y-maze chambers, animal tracking software and artificial intelligence techniques to quantify effects of magnetic fields on the swimming direction of catfish. They placed a permanent Neodymium Rare Earth Magnet (11.5 × 3.18 × 2.2 cm) with a horizontal magnetic flux of 577 mT at the magnet's surface at 10 cm from the end of one of the Y-maze arms and found that catfish consistently swam away from magnetic fields over 20 μT. The catfish also showed adaptability to changing magnetic field direction and location. The magnetic avoidance was not influenced by school behavior. Sham exposures produced no avoidance. Such exposures might be found near some underwater cables.

To further elucidate findings of species reactions near underwater cables and fill in knowledge gaps since the 2011 Tricas and Gill review [36], Hutchinson et al. [531] conducted both field and laboratory modeling studies of both AC and DC fields on the American lobster (*Homarus americanus*) and the little skate (*Leucoraja erinacea*). They noted that in previous studies, while behavioral responses had been seen, findings were unable to determine if significant biological effects (e.g., population changes) occurred. The American lobster was modeled because it is a magnetosensitive species [536] and concern existed that EMF from cables might restrict movements and/or migration. Lobsters may migrate up to 50 mi (80 km) one way from deep waters to shallow breeding grounds. The little skate was used as a model for the most electro-sensitive taxa of the elasmobranchs, which may be attracted by/to the EMF of cables, particularly for benthic species, thereby altering their foraging or movement behavior. Both models were therefore thought indicative of potential EMF impacts. In this robust field study, the researchers found that the American lobster exhibited a statistically significant but subtle change in behavioral activity when exposed to the EMF of the HVDC cable (operated at a constant power of 330 MW at 1,175 Amps). The little skate exhibited a strong behavioral response to EMF from a cable powered for 62.4% of the study with the most frequently transmitted electrical current at 16 Amps (at 0 MW, 37.5% of time), 345 Amps (100 MW, 28.6%) and 1,175 Amps (330 MW, 15.2%). They concluded that for both species, the behavioral changes have biological relevance regarding how they will move around and are distributed in a cable-EMF zone, but they noted that the EMF did not constitute a barrier to movements across the cable for either species.

Of interest in this study were the actual field readings near cables. Unexpected significant AC magnetic and electric fields did not match computer models and were observed to be associated with both of the DC power cables studied. The maximum observed AC values along the cable axis were 0.15 μT and 0.7 mV/m for the magnetic and electric fields respectively for one cable, and 0.04 μT and 0.4 mV/m respectively, for the other cable. Also, the cross section of the EMF peaks exhibited by the DC subsea power cables were broader than anticipated at both studied. The DC and AC magnetic fields reached background levels on either side of the cable on a scale of c.a.5 and 10 m from the peak observed value respectively, whereas the AC electric fields reached background on a scale of 100 m (328 ft) from the peak value. Peak observed values occurred almost directly above the cable axis location; there was an offset of 3.3 ft (<1 m) where the cable was twisted. The researchers noted that this observation of AC fields, with broad areas of EMF distortion being associated with DC cables, increased the complexity of interpreting the studies of EMF's biological effects from DC cables. The AC electric fields associated with the AC sea2shore cable (1–2.5 mV/m) were higher than the unanticipated AC electric fields produced by the DC cables (0.4–0.7 mV/m). The magnetic field produced by the AC sea2shore cable (range of 0.05–0.3 μT) was ~10 times lower than modeled values commissioned by the grid operator, indicating that the three-conductor twisted design achieves significant self-cancellation. This entire aspect of the study indicates the need for accurate field assessment, not just computer modeling, and well-designed systems since anomalies occur.

Nyqvist et al. [498] in a thorough review, focused on marine mammals and the use of underwater electromagnetic surveys that map petroleum deposits in seabeds via strong induced EMFs in varied directional applications. They found that EMFs created during such active surveying were within the detectable ranges of marine animals and the fields can potentially affect behavior in electro-perceptive species, but they noted that effects should be limited to within a few kilometers as the electric and magnetic fields created attenuate rapidly. They added that in migrating marine animals, exposures are of short duration and most are close to naturally occurring levels but cautioned that lack of studies is a concern, especially for the most sensitive elasmobranchs at highest risk for disturbance to electric fields. They also noted that with induced magnetic fields, animals using magnetic cues for migration or local orientation during certain time-windows for migration, orientation, or breeding, could be most affected by this surveying technology.

Taorimina et al. [537] studied both static and time-varying magnetic fields on the behavior of juvenile European lobsters (*Homarus gammarus*). Using two different behavioral assays, day-light conditions to stimulate sheltering behavior and exposures to an artificial magnetic field gradient (maximum intensity of 200 μT), they found that juvenile lobsters did not exhibit any behavioral changes compared to non-exposed lobsters in the ambient magnetic field. No differences were noted on the lobsters' ability to find shelter or modified their exploratory behavior after one week of exposure to anthropogenic magnetic fields (225 ± 5 μT) which remained similar to behavior in controls. They concluded that neither static nor time-varying anthropogenic magnetic fields at those intensities significantly impacted the behavior of juvenile European lobsters in daylight conditions, but they noted that evidence exists showing magnetosensitivity changes during different life stages in lobster species, and that since their modeling was on juveniles, their study was therefore an incomplete picture requiring further study.

Scott et al. [538] focused on ELF-EMF effects on commercially important edible/brown crab species (*Cancer pagurus*) and what they found was startling. In laboratory tanks, they simulated EMF (with Helmholtz coils, 2.8 mT evenly distributed, assessments during 24 h periods) that would be emitted from sub-sea power cables now commonly used at offshore renewable energy facilities. They measured stress related parameters ((L-lactate, D-glucose, haemocyanin and respiration rate) along with behavioral and response parameters (antennal flicking, activity level, attraction/avoidance, shelter preference and time spent resting/roaming). They found that although there was no EMF effect on haemocyanin concentrations, respiration rate, activity level or antennal flicking rate, there were significant changes in haemolymph L-lactate and D-glucose natural circadian rhythms, indicating alterations in hormones. Crabs also showed an unusually high attraction to EMF-exposed shelter areas (69%) compared to control shelter areas (9%) and significantly reduced their time roaming by 21%, with adverse implications for food foraging, mating, and overall health. They noted that EMF clearly altered behavior. Crabs spent less time roaming around the tank and more time in a shelter in direct contact with the EMF source, indicating natural roaming/food-or-mate-seeking behavior had been overridden by attraction to EMF. In fact, crabs consistently chose an EMF-exposed shelter over a non-exposed one and were always drawn to the EMF. The results appear to predict that in benthic areas surrounding EMF-emitting cables, there will be an increase in the abundance of *Cancer pagurus* present. They noted that such potential crab aggregation around benthic cables and the subsequent physiological changes in L-lactate and D-glucose levels caused by EMF exposure, is a concern regarding feeding rates, mating, and especially egg incubation directly in increased EMF environments. They concluded that long term investigations are needed regarding chronic EMF exposure, especially on egg development, hatching success and larval fitness, and added that EMF emitted in marine environments from renewable energy devices must be considered as part of the study of cumulative impacts during the planning stages.

Clearly ELF-EMF can affect myriad aquatic species at intensity levels found in proximity to underwater cables at environmental intensities.

Fish: RF-EMF

As mentioned, RFR is of minimal environmental concern for fish since aquatic environments, while highly conductive mediums, also highly attenuate EMF at higher frequencies. This may change in the near future as new technologies now exist that may surpass these obstacles [98], thereby introducing for the first time novel new RFR exposures underwater. Longer wave wireless ELF with expanded ranges are used in anthropogenic sonar (sound navigation ranging), primarily for military applications. These travel easily through water and are known to adversely affect cetaceans and other species that rely on their natural sonar for communication, migration, reproduction and food finding. But sound waves are not considered “EMF” in the strict sense of the term; since the focus of this paper is EMF, sound waves are tangential here. But acoustic damage, especially to cetaceans from military and commercial applications, is well documented and ELF cables used for underwater military submarine communications can have significant EMF exposures near cables. Just because this paper does not address impacts from sound waves in detail does not mean they are without serious effects.

There are, however, three recent studies of RFR on zebrafish included here because it is plausible that such exposures could exist near shallow aquatic environments under some circumstances. Nirwane et al. [539] studied 900-MHz GSM RFR effects on zebrafish (*D. rerio*) neurobehavioral changes and brain oxidative stress as a model for human exposures to cell phones. Exposures were applied daily for 1 h, 14 days, with SAR 1.34 W/Kg. They found 900-MHz GSM radiation significantly decreased socialization and increased anxiety as demonstrated by significant increased time spent in bottom areas, freezing behaviors, and duration and decreased distance travelled, as well as decreased average velocity and number of entries to the upper half of the tank. Exposed zebrafish spent less time in the novel arm of a Y-Maze indicating significant impaired learning compared to the control group. Exposure also decreased superoxide dismutase (SOD) and catalase (CAT) activities while increased levels of reduced glutathione (GSH) and lipid peroxidation (LPO) were encountered indicating compromised antioxidant defense. Post-exposure treatment with melatonin in the water, however, significantly reversed the induced neurobehavioral and oxidative changes.

Piccinettia et al. [540] investigated *in vivo* effects on embryonic development in zebrafish at 100 MHz thermal and nonthermal intensities via a multidisciplinary protocol. Results found 100 MHz RFR affected embryonic development from 24 to 72 h post fertilization in all the analyzed pathways. Most notably at 48 h post fertilization, reduced growth, increased transcription of oxidative stress genes, onset of apoptotic/autophagic processes and a modification in cholesterol metabolism were seen. EMF affected stress by triggering detoxification mechanisms. At 72 h post fertilization, fish partially recovered and reached hatching time comparable to controls. The researchers concluded that EMF-RFR unequivocally showed *in vivo* effects at non-thermal levels.

Dasgupta et al. [541] used embryonic zebrafish models at 3.5 GHz SAR ≈ 8.27 W/kg and exposed developing zebrafish from 6 to 48 h post fertilization, then measured morphological and behavioral endpoints at 120 h post fertilization. Results found no significant impacts on mortality, morphology or photomotor response but noted a modest inhibition of startle response suggesting some levels of sensorimotor disruptions. They concluded that exposures at low GHz levels are likely benign but nevertheless entailed subtle sensorimotor effects. Such effects can affect fish survival in various ways, including inhibited response time to predators, among others. This study was done with an eye toward potential human bioeffects at frequencies used in 4 and 5G technology. It was also conducted at intensities higher than the focus of this paper.

If new technology overcomes the conductivity/attenuation limitations of aquatic environments and introduces more RFR to aquatic species, studies like those cited above may soon have more environmental relevance, even at higher intensities than explored here.

Turtles

Oceanic sea turtle migration joins that of other renowned long-distance migratory species like salmon and over-land monarch butterfly treks, spanning thousands of kilometers and traversing multiple complex environments throughout their life cycles. Sea turtles have long been known to use geomagnetic fields for orientation [542, 543]. Freshwater species (e.g., *Chelydra serpentina*) have also been shown to have a magnetic sense capable of artificial disruption [92] as do terrestrial box turtles (*Terrapene carolina;* [544]).

Sea turtles demonstrate natal homing behavior — the ability to return over great distances to their exact birth location to reproduce [89] and because of anthropogenic disruptions of nesting grounds along beaches, this reproductive homing drive imperils them today. The underlying mechanism is still imperfectly understood but involves 'imprinting' of the intensity and inclination angle of the geomagnetic field at the birth location [545]. The information is then later used in maturity to return to their place of origin.

Sea turtles are by far the most studied models for turtle magnetoreception, especially by the Lohmann Laboratory at the University of North Carolina, U.S. [323, 546–558].

Irwin and Lohmann [559] discussed the advantages and disadvantages of various research approaches used to investigate magnetic orientation behavior in turtles. These include the use of large magnetic coil systems in laboratory settings to generate relatively uniform fields over large areas [560] which allow the magnetic field to be artificially altered and carefully controlled to determine changes in behavioral orientation. This approach, however, is unsuited for manipulating exposures around animals in natural environments or for studying localized body magnetoreceptors, which in turtles are still a mystery. Another approach is to attach a small magnet or electromagnetic coil to an animal to disrupt magnetic orientation behavior — a far easier approach in hatchlings than in juvenile or mature free-swimming species. They note that if the imposed field from an attached magnet or coil is strong enough to interfere with the Earth's field, behavioral orientation changes [116, 544, 561] and the performance of a conditioned response [367, 562] can be observed. This latter approach has been used in field studies for the purpose of blocking access to normal magnetic information [544, 561, 563–565] and to localize magnetoreceptors by disrupting the field around a specific terrapin body part [562]. This technique's disadvantage, however, is that fields rapidly change with distance from the source, making it difficult to quantify the fields that the animal actually experiences.

Most sea turtle studies have involved large magnetic coil systems but Irwin and Lohmann [559] attached small magnets greater in strength than the Earth's fields to two groups of loggerhead sea turtle hatchlings (*Caretta caretta* L.) under laboratory conditions in which turtles are known to orient magnetically [473, 546, 548–550]. They found that magnetic orientation behavior in hatchling turtles can be disrupted via small magnets attached to the carapace which then create exposures over the entire body. They concluded that such an approach can be used to finally determine local magnetoreceptors by varying the location of the magnet and using smaller, weaker magnets that alter the field only around specific anatomical target sites.

In loggerhead sea turtles, there is evidence of an inclination compass [473, 550] that is functionlly similar to the bird magnetic compass reported in European Robins [566, 567]. Lohmann and Lohmann [550] investigated an inclination compass in sea turtles and found it was a possible mechanism for determining latitude. Also investigated were detection of magnetic intensity [551]; natural regional magnetic fields used as navigational markers for sea turtles [557]; and sea turtle hatchlings' mapping abilities [545]. Sea turtles are also known to have magnetite in their heads [104, 568]. Studies with young sea turtles have shown that a significant portion of their navigational abilities involve magnetoreception following hatching [569] — imprinting with the Earth's magnetic field being one of several cues hatchlings use as they first migrate offshore [546, 554]. The magnetic fields that are unique to different areas at sea eventually serve as navigational markers to guide swimming direction to important migratory routes. As juveniles mature, they form topographical magnetic maps where they live that direct them to specific regions. But it has remained largely unknown if mature turtles, specifically nesting females, use such mechanisms in open-sea homing as this magneto-sense may change over time.

Field studies are notoriously difficult with large species at sea but Papi et al. [564] studied mature green turtles (*Chelonia mydas*) during their post-nesting migration over 1,243 mi (2,000 km) from their nesting grounds on Ascension Island in the middle of the Atlantic Ocean back to their Brazilian feeding grounds. They were investigating whether mature female turtles use an inclination compass and geomagnetic fields for direction, or by inference (once that sense is disturbed) by some other means as yet determined. Papi et al. [564] attached very strong DC magnets — significantly stronger than the Earth's fields — to disturb and overcome natural magnetoreception, and thereby determine if they could still navigate back to Ascension Island. Controls had nonmagnetic brass bars attached and some had transmitters glued to their heads. All had tracking devices that communicated with satellites, thus creating strong multi-frequency static and pulsed RFR exposures. Seven turtles were each fitted with six powerful static magnets that produced variable artificial fields surrounding the whole turtle, making reliance on a geomagnetic map impossible. The study's travel courses were very similar to those of eight turtles without magnets that had been tracked via satellite over the same period in the previous year. No differences between the magnetically exposed test turtles and untreated turtles were found regarding navigational performance and general course direction. They concluded that magnetic cues were not essential to turtles on the return trip and speculated that perhaps other factors such as smell or wave current direction may come into play.

Luschi et al. [563], like Papi et al. [564], also investigated the role of magnetoreception and homing in mature sea turtles but used a different design and found very different results. In a large field study in the Mozambique Channel, 20 mature pre-nesting green turtles were also equipped with both strong magnets and satellite tracking devices. The turtles were gathered at their nesting beach on Mayotte Island before egg-laying and transported to four open-sea sites 62–75 mi (100–120 km, respectively) away. There were five releases of four turtles each with three different treatments: turtles magnetically 'disturbed' only during transportation with magnets removed before release; those treated only during the homing trip with magnets attached just prior to release; and controls with nonmagnetic brass discs attached to their heads. Treated turtles had very strong moveable magnets attached to their heads to induce varying magnetic fields around them either at the nesting beach at the start of the relocation journey or on the boat just prior to release for the homing trip. All groups had satellite transmitters attached to their carapaces, thereby creating in the opinion of the authors of this paper, an additional exposure that was not considered as a variable. The researchers also included ocean currents in their assessments, estimated by using oceanographic remote sensing measurements. All but one turtle eventually returned to Mayotte to complete delayed egg-laying. But treated turtles, whether treated during transportation or homing, took significantly longer to reach the destination vs. controls — a surprising finding. Most homing routes showed very long circuitous curved and looping patterns before reaching their target. Control paths were direct. Both treated turtle groups were clearly impaired by the MF exposure, indicating significant recovery time needed between exposure and correcting positional behavior. The researchers hypothesized the existence of a navigational role for geomagnetic information being gathered by those turtles in the passive transportation group, as well as the possibility that magnetic disturbance during transportation may have persisted for some time after the removal of the magnets in that group, thus rendering the two treated groups functionally equivalent during their homing journeys. They also noted that exposures may have physically altered magnetite particles, thus creating a longer lasting effect but they said that since long-lasting after-effects of magnet application have not been described, this theory could neither be inferred nor dismissed.

Lohmann [323] reviewed both of the above studies and added that in addition to the two causal hypotheses of Luschi et al. [563] regarding their unexpected findings of turtle circuitous migration routes, another explanation would include the positioning of the satellite transmitters in the Papi et al. [564] study on turtle heads vs. on the carapace of the Luschi models. He added that since satellite transmitters also produce magnetic fields capable of disrupting magnetoreception, and since the Papi group also attached satellite transmitters on the heads of several control turtles, that re-analyzing the Papi study using only turtles with satellite transmitters placed on the carapace like the Luschi study could show evidence consistent with the hypothesis that adult turtles exploit magnetic cues in navigation. He concluded that sea turtles, like all other animals studied to date, likely exploit multiple cues for navigation since even with artificial magnetic disturbance causing impaired performance, the magnets in either study did not prevent turtles from eventually reaching their target beaches. This implies that turtles can also rely on other sources of information [570, 571] such as celestial compasses, wave direction [572], or olfactory cues like other species — a significant finding.

The sum total of the studies mentioned above is that sea turtle species are highly sensitive to Earth's fields and are capable of adapting to subtle anthropogenic disruption.

Turtles: RF-EMF

Turtles may also be senstitive to RFR, especially during incubation while on land, and/or initial hatchling stages if they are exposed to anthopogenic RF-EMF that could distort the imprinting memory they use in later life to locate their birthsite beaches again. For example, if a radar or communications base station is installed on or near the beach of a nesting site, could that affect the initial "imprinting" process? Perhaps augment imprinting and make return easier? Or conversely overwhelm the subtle imprinting process at the start and make return impossible? If the latter is valid, such technology could lead to extinction of sensitive species since it interrupts the reproduction process. In the very least, in sensitive species, disorientation might result as discussed above.

To characterize the underlying compass mechanisms in turtles, Landler et al. [92] studied freshwater juvenile snapping turtles' (*Chelydra serpentine*) ability for spontaneous magnetic alignment to the Earth's geomagnetic fields. Using exposure to low-level RFR near the Larmor frequency (1.2 MHz) that is related to free radical pair formation, turtles were first introduced to the testing environment without the presence of RFR ("RF off, RF off") and they were found to consistently align toward magnetic north. But when subsequent magnetic testing conditions were initially free of RFR, then included an introduced signal ("RF off, RF on"), they became disoriented. Thus, introduction of a RFR field could affect the turtles' alignment response to the natural magnetic field. The RFR field used was only 30–52 nT (1.43 MHz). In the following reverse scenario, when the turtles were initially introduced to the testing environment with RFR present but then removed ("RF on, RF off"), they became disoriented when tested *without* RFR. And with RFR on in both cases ("RF on, RF on"), they aligned in the opposite direction toward magnetic south. Clearly test turtles were affected by the exposures. The researchers concluded that the sensitivity of the spontaneous magnetic alignment response of the turtles to RFR was consistent with a radical pair mechanism (see "Mechanisms" above). In addition, they concluded that the effect of RFR appeared to result from a change in the pattern of magnetic input, rather than elimination of magnetic input altogether. Their findings indicated that turtles, when first exposed to a novel environment, form a lasting association between the pattern of magnetic input and their surroundings, and that they may form a larger internal GPS-like mapping ability when they meet any new magnetic reference framework based on natural magnetic cues, from multiple sites and localities.

They also showed that RFR at or near the Larmor frequency (1.2–1.43 MHz) had the ability to disrupt snapping turtle natural orientation, establish its own novel orientation, and completely reverse a natural orientation, leading back to the complex questions asked above regarding imprinting and possible reproductive disruption. Although the Landler et al. study [92] was conducted in a freshwater, non-homing species, snapping turtles are long-lived with a low reproduction success rate. Even small disruptions to this species from anthropogenic sources could have an outsized population effect over time. If this freshwater species is any indication of potential RFR effects, researchers need to further investigate RFR in long-distance migrating turtle species that imprint on land. We simply do not know the full range of possible effects across frequencies with which turtle species come in contact at vulnerable points throughout development and lifetimes.

Nematodes and smaller biota

There are reports of sensitivity to EMF in lesser taxa as well. EMF is known to affect numerous other species including: nematodes (Earth and aquatic worms), mollusks (snails), amoeba (single-celled organisms), molds, algae, protozoans, yeast, fungi, bacteria, and viruses (to a limited extent) — with ramifications for creation of antibiotic resistant bacteria strains. Below are some representative examples of observed effects.

Nematodes

Common soil-based nematode species like *C. elegans* serve as a useful whole-organism model for genetic and multicellular organism investigations. They are routinely used as a research model to investigate key biological processes including aging, neural system functioning, and muscle degeneration, to name a few. This species' genetic and phenotypic traits are extremely well documented and they can thus be used as important proxies for quantitative analyses [573]. Nematodes have a short lifespan, are hermaphrodites, and demonstrate effects quickly. As lab models they are used primarily for information that can be applied to humans but we can also glean important information and extrapolate to environmental exposures under certain circumstances. Healthy soil worm populations are critical to soil health upon which we all depend.

Hung et al. [574] investigated static magnetic field (SMF) effects on life span and premature aging in *C. elegans*. Nematodes were grown in SMFs varying from 0 to 200 mT. They found that SMF's accelerated development and reduced lifespan in wild-type nematodes. They also found increases in heat shock proteins that were selective and dose dependent.

Vidal-Gadea et al. [66] investigated magnetic orientation in *C. elegans* to identify magnetosensory neurons and found that they orient to the Earth's geomagnetic field during vertical burrowing migrations. Well-fed worms migrated up, while starved worms migrated down. Populations isolated from around the world were found to migrate at angles to the magnetic vector that would vertically translate to their native soil, with northern- and southern-hemisphere worms displaying opposite migratory preferences in conjunction with natural geomagnetic fields. They also found that magnetic orientation and vertical migrations required the TAX-4 cyclic nucleotide-gated ion channel in the AFD sensory neuron pair while calcium imaging showed that these neurons respond to magnetic fields even without synaptic input. They hypothesized that *C. elegans* may have adapted magnetic orientation to simplify their vertical burrowing migration by reducing the orientation task from three dimensions to one.

C. elegans have also demonstrated sensitivity to electric fields via electrotaxis (also known as galvanotaxis) which is the directed motion of living cells or organisms guided by an electric field or current and often seen in wound healing. Sukul and Croll [575] found that nematodes exposed to an electrical current (0.02–0.04 mA, potential differences 2–6 V) demonstrated a directional sensorily-mediated orientation toward the current at first, but at 2 mm from the electrode, individual worms increased reversing behaviors which then remained uniform as they moved in a constant direction parallel to the exposure. A few which did not reverse direction died (presumably from electrocution) at 6 V or 0.4 mA. They concluded that adult *C. elegans* move directionally at selected combinations of voltage and potential differences and that electrophoresis could be eliminated.

Gabel et al. [576] also investigated electric field effects on directionality on *C. elegans* with an eye toward better understanding how the nervous system transforms sensory inputs into motor outputs. They used time-varying electric fields modulated at 100 Hz across an agar surface with a defined direction and amplitude up to 25 V/cm. They found that the nematodes deliberately crawl toward the negative pole in an electric field at specific angles to the direction of the electric field in persistent forward movements with the preferred angle proportional to field strength. They also found that the nematodes orient in response to time-varying electric fields by using sudden turns and reversals (normal reorientation maneuvers). They also found that certain mutations or laser ablation that disrupt the structure and function of amphid sensory neurons also disrupted their electrosensory behavior and that specific neurons are sensitive to the direction and strength of electric fields via intracellular calcium dynamics among the amphid sensory neurons. This study showed that electrosensory behavior is crucial to how the *C. elegans* nervous system navigates and can be disrupted at some intensities found in the environment.

Maniere et al. [573] also found *C.elegans* was sensitive to electric fields and that when submitted to a moderate electric field, worms move steadily along straight trajectories. They hypothesized that imposing electric fields in research settings was an inexpensive method to measure worms' crawling velocities and a method to get them to self-sort quickly by taking advantage of their electrotactic skills.

An early RFR study of *C elegans* by Daniells et al. [577] found this species to be a useful model for investigating stress-responses. In the majority of investigations, they used 750 MHz with a nominal power of 27 dBm; controls were shielded and all temperatures were strictly controlled. Stress responses were measured in terms of beta-galactosidase (reporter) induction above control levels. Response to continuous microwave radiation showed significant differences from 25 degrees C in controls at 2 and 16 h, but not at 4 or 8 h. Using a 5×5 multiwell plate array exposed for 2 h, the 25 microwaved samples showed highly significant responses compared with a similar control array. Experiments in which the frequency and/or power settings were varied suggested a greater response at 21 than at 27 dBm, both at 750 and 300 MHz indicating a nonlinear effect, although extremely variable responses were observed at 24 dBm and 750 MHz. Lower power levels tended to induce greater responses — the opposite of simple heating effects. They concluded that microwave radiation causes measurable stress to transgenic nematodes via increased levels of protein damage within cells at nonthermal levels.

Tkalec et al. [578] found oxidative and genotoxic effects in earthworms (*Eisenia fetida*) exposed *in vivo* to RFR at 900 MHz, at 10, 23, 41 and 120 V m(-1) for 2 h using a Gigahertz Transversal Electromagnetic (GTEM) cell. All exposures induced significant effects with modulation increasing such effects. Their results also indicated antioxidant stress response induction with enhanced catalase and glutathione reductase activity, indicating lipid and protein oxidative damage. Antioxidant responses and damage to lipids, proteins and DNA differed depending on EMF level, modulation, and exposure duration.

Aquatic and semi-aquatic worm species also show sensitivity to EMF. Jakubowska et al. [579] investigated behavioral and bioenergetic effects of EMF at 50 Hz, 1 mT fields (comparable to exposures near underwater cables) in polychaete ragworms (*Hediste diversicolor)* that live and burrow in the sand/mud of beaches and estuaries in intertidal areas of the North Atlantic. While they found no attraction or avoidance behavior to EMF, burrowing activity was enhanced with EMF exposure, indicating a stimulatory effect. Food consumption and respiration rates were unaffected but ammonia excretion rate was significantly reduced in EMF-exposed animals compared to control conditions at only geomagnetic fields. The mechanisms remained unclear. The authors said this was the first study to demonstrate effects of environmentally realistic EMF values on the behavior and physiology of marine invertebrates.

Van Huizen et al. [67] investigated effects of weak magnetic fields (WMF) on stem-cells and regeneration in an *in vivo* model using free-swimming flatworms (*Planaria* ssp*)* that are capable of regenerating all tissues including the central nervous system and brain. This regeneration ability is due to the fact that about 25% of all their cells are adult stem cells (ASC). Injury is followed by a systemic proliferative ASC response that initially peaks at ~ 4 h, followed by ASC migration to the wound site over the first 72 h when a second mitotic peak occurs. Like salamander regeneration (see “Amphibians” above) this activity produces a blastema — a group of ASC cell growth that forms the core of new tissues. Full regeneration of damaged planaria tissues or organs occurs through new tissue growth and apototic remodeling/scaling of old tissues within 2–3 weeks. Following amputation above and below the pharynx (feeding tube), they exposed amputation sites to 200 μT WMF. At three days post-amputation, they found that 200 μT exposure produced significantly reduced blastema sizes compared to both untreated and earth-normal 45 μT field strength controls, indicating a WMF interference effect to regeneration. They also found that the 200 μT exposure was required early and had to be maintained throughout blastema formation to affect growth, and that shorter, single-day exposures failed to affect blastema size. In addition, they found weak magnetic fields produced field strength–dependent effects. These included significant reductions of blastema size observed from 100–400 μT, but conversely, a significant increase in outgrowth occurred at 500 μT. They hypothesized that WMF effects were caused by altered reactive oxygen species (ROS) levels, which peak at the wound site around 1-h post-amputation and are required for planarian blastema formation. This study shows that weak anthropogenic magnetic fields can affect stem cell proliferation and subsequent differentiation in a regenerative species, and that field strength can increase or decrease new tissue formation *in vivo*. This is a significant finding for regenerating species of all kinds, and may affect non-regenerating species as well. Sea lamprey eels (*Petromyzon marinus*), a fish species, are also known to regenerate even after multiple amputations [580].

Mollusks, amoeba, molds, algae, protozoans

Mollusks (marine versions are called chitons) are long known to manufacture magnetite in their teeth and to use fields weaker than the geomagnetic field for kinetic movement and direction [52, 117, 340, 524]. Lowenstam [118] first discovered that magnetite was the major mineral in the teeth of marine chitons, thought to give teeth their natural hardness. But Ratner [62] discovered chitons use magnetite as a magnetic compass when he found a number of chiton species have radulae (tongues) that are covered by ferro-magnetic (magnetite) denticles. The radulae of *Acompapleura granulata* and *Chiton squamosis* were also found to be ferromagnetic but the shells were not. Live specimens of a chiton (*Chaetopleura apiculata*) that also have ferro-magnetic radulae were found to rotate more and move farther in a magnetic field weaker than in the Earth’s stronger geomagnetic field, indicating a nonlinear directionality. Ratner concluded that chitons are responsive to magnetic fields and demonstrate kinetic movements within them.

Some snails are sensitive to EMFs. Nittby et al. [581] observed analygesic effects in land snails (*Helix pomatia*) caused by GSM-1900 RFRs when snails lost sensitivity to pain on a hot plate test after nonthernal exposure to RFR.

Smaller organisms have also long shown effects from EMF. Goodman et al. [582] found delays in mitotic cell division in slime mold (*Physarum polycephalum*) with ELF-EMF exposures. Friend et al. [583] found perpendicular and parallel elongation of the giant amoeba Chaos chaos (*Chaos carolinensis*) in alternating electric fields over a wide frequency range (1 Hz–10 MHz) with characteristic changes as a function of frequency. Marron et al. [584] found effects on ATP and oxygen levels in another species of slime mold (*P. polycephalum*) after exposures to 60 Hz sinusoidal electric and magnetic fields. Luchien et al. [585] found a stimulating effect on the productivity of the algal biomass (*Chlorella sorokiniana*) for a magnetic field of 50 Hz but an inhibitory effect at 15 Hz in these microalgae.

Protozoans, thought to be more related to animals than microbes, also show sensitivity to EMF. Protozoans, as single-celled eukaryotes, are generally larger than bacteria which are classified as prokaryotes. The two organisms are structurally different: bacterial cells lack a nucleus while protozoa contain organelles such as mitochondria. Bacteria generally absorb nutrients through their cell walls while protozoa feed on bacteria, tissue, and organic matter and can be both infectious and parasitic. These protozoa include human parasites that cause diseases such as amoebic dysentery, malaria, giardiasis, leishmaniasis, trichomoniaisis, toxoplasmosis and others. Animal species are also affected by protozoans which can severely weaken and shorten their lifespans.

Rodriguez-de la Fuente et al. [586] tested ELF-EMF (60 Hz, 2.0 mT for 72 h) on two infectious protozoans, *Trichomonas vaginalis* and *Giardia lamblia*, and found growth alterations in both species which they attributed to alterations in cell cycle progression and cellular stress. Cammaerts et al. [587], used RFR (GSM 900-MHz at 2 W vs. control) on protozoans (*Paramecium caudatum*) and found individuals moved more slowly and sinuously than usual and that their physiology was affected. Paramecia became broader, pulse vesicles had difficulty expelling content to the outside of their cells, cilia moved less efficiently, and trichocysts became more visible — all effects that indicate poor functioning or cell membrane damage. They hypothesized that the first impact of RFR could be to cell membranes.

Clearly there are multiple effects at all levels documented in lower taxa from multi-frequency exposures that are now found in the environment.

Yeast and fungi

Yeast is often used in lab models, especially since 1996 when a complete genomic sequence of *Saccharomyces cerevisiae* was created. In fact it is now considered a "premier model" [588] for eukaryotic cell biology as well as having helped establish whole new fields of inquiry such as "functional genomics" and "systems biology" which focus on the interactions of individual genes and proteins to reveal specific properties of living cells and whole organisms.

EMF research is rich with studies using yeast models too numerous to fully analyze here. However we include a small sample of recent EMF research with potential significance to environmental exposures.

Lin et al. [589] investigated glucose uptake and transcriptional gene response to ELF-EMF (50 Hz) and RFR (2.0 GHz) on several strains of budding yeast (*S. cerevisiae*). Results determined that ELF-EMF and RFR exposure can upregulate the expression of genes involved in glucose transportation and the tricarboxylic acid (TCA) cycle, but not glycolysis pathways, thus showing that such exposures can affect energy metabolism which is closely related with cellular response to environmental stress. Glucose metabolism is fundamental to all living cells' need for energy, with related significance to many disease states including most cancers.

In a magnetic field study by Mercado-Saenz et al. [590], premature aging and cellular instability were found in yeast (*S. cerevisiae*) exposed to low frequency, low intensity sinusoidal magnetic fields (SMF continuous exposure at 2.45 mT, 50 Hz) and pulsed magnetic fields (PMF 1.5 mT, 25 Hz, 8 h/day). Chronological aging was evaluated during 40 days and cellular stability was evaluated by a spontaneous mutation count and the index of respiratory competence (IRC). They found exposure to PMF produced accelerated aging while SMF did not, and decreased mitochondrial mutation during aging was also seen with PMF. No alterations in respiratory competence were observed for either SMF or PMF exposures. They concluded that exposure to PMF accelerated chronological aging and altered the spontaneous frequency of mitochondrial mutation during the aging process, whereas the SMF used had no effect, thus showing abnormal effects on cell activity from pulsed exposures.

Because yeast cells are known to be sensitive to magnetic fields, some industrial and therapeutic applications to human health have been investigated. These investigations serve to illuminate what we know about yeast and fungal reactions to EMF in general, as well as specific uses. For industrial applications, Wang et al. [591] investigated low level static magnetic fields (SMF) on mold (*Aspergillus versicolor*) growth which can have high impacts on metal corrosion in environmental conditions conducive to mold growth. This is especially problematic in fine electronic circuit boards produced today. Using a

10 mT static magnetic field (SMF) perpendicular to the surface of printed circuit boards, they found the magnetic field inhibited mold growth and surface corrosion which were slowed down, unlike control boards without applied magnetic fields where mold formed a spore-centered corrosion pit that then led to macroscopic regional uniform corrosion. This demonstrated changes in cell/spore growth at a low intensity exposure that can be found in the environment.

Also with an eye toward commercial possibilities, Sun et al. [592] found that a polysaccharide of *Irpex lacteus* (a white-rot fungus found widely in the environment which breaks down organic materials but also is commercially used to treat nephritis in humans) was sensitive to low-intensity ELF-EMF as demonstrated by increased biomass and polysaccharide content, as well as induced malformed twists on the sample cell surfaces. Polysaccharides are carbohydrates with a large number of sugar molecules used as energy sources in living cells. They identified varying changes in multiple differentially expressed genes after exposure to alternating current EMF (50 Hz, 3.5 mT, 3 h per day, for 4 days). They found initial sharp increases in growth rates in exposed samples that were then marked by significant declines in EMF's influence over time, although there were also important lasting effects. Global gene expression alterations from EMF indicated pleiotropic effects (capable of affecting multiple proteins or catalyzing multiple reactions) were related to transcription, cell proliferation, cell wall and membrane components, amino acid biosynthesis and metabolism. Polysaccharide biosynthesis and metabolism were also significantly enriched in the EMF-exposed samples. They concluded that EMF significantly increased amino acid contents and was therefore deemed a suitable method for increasing fermentation of microorganisms, presumably for commercial use. However, the significance of this study to environmental exposures relates to the multiple ways that ELF alternating current common to electric power generation changed yeast gene expression. There is at least one clinical case of a different strain of *I. lacteus* taking on a rare infectious and dangerous quality in an immunocompromised human [593]. The question is: can now-ubiquitous ELF-EMF contribute to potentially emerging new forms of yeast contagion?

The same question arises with *Candida albicans* and other pathogenic yeasts that have rapidly developed resistance to antifungal medications. *C. albicans* can live harmlessly in human microflora, but certain lifestyle circumstances or immunosuppression can turn it into an opportunistic pathogen. It can also infect some non-human animals. While chronic mucocutaneous candidiasis can infect the skin, nails, and oral and genital mucosae, under high host immunodeficiency *C. albicans* can enter the bloodstream and induce systemic infections with mortality between 30 and 80% [594]. There has been increasing resistance of *C. albicans* to traditional antifungal agents, such as fluconazole and amphotericin B [595, 596]. Resistance mechanisms include overproduction of membrane drug efflux transporters and/or changes in gene expression [597].

Two investigations in search of new therapeutic strategies were conducted using EMF. Sztafrowski et al. [594] investigated the use of static magnetic fields (SMF, 0.5 T) on *C. albicans* cultures in the presence of two commonly used antifungal medications. Their aim was to assess whether SMF had any impact on general viability of *C. albicans* hyphal transition and its susceptibility to fluconazole and amphotericin B. They found reduction of *C. albicans* hyphal length in EMF-exposed samples. They also found a statistically significant effect on *C albicans* viability when SMF was combined with amphotericin B. They hypothesized that this synergistic effect may be due to the plasma membrane binding effects of amphotericin B and that SMF could influence domain orientation in the plasma membrane. They concluded, with caution, that the use of a SMF in antifungal therapy could be a new supporting option for treating candidas infections.

Novickij et al. [598] also focused on therapeutic possibilities given the multi-drug resistance and side effects to antifungal therapies. Their aim was to optimize the electroporation-mediated induction of apoptosis using pulses of varied duration (separately and in combination with formic acid treatment) and to identify yeast apoptotic phenotypes. They focused on nonthermal nanosecond pulsed electric fields (PEF 3 kV, 100 ns – 1 ms squarewave; and 250, 500, 750 ns duration 30 kV/cm PEF, 50 pulses, 1 kHz) as a therapeutic alternative and/or to enhance effects in combination with conventional treatments. In three yeast models, *S. cerevisiae* (as control) and drug resistant *Candida lusitaniae* and *Candida guilliermondii*, they found that nanosecond PEF induced apoptosis in all three strains. Combining PEF with a weak formic acid solution improved induced apotosis and inactivation efficacy in the majority of the yeast population. Yeast cells showed DNA breaks and other changes. They concluded that PEF could be a useful new non-toxic protocol to treat some fungal diseases and minimize tissue damage.

Choe et al. [599] studied ion transportation and stress response on a yeast strain (K667) to ELF-EMF (60 Hz, 0.1 mT, sinusoidal or square waves), specifically investigating internal ionic homeostasis via the cell membrane involving metal ions and cation transports (cations are ionic species of both atoms and molecules with a positive charge). They found significantly enhanced intracellular cation concentrations as ELF-EMF exposure time increased, as well as other changes. This study has implications for soil health as yeast can be an integral aspect of how healthy organic soil matter is formed. They concluded that EMF and yeast could also play a role in the bioremediation processes in metal-polluted environments.

Lian et al. [600] studied effects of ELF-EMF (50 Hz, 0–7.0 mT) and RFR (2.0 GHz, 20 V/m, temperature at 30 °C, average SAR single cell/0.12 W/kg) on two budding yeast strains (NT64C and SB34) and prion generation/propagation. They found under both EMF exposures that *de novo* generation and propagation of yeast prions (URE3) were elevated in both yeast strains. The prion elevation increased over time and effects were dose-dependent. The transcription and expression levels of heat shock proteins and chaperones were not statistically significantly elevated after exposure but levels of reactive oxygen species (ROS), as well as superoxide dismutase (SOD) and catalase (CAT) activities were significantly elevated after short-term, but not long-term exposure. This work demonstrated for the first time that EMF exposure could elevate the *de novo* generation and propagation of yeast prions, supporting the researcher's hypothesis that ROS may play a role in the effects of EMF on protein misfolding. ROS levels also mediate other broad effects of EMF on cell function. They concluded that effects of EMF exposure on ROS levels and protein folding may initiate a cascade of effects negatively impacting many biological processes.

The effects of EMF on protein folding cannot be overstated. Proteins must fold into proper three-dimensional conformations to carry out their specific functions — intact proteins are critical to the existence of all life. Misfolding not only impairs function but leads to disease. Folding inside of cells does not happen spontaneously but rather depends on molecular helpers called chaperones. Protein misfolding has been implicated in Alzheimer's, Parkinson's, and Huntington's diseases, among others. The devastating Creutzfeldt–Jakob disease is caused by prion misfolding in the brain, which causes abnormal signaling in neurons that eventually leads to paralysis and death. Wildlife can also suffer from prion diseases such as chronic wasting in deer, elk, and other cervids, and cattle can suffer from so-called "mad-cow" disease. The two studies from above [599, 600] have implications for how such diseases are spread through soil with possible links to environmental EMFs.

It is clear from the above that ELF-EMF and RF-EMF, using multiple signaling characteristics, are biologically active in both temporary and permanent ways in yeast/fungi species with wide environmental implications across numerous taxa.

Bacteria

Strains of bacteria are known to be magnetotactic and use geomagnetic fields for direction. Blakemore [63] was the first to suggest in 1973 that bacteria in North American saltwater marsh muds use magnetite as a sensor when he discovered not only that bacteria were highly attracted to an external magnet but they also had magnetite crystals that caused them to align with the lines of the Earth's magnetic fields. This was also discovered to be geolocation specific to the North Pole in northern samples and South Pole-seeking in southern species [52, 63, 511]. The bacteria showed "mud-up" and "mud-down" behavior along magnetic field gradients when mud was disturbed, indicating a magnetic compass. Since that early work, a whole new field called electromicrobiology has developed with discoveries that include some electro-active bacteria being responsible for magnetite formation, with others creating their own electric "wires" in mud flats with implications for new technologies [601].

Among the more troubling EMF effects are bacterial alterations with pressing implications for antibiotic resistance. Since the 1940s [602], nonthermal effects were documented in bacterial, viral, and tissue cultures with applied low-repetition 20-MHz pulses. Most studies spanning the 1940s though the 1980s focused on EMF's ability to kill microbes and fungi in human food sources at high intensity, consequently most research was focused on thermal intensities. That work still continues today as microwaves have been shown to be an efficient means for killing microbes [50]. But microbes also react to much lower nonlethal intensities and recent work finds effects from both ELF and RFR.

The common bacteria *Escherichia coli*, which can live harmlessly in the gut of humans and many other animal species, can also turn virulent and kill through food-borne illnesses. *E. coli* comes in many strains, is well studied, and now considered the most genetically and physiologically characterized bacterium. *E. coli* encounter varied and numerous environmental stressors during growth, survival, and infection, including heat, cold, changes in Ph levels, availability of food/water supplies, and EMF. Along with other bacteria, they respond by activating groups of genes and heat shock proteins (see "Mechanisms" above) which can eventually lead to stress tolerance for survival purposes. But induced stress tolerance can also lead to increased virulence, as well as enhanced tolerance to other stressors that confer cross-protection [603].

Salmen and colleagues [604, 605] published papers of EMF effects on bacterial strains documenting the growing investigation of microbes related to antibiotic resistance with many findings stressing responses to EMF [606–610]. Cellini et al. [611] investigated *E. coli*'s adaptability to environmental stress induced by ELF exposures to 50-Hz magnetic fields at low intensities (0.1, 0.5, 1.0 mT) vs. sham controls. They found exposed samples and controls displayed similar total and culturable counts, but increased cell viability was observed in exposed samples re-incubated for 24 h outside of the test solenoid compared to controls. Exposure to 50 Hz EMF (20–120 min) also produced a significant change in *E. coli* morphotype with a presence of coccoid cells aggregated in clusters after re-incubation of 24 h outside of the magnetic field-solenoid. Atypically lengthened bacterial forms were also noted, indicating probable alteration during cell division. Some differences in RNA-AFLP analysis were also seen for all intensities evaluated. They concluded that exposure to 50-Hz ELF-EMF is a bacterial stressor as evidenced by its immediate response in modifying morphology (from bacillary to coccoid) and inducing phenotypical and transcriptional changes. Despite this stressor effect, it was also seen that exposed samples significantly increased viability, suggesting the presence of VBNC cells. They concluded that further studies were needed to better understand ELF-EMF in bacterial cell organization. They did not extrapolate to the obvious — that *E. coli* was changed in an abnormal way but nevertheless strengthened in viability — a recipe for antibiotic resistance.

Crabtree et al. [612], in a small human study, investigated the biomic relationship of human bacteria exposed to both static magnetic fields (SMF) and RFR. Using laboratory culture strains and isolates of skin bacteria collected from the hand, cheek, and chin areas of four volunteers who had different (self-reported) cell phone use histories, they found varied growth patterns of *E. coli*, *Pseudomonas aeruginosa*, and *Staphylococcus epidermidis* under static magnetic fields on different bacterial species. Isolates of skin microbiota showed inconsistent growth among the test subjects, likely due to their differing cell phone usage histories (classified as heavy, medium and light) and other variables. The growth of *Staphylococci* was increased under RFR in certain individuals while in others growth was suppressed. This was complicated by the different body areas tested, some with higher chronic exposures such as the hands, as well as other variables when one test subject used an antibacterial face wash. Volunteers in the heavy use category showed less bacterial growth on the hands, possibly due to microbe habituation. Overall, and despite the small sample, they concluded RFR can disrupt the balance in skin microbiota, making it more vulnerable to infection by specific opportunistic and/or other foreign pathogens. They noted that both SMF and RF-EMFs have significant but variable effects on the growth of common human bacteria; that bacterial growth was either unaffected, increased, or suppressed depending on the species of bacteria; and that bacterial responses seemed to be determined by historic exposure to RF-EMF and life style. This study, even with inherent limitations, indicates changes in microbes with EMFs and may prove a novel way to study bacteria with significance for real-life exposures to humans and animals alike.

Salmen et al. [605] also found highly variable results from RFR (900 and 1,800 MHz) effects on DNA, growth rate, and antibiotic susceptibility in *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *P. aeruginosa*. Using an active cell phone handset, they exposed bacteria to 900 and 1,800 MHz for 2 h, then injected samples into a new medium where growth rate and antibiotic susceptibility were evaluated. Regarding DNA, they found no differences in *S. aureus* and *S. epidermidis* when exposed to 900 and 1,800 MHz vs. controls, but *P. aeruginosa* showed changes in DNA band patterns following such exposures. Regarding growth rates, with the exception of a significant decrease after 12 h exposure to 900 MHz, no significant effects on growth of *S. aureus* and *S. epidermidis* were seen. But the growth of *P. aeruginosa* was significantly reduced following exposure for 10 and 12 h to 900 MHz, while no significant reduction in growth followed exposure to 1,800 MHz. Regarding antibiotic susceptibility, in the drugs studied (i.e., amoxicillin 30 mg, azithromycin 15 mg, chloramphenicol 10 mg, and ciprofloxacin 5 mg), with the exception of *S. aureus* treated with amoxicillin (30 mg), EMF-exposure had no significant effect on bacterial sensitivity to antibiotics. This study shows variability among bacterial species not only to different frequencies common in the environment today but also to changes in sensitivity to some antibiotics but not others. There may have been design problems with this study, however.

Several studies investigated WiFi signals on bacterial strains. Taheri et al. [610] assessed exposure to 900-MHz GSM mobile phone radiation and 2.4-GHz RFR from common WiFi routers to see if cultures of *Listeria monocytogenes* and *E. coli* resulted in altered susceptibility to 10 different antibiotics. They found narrow windows in which microbes became more resistant: For L. *monocytogenes* no significant changes in antibacterial activity between exposed and nonexposed samples — except for Tetracycline (Doxycycline) — were noted. For *E. coli*, however, there was a significant change in antimicrobial activities suggesting RFR exposures can influence antibiotic susceptibility of *E. coli* more than in *Listeria*. For window and pronounced effects, they found *L. monocytogenes* exhibited different responses to each antibiotic. For Doxycycline, the window occurred after 6 h exposure to WiFi and mobile phone-RFR. After 9 h of exposure to WiFi for Ciprofloxacin and Sulfonamide (Tremethoprin/sulfamethoxazole), bacteria tended to become more resistant. By contrast, the pattern for Levofloxacin and Penicillin (Cefotaxime/Deftriaxone) showed increased sensitivity. For *E.coli*, the pattern of the response to WiFi and mobile phone RFR was the same: maximum antibiotic resistance was seen between 6 and 9 h of exposure but after 12 h, a stress response lead to a return to preexposure conditions indicating an adaptive reaction. Taheri et al. [609] found similar nonlinear window effects and differences in growth rates in *Klebsiella pneumonia*, while Mortazavi et al. [613] found similar window effects in *E coli*. In addition, they saw significant increased growth rates after radiation exposures in both Gram-negative *E. coli* and Gram-positive *L. monocytogenes*. They concluded that such window effects can be determined by intensity and dose rate; that exposure to RFR within a narrow window can make microorganisms resistant to antibiotics; and that this adaptive phenomenon is a human health threat. The same can be inferred for many non-human species.

Said-Salman et al. [614] evaluated non-thermal effects of WiFi at 2.4 GHz for 24 and 48 h (using a WiFi router as the source) on the pathogenic bacterial strains *E. coli* 0157H7, *S. aureus, and S. epidermis* for antibiotic resistance, motility, metabolic activity and biofilm formation. Results found that WiFi exposure altered motility and antibiotic susceptibility of *E. coli* but there was no effect on *S. aureus and S. epidermis*. However, exposed cells (vs. unexposed controls) showed an increased metabolic activity and biofilm formation ability in *E. coli*, *S. aureus and S. epidermis*. They concluded that WiFi exposure acted as a bacterial stressor by increasing antibiotic resistance and motility of *E. coli*, as well as enhancing biofilm formation in all strains studied. They indicated the findings may have implications for the management of serious bacterial infections.

Movahedi et al. [615] also investigated antibiotic resistance, using short-term exposure to RFR from a mobile phone simulator (900 MHz, 24 h) on *P. aeruginosa* and *S. aureus* against 11 antibiotics. They found significant changes in structural properties and resistance to the numerous antibiotics studied. *P. aeruginosa* was resistant to all antibiotics after 24 h of exposure vs. non-exposed controls while *S. aureus* bacteria were resistant to about 50%. They also found structural changes in all exposed samples and increased cell wall permeability.

In a field study near cell towers, Sharma et al. [616] looked at changes in microbial diversity and antibiotic resistance patterns in soil samples taken near four different base stations with control samples taken >300 m away. *Stenotrophomonas maltophilia, Chryseobacterium gleum,* and *Kocuria rosea* were isolated and identified in soil samples collected near the exposed zones. They found greater antibiotic resistance in microbes from soil near base stations compared to controls, with a statistically significant difference in the pattern of antibiotic resistance found with nalidixic acid and cefixime when used as antimicrobial agents. They concluded that cell tower radiation can significantly alter the vital systems in microbes and make them multi-drug resistant.

Researchers have also investigated ELF-EMF effects on bacterial growth and antibiotic sensitivity. Segatore et al. [608] investigated 2 mT, 50 Hz exposures on *E. coli* ATCC 25922 and *P. aeruginosa* ATCC 27853 and found EMF significantly influenced the growth rate of both strains, notably at 4, 6, and 8 h of incubation. The number of cells was significantly decreased in exposed bacteria vs. controls. And at 24 h incubation, the percentage of cells increased (*P. aeruginosa* ~ 42%; *E. coli* ~ 5%) in treated groups vs. controls which suggested to the researchers a progressive adaptive response. However, they saw no remarkable change in antibiotic sensitivity. Potenza at al. [617] also found effects at high-intensity static magnetic fields at 300 mT on growth and gene expression in *E.coli* but that would be a high environmental exposure.

Viruses

There is a paucity of research on viral species and EMF, likely due to the fact that viruses lack ferromagnetic materials, are difficult to study, and don't make good general lab models other than to investigate their direct impact on specific *in vivo* end points. Virology research thrives in its own specialized niche and has not been used for basic modeling like so many other living life forms as noted throughout this paper. There is long-standing debate on whether viruses are even alive.

However, one wide-ranging discussion by Zaporozhan and Ponomarenko [618] hypothesized a possible complex mechanistic link between influenza pandemics, natural sun spot cycles, and non-thermal effects of weak magnetic fields via cryptochromes/radical pairs, gene expression pathways, and stress-induced host immunological alterations favorable to influenza epidemics. Noting that most — though not all — major influenza epidemics occurred in time intervals starting 2–3 years before and ending 2–3 years after maximum solar activity, they hypothesized that solar cycles are able to both regulate and entrain processes of biological microevolution in viral species (among others), as well as influence human biorhythms in synergistic ways that could lead to influenza epidemics. Although others have also noted links between influenza pandemics and sunspot activity — possibly based on changes in migratory bird patterns as viral vectors [619–621]— and some have linked sun spots with other adverse human health events, these effects remain of interest but are still hypothetical. UV radiation, which is not covered in this paper, is known to suppress cell-mediated immunity and is therefore capable of adversely affecting the course of a viral infection in some mammal species. Ambient EMF in lower frequency ranges may also be reducing immune viability across species which can theoretically foster opportunistic virulence. Far more EMF research needs to be conducted on viruses; one fruitful approach might be synergistic investigations in virus-infected plant species.

The previous studies of microbes show a pattern of sensitivity in microorganisms to EMF with associations that encompass a wide range of critical changes, including consistent stress responses, alterations in growth and viability, cell membrane alterations, and clear patterns of how easily antibiotic resistance forms in microbial life to now ubiquitous EMF levels.

Plants (see Part 2, Supplement 4, for a table of flora studies: ELF, RFR)

Plants have evolved in highly sensitive ways to natural and manmade EMF in all phases of germination, growth and maturation [31]. Magnetoreception, which is well documented in animals such as birds, has also been described in plants [622] and plant species can respond to subtle changes in EMF in the environment, including in whole plant communities [623]. They may even 'communicate' and gather various kinds of 'information' via electrical signals in neuron-like cells in root tips and elsewhere [624]. Some hypothesize [625] that a form of vibrational and acoustic sensitivity around 220 Hz may play a role in plant life, although not everyone agrees [626].

Almost all vegetation is subject to complex multi-frequency fields due to their soil-based root systems and high water content, plus above-ground ambient RFR exposures makes plants uniquely susceptible to effects near transmission towers [623, 627]. Many EMF studies have found both growth stimulation as well as dieback. The presence of numerous RFR-emitters in the German and Swiss Alps is thought to have played a role in the deforestation there [628]. The 'browning' of treetops is often observed near cell towers, especially when water is near tree root bases [25]. Treetops, with their high moisture content and often thick vegetative canopy, are known RFR waveguides. In fact, military applications utilize this capability in treetops for communication signal propagation in remote areas and for guidance of low-flying weapons systems [629].

How flora interacts with EMF is still a mystery but a clear pattern has emerged in researching the database for this paper: static ELF-EMF has largely been found beneficial to plant and seed growth [630] while RFR is detrimental. Plants clearly have magnetoreception in their stationary condition. The normal ground state of magnetic fields for plants is the relatively constant natural geomagnetic field that averages between 25 and 65 μT depending on location and seasonal variations [631]. Atmospheric changes, such as thunderstorms and lightning, can cause intermittent changes in ambient magnetic fields. These activities are also generally associated with rainwater critical to virtually all plant life. Plants can detect these changes and prepare for growth using the upcoming rainfall. Trees are seen extending their branches skyward long before rain actually occurs and such changes match alterations in tree polarities [632].

There are many studies showing an increase in the growth rate in plants, such as studies of seed germination exposed to alternating magnetic fields. Plants also respond similarly to high intensity static magnetic fields. This may mean that the physiological mechanism in plants that causes magnetic field-induced growth is finely tuned to a certain intensity of magnetic flux. Any variation in intensity or shape of the ambient magnetic field could activate or hinder this growth mechanism.

Lightning, for instance, generates fast and intense electromagnetic pulses (EMP). EMP has consistently been shown to cause biological effects [633] with just one pulse. Plants may have mechanisms so sensitive that they can detect the energy of EMP from kilometers away. The pulse causes a transient change in the environmental magnetic field that may be detected by one or more of the mechanisms mentioned in the "Mechanisms" section above, as well as discussed below. EMP has been closely investigated for military applications for its ability at high intensities to disable electronics. While much of the military-supported research finds no biological effects from EMP exposure, non-military supported research does show effects. This parallels the same findings in industry vs. non-industry research patterns [165, 634].

There is a long history on the study of effects of EMF exposure on plant growth, notably, the work of the Indian scientist Sir Jagadish Bose (1858–1937) who proposed the electric nature of plant responses to environmental stimuli and studied effects of microwaves on plant tissues and membrane potentials [635]. Interestingly, Bose investigated the effects of millimeter waves [636] now applicable to 5G technology. Bose, arguably, was a pioneer of wireless communication.

Another early pioneer in EMF effects on plants was Harold Saxon Burr (1889–1973) at Yale University who investigated the electric potential of trees in two tree species (a maple and an elm) located on one property and another maple tree for comparison growing 40 miles (64 km) away. Measurements of numerous parameters were taken using embedded electrodes that recorded hourly from 1953 to 1961 [637]. Simultaneous records of temperature, humidity, barometric pressure, sunlight, moon cycles, sunspot activity, weather conditions, atmospheric-potential gradients, earth-potential gradients, and cosmic rays were correlated with tree potentials. Burr also installed equipment that measured the potential between electrodes in the Earth (about 10 miles apart) and the potential gradient of the air, and found that the air and Earth potentials fluctuated exactly with the phase of the tree potentials although the trees were not always synchronous. Burr ultimately found that the electrical environment correlated closely with tree potentials in a kind of entrainment to diurnal, lunar and annual cycles. Meteorological parameters did not correlate in any immediate way other than when passing thunderstorms elicited anomalous behavior in the trees in direct parallel to measurements with the Earth electrodes. This follows the theory noted above that plants can sense EMP and take immediate information from it.

There are no other long-term field studies as detailed as Burr's of magnetic field effects on a plant species. However, another field study of RFR in Latvia [638] measured effects directly on trees near the Skrunda Radio Location Station, an early warning radar system that operated from 1971 to 1998. The system operated in the 156–162 MHz frequency range transmitting from four pulsed two-way antennas that had operated continuously for over 20 years by the time of the study. In permanent plots in pine forest stands, at varying distances from the radar station and in control areas, tree growth changes were measured and analyzed using retrospective tree ring data. They found a statistically significant negative correlation between the relative additional increment in tree growth and the intensity of the electric field with the radial growth of pine trees diminished in all plots exposed to RFR. The decreased growth began after 1970, which coincided with the initial operation of the station and was subsequently observed throughout the period of study. The effects of many other environmental and anthropogenic factors were also evaluated but no significant effects on tree growth were correlated. This may have been the first detailed field study of plants and RFR.

Many studies of EMF and plants are today conducted in laboratories and have often focused on growth promotion to create higher yields of food-producing plants. Effects of static EMF, pulsed EMF, ELF-EMF, and RF-EMF have been reported. There are, in fact, over 200 studies on plants and EMF alone — too numerous to review here. See Part 2, Supplement 4, for a Table of studies on plant seedlings and development based on the types of EMF's tested.

As noted in Supplement 4 and in Halgamuge [627], frequently static and ELF-magnetic fields generally improve plant growth whereas RFR retards it. This is the opposite of results from animal and animal-cell culture experiments in which ELF-MF usually produces the same effects as RFR. It is interesting to note that Hajnorouzi et al. [639] and Radhakrishma et al. [640] proposed that MF decreases environmental stress in plants whereas Vian et al. [641, 642] considered RFR as a systemic stressor. A major morphological difference between animal and plant cells is that plant cells have a cell wall that is an active physiological organelle which regulates growth and cell division and controls cellular communications. The cell wall contains a considerable amount of water [643]. Is it possible that absorption of RFR by cell-wall water causes a microthermal effect that adversely affects plant cell functions and even causes cell death, whereas thermal effects are not likely to occur with ELF-EMF exposure.

Some plant roots have been found sensitive to both ELF and RFR. Belyavskaya [644] found a strong cytochemical reaction in pea root cells after exposure to low level magnetic fields. Kumar et al. [645] found cyto- and genotoxicity in root meristems of *Allium cepa* with 900-MHz and 1,800-MHz RFR. Chandel et al. [646] studied cytotoxic and genotoxic activity on DNA integrity in root meristems of *A. cepa* using 2,100-MHz RFR and found exposure caused DNA damage with a significant decrease in HDNA accompanied by an increase in TDNA while TM and OTM did not change significantly compared to controls. Biological effects were dependent on the duration of exposure with maximum changes seen at 4 h.

In a series of studies, Stefi et al. [647–649] investigated the effects of long term RFR exposure from the base units of common cordless DECT phone systems (pulsed transmission mode 1,882 MHz, 24 h/day, 7 d/week) on various plant species (*Arabidopsis thaliana, Pinus halepensis, Gossypium hirsutum* respectively) and found structural and biochemical alterations. Compared to controls in Faraday cages, exposed plant biomass was greatly reduced and leaf structure was only half as thick. Leaves were thinner and possessed greatly reduced chloroplasts which contributed to overall reduced vitality. Root systems were also adversely affected. They concluded that RFR is a stressor and noxious to plant life. A study of similar design [650] did not find the same effects on maize (*Zea mays*) which they attributed to that plant's structural differences although chloroplasts were severely affected (see also Kumar et al. [651]).

Jayasanka and Asaeda [652] published a lengthy review that focused on microwave effects in plants. Studies indicate effects depend on the plant family and growth stage involved; and exposure duration, frequency, and power density, among other factors. They concluded that even for short exposure periods (<15 min to a few hours), nonthermal effects were seen that can persist for long periods even if initial exposures were very short. In addition, they noted that since base stations operate 24 h/day, neither short exposures nor recovery periods are possible in natural habitats as plants are continuously exposed throughout their life cycles. They said that variations in the power density and frequency of microwaves exert complex influences on plants, and that clearly diverse plant species respond differently to such factors. They concluded it is necessary to rethink the exposure guidelines that currently do not take nonthermal effects into consideration.

There are numerous reports of adverse RFR effects on mature flora. Waldman-Salsam et al. [653] reported leaf damage in trees near mobile phone towers/masts. In a detailed long-term field monitoring study from 2006 to 2015 in two German cities, they found unusual and unexplainable tree damage on the sides of trees facing the towers and correlated it to RFR measurements vs. control areas without exposures. They found that tree-side differences in measured values of power flux density corresponded to tree-side differences in damage. Controls, which consisted of 30 selected trees in low radiation areas without visual contact to any phone mast and power flux density under 50 μW/m^2, showed no damage. They concluded that nonthermal RFR from mobile phone towers is harmful to trees and that damage that affects one side eventually spreads to the whole tree.

Vian et al. [642] published a review of plant interactions with high frequency RFR between 300 MHz and 3 GHz and noted that reports at the cellular, molecular, and whole plant scale included: numerous modified metabolic activities (reactive oxygen species metabolism, α- and β-amylase, Krebs cycle, pentose phosphate pathway, chlorophyll content, and terpene emission among others); altered gene expression (calmodulin, calcium-dependent protein kinase, and proteinase inhibitor); and reduced growth (stem elongation and dry weight) after nonthermal RFR exposure. They said changes occur in directly exposed tissues as well as systemically in distant tissues and proposed that high-frequency RFR be considered a genuine environmental factor highly capable of evoking changes in plant metabolism.

Halgamuge [627] also published a review that found weak non-thermal RFR affects living plants. The author analyzed data from 45 peer-reviewed studies of 29 different plant species from 1996 to 2016 that described 169 experimental observations of physiological and morphological changes. The review concluded that the data substantiated that RFR showed physiological and/or morphological effects (89.9%, p<0.001). The results also demonstrated that maize, roselle, pea, fenugreek, duckweeds, tomato, onions and mungbean plants are highly sensitive to RFR and that plants appear more responsive to certain frequencies between 800 and 1,500 MHz (p<0.0001); 1,500 and 2,400 MHz (p 0.0001); and 3,500 and 8,000 MHz (p=0.0161). Halgamuge [627] concluded that the literature shows significant trends of RFR influence on plants.

There is particular concern for impacts to flora and 5G since millions of small antennas mounted on utility poles, transmitting in MMW and other broadband frequencies, already are — or will soon be — in very close proximity to vegetation, creating both near- and -far field exposures. As noted in Halgamuge [627], the following are some studies investigating GHz frequencies already in use or planned for 5G that found significant effects on plants: Tanner and Romero-Sierra [654] on accelerated growth of Mimosa plant (10 GHz, 190 mW/cm^2, 5–10 min); Scialabba and Tamburello [655] on reduced hypocotyls growth rate in radish (*Raphanus sativus*) (10.5 GHz, 8 mW or 12.658 GHz, 14 mW for 96 h); Tafforeau et al. [656] induced meristem (actively dividing group of cells) production in *Linum usitatissimum* (105 GHz for 2 h at 0.1 mW/cm^2); and Ragha et al. [657] (9.6 GHz, 30 min) found germination depended on exposure parameters on *Vigna radiata*, *Vigna aconitifolia*, *Cicer arietinum* and *Triticum aestivum* plants. This is an area in immediate need of further investigation given the results from the previous studies.

A thorough review of RFR effects to trees and other plants was published by Czerwinski et al. [622] who reported that ecological effects on whole plant communities could occur at a very low exposure level of 0.01–10 μW/cm^2 — certainly comparable to limits examined in this paper. They focused on frequencies between 0.7 and 1.8 GHz and included multiple complex indicators for plant types, biometrics, and environmental factors. It was the first comprehensive paper that extended beyond using narrower research methods. They noted that although the literature on the effects of RFR on plants is extensive, not a single field study had assessed the biological response at the level of a whole plant community, biome, or ecosystem, but rather focused mostly on short-term laboratory studies conducted on single species. They said, "…This dissonance is particularly striking in view of the fact that alterations in a plant community's structure and composition have long been considered to be well founded, sensitive and universal environmental indicators." The paper serves as a predictive model for complex future field studies on larger ecosystems.

Interesting EMF synergistic effects were found with static magnetic fields and bacteria in plants. Seeking nonchemical methods to improve seed germination after prolonged periods of storage when seed viability can deteriorate, Jovičić-Petrović et al. [658] studied the combined effects of bacterial inoculation (*Bacillus amyloliquefaciens* D5 ARV) and static magnetic fields (SMF, 90 mT, 5 and 15 min) on white mustard (*Sinapis alba* L.) seeds. Their results found that biopriming with the plant growth-promoting *B. amyloliquefaciens* increased seed growth by 40.43%. Seed response to SMF alone was dependent on treatment duration. While SMF at 5 min increased the germination percentage, exposure at 15 min lowered seed germination compared with the control. However, the negative effect at the longer exposure was neutralized when combined with the bacterial inoculation. Both germination percentages were significantly higher when SMF was combined with the bacteria (SMF, 5 min, + D5 ARV; and SMF, 15 min + D5 ARV; 44.68 and 53.20%, respectively) compared with control. They concluded that biopriming and SMF treatment gave better results than bacterial inoculation alone. The highest germination percentage — 53.20% of germinated seeds — was seen with the bacterium and 15 min exposure to 90 mT, demonstrating a synergistic effect. They concluded that such techniques can be used for old seed revitalization and improved germination.

Even aquatic plants have been found sensitive to artificial electric fields. Klink et al. [659] assessed electric field exposures on growth rates and the content of trace metals of *Elodea canadensis*. Plants were exposed in a laboratory to an electric field of 54 kV/m for seven days. Plant length and Fe, Mn, Ni, Pb, and Zn were measured. Results showed the applied electric fields slightly enhanced root growth. They also found changes in mineral absorption; Mn and Ni were significantly lower while Pb and Zn were significantly higher in exposed plants. Fe content did not differ between control and exposed plants. They concluded that electric fields had potential use for phytoremediation in trace metal contaminated waters. This study also has implications for long term aquatic plant health in general.

Also working with electric fields, Kral et al. [660] found fascinating regeneration in plant root tips in *Arabidopsis* at varying electric field exposures and time durations with the weaker exposures producing the most growth. They found that imposed electric fields can perturb apical root regeneration and that varying the position of the cut and the time interval between excision and stimulation made a difference. They also found that a brief pulse of an electric field parallel to the root could increase by up to two-fold the probability of its regeneration, perturb the local distribution of the hormone auxin, and alter cell division regulation with the orientation of the root towards the anode or the cathode playing a role.

While mechanisms are still unclear regarding how EMFs affect plants, oxidative effects appear to play a significant role. Oxidative changes have been reported in many studies in plants after exposure to EMF [578, 639, 661–671]. EMF-related stress has been proposed by Vian et al. [641, 642], Roux et al. [672, 673], and Radhakrishma et al. [640]. Other mechanisms affecting plants such as ferromagnetism, radical-pairs, calcium ions and cryptochromes have also been proposed [674, 675].

It is apparent that plant growth and physiology — with their root systems anchored in the ground while their 'heads' manifest in the air — are affected by exposure to EMF in complex synergistic ways and that they are susceptible to multi-frequency exposures throughout their life spans.

Conclusion

Effects from both natural and man-made EMF over a wide range of frequencies, intensities, wave forms, and signaling characteristics have been observed in all species of animals and plants investigated. The database is now voluminous with *in vitro, in vivo,* and field studies from which to extrapolate. The majority of studies have found biological effects at both high and low-intensity man-made exposures, many with implications for wildlife health and viability. It is clear that ambient environmental levels are biologically active in all non-human species which can have unique physiological mechanisms that require natural geomagnetic information for their life's most important activities. Sensitive magnetoreception allows living organisms, including plants, to detect small variations in environmental EMF and react immediately as well as over the long term, but it can also make some organisms exquisitely vulnerable to man-made fields. Anthropogenic EMF may be contributing more than we currently realize to species' diminishment and extinction. Exposures continue to escalate without understanding EMF as a potential causative and/or co-factorial agent. It is time to recognize ambient EMF as a potential novel stressor to other species, design technology to reduce exposures to as low as reasonably achievable, keep systems wired as much as possible to reduce ambient RFR, and create laws accordingly — a subject explored more thoroughly in Part 3.

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Part 2: supplements

Supplement 1: Genetic Effects of RFR Exposure
Supplement 2: Genetic Effects at Low Intensity Static/ELF EMF Exposure
Supplement 3: Biological Effects in Animals and Plants Exposed to Low Intensity RFR
Supplement 4: Effects of EMF on plant growth

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Part 2. Supplement 1.
Genetic Effects at Low Level RFR Exposure

RFR studies	Power density/SAR (<0.1 W/Kg)	Effects observed
Aitken et al. (2005)	Mice to 900-MHz RFR for 7 days at 12 h/day; SAR 0.09 W/kg	Mitochondrial genome damage in epididymal spermatozoa.
Akdag et al. (2016)	Male Wistar-Albino rats to 2400 MHz RFR from a Wi-Fi signal generator for a year; SAR 0.000141 (min)-0.007127 (max) W/kg	DNA damage in testes.
Alkis et al. (2019a)	Rats exposed to 900 MHz (brain SAR 0.0845 W/kg), 1800 MHz (0.04563 W/kg), and 2100 MHz (0.03957 W/kg) RFR 2 h/day for 6 months	Increased DNA strand breaks and oxidative DNA damage in brain.
Alkis et al. (2019b)	Rats exposed to 900 MHz, 1800 MHz, and 2100 MHz RFR 2 h/day for 6 months; maximum SAR over the rat 0.017 W/kg	DNA strand beaks and oxidative DNA damage in testicular tissue.
Atasoy et al. (2013)	Male Wister rats exposed to 2437 MHz (Wi-Fi) RFR; 24 h/day for 20 weeks; maximum SAR 0.091 W/kg	Oxidative DNA damage in blood and testes.
Beaubois et al. (2007)	Leaves of tomato plant exposed to 900-MHz RFR for 10 min at 0.0066 mW/cm^2	Increased expression of leucine-zipper transcription factor (bZIP) gene.
Belyaev et al. (2005)	Lymphocytes from human subjects exposed to GSM 915 MHz RFR for 2 h ; SAR 0.037 W/kg;	Increased condensation of chromatin.
Belyaev et al. (2009)	Human lymphocytes exposed to UMTS cell phone signal (1947.4 MHz, 5 MHz band	Chromatin affected and inhibition of DNA double-strand break.

	width) for 1 h; SAR 0.04 W/kg	
Bourdineaud et al. (2017)	Eisenia fetida earthworms exposed to 900 MHz for 2 h; SAR 0.00013-0.00933 W/kg	DNA genotoxic effect and HSP70 gene expressions up regulated.
Campisi et al. (2010)	Rat neocortical astroglial to CW 900 MHz RFR for 5, 10, or 20 min; incident power density 0.0265 mW/cm^2	Significant increases in DNA fragmentation.
Chaturvedi et al. (2011)	Male mice exposed to 2450 MHz RFR, 2 h/day for 30 days; SAR 0.03561 W/kg	Increased DNA strand breaks in brain cells.
Deshmukh et al. (2013)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 30 days.	Increased DNA strand breaks in brain tissues.
Deshmukh et al. (2015)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 180 days.	Increased DNA strand breaks in brain tissues.
Deshmukh et al. (2016)	Male Fischer rats exposed to 900 MHz (0.0005953 W/kg), 1800 MHz (0.0005835 W/kg), and 2450 MHz (0.0006672 W/kg) RFR for 2 h/day, 5 days/week for 90 days.	Increased DNA strand breaks in brain tissues.
Eker et al. (2018)	Female Wistar albino rats exposed to 1800-MHz RFR for 2 h/day	Caspase-3 and p38MAPK gene expressions increased in eye tissues.

	for 8 weeks; SAR 0.06 W/kg	
Furtado-Filho et al. (2014)	Rats of different ages (0-30 days) exposed to 950 MHz RFR for 0.5 h/day for 51 days (21 days of gestation and 6-30 days old): SAR pregnant rat 0.01-0.03 W/kg; neonate 0.88 W/kg, 6-day old 0.51 W/kg, 15-day old 0.18 W/kg, 30-day old 0.06 W/kg.	Decreased DNA strand breaks in liver of 15-day old and increased breaks in 30-day old rats..
Gulati et al. (2016)	Blood and buccal cells of people lived close (<400 meters) to a cell tower; 1800 MHz, Maximum power density (at 150 meters) 0.00122 mW/cm^2, some subjects lived in the area for more than 9 yrs	Increased DNA strand breaks in lymphocytes and micronucleus in buccal cells.
Gürler (2014)	Wistar rats exposed to 2450 MHz RFR 1 h/day for 30 consecutive days; power density 0.0036 mW/cm^2	Increased oxidative DNA damage in brain and blood.
Hanci et al. (2013)	Pregnant rats exposed 1 h/day on days 13-21 of pregnancy to 900-MHz RFR at power density 0.0265 mW/cm^2.	Testicular tissue of 21-day old offspring showed increased DNA oxidative damage.
He et al. (2016)	Mouse bone marrow stromal cells exposed to 900 MHz RFR 3 h/day for 5 days; SAR 4.1 x 10^{-4} W/kg (peak), 2.5 x 10_{-4} W/kg (average)	Increased expression of PARP-1 mRNA
Hekmat et al. (2013)	Calf thymus exposed to 940 MHz RFR for	Altered DNA structure at 0 and 2 h after exposure.

	45 min; SAR 0.04 W/kg	
Keleş and Süt (2021)	Pregnant rats exposed to 900-MH RFR at 0.0265 mW/cm2; 1 h/day from E13.5 until birth; thoracis spine of offspring examined.	Down regulation of H3K27me3 gene, am epigenetic modification to the DNA packaging protein Histone H3 in motor nerons.
Kesari and Behari (2009)	Male Wistar rats exposed to 50 GHz RFR for 2 h/day for 45 days; SAR 0.0008 W/kg	Increased in brain tissue DNA strand.
Kumar R. et al. (2021)	Male Wistar rats exposed to 900, 100, 2450 MHz RFR at SARs of 5.84×10^{-4} W/kg, 5.94×10^{-4} W/kg and 6.4×10^{-4} W/kg respectively for 2 h per day for 1-month, 3-month and 6-month	Microwave exposure with increasing frequency and exposure duration brings significant ($p < 0.05$) epigenetic modulations which alters gene expression in the rat hippocampus. Global DNA methylation was decreased and histone methylation was increased.
Kumar S. et al. (2010)	Male Wistar rats exposed to 10-GHz RFR for 2 h a day for 45 days, SAR 0.014 W/kg	Increased micronucleus in blood cells.
Kumar S. et al. (2013)	Male Wistar rats exposed to 10 GHz RFR for 2 h a day for 45 days; SAR 0.014 W/kg	Increased micronucleus in blood cells and DNA strand breaks in spermatozoa.
Marinelli et al. (2004)	Acute T-lymphoblastoid leukemia cells exposed to 900 MHz RFR for 2-48 h, SAR 0.0035 W/kg	Increased DNA damage and activation of genes involved in pro-survival signaling.
Markova et al. (2005)	Human lymphocytes exposed to 905 and 915 MHz GSM signals for 1 h; SAR 0.037 W/kg	Affected chromatin conformation and 53BP1/gamma-H2AX foci
Markova et al. (2010)	Human diploid VH-10 fibroblasts and human	Inhibited tumor suppressor TP53 binding protein 1 (53BP1) foci

	adipose-tissue derived mesenchymal stem cells exposed to GSM (905 MHz or 915 MHz) or UMTS (1947.4 MHz, middle channel) RFR for 1, 2, or 3 hr; SAR 0.037-0.039 W/kg	that are typically formed at the sites of DNA double strand break location.
Megha et al. (2015a)	Fischer rats exposed to 900 and 1800 MHz RFR for 30 days (2 h/day, 5 days/week), SAR 0.00059 and 0.00058 W/kg	Reduced levels of neurotransmitters dopamine, norepinephrine, epinephrine, and serotonin, and downregulation of mRNA of tyrosine hydroxylase and tryptophan hydroxylase (synthesizing enzymes for the transmitters) in the hippocampus.
Megha et al. (2015b)	Fischer rats exposed to 900, 1800, and 2450 MHz RFR for 60 days (2 h/day, 5 days/week); SAR 0.00059, 0.00058, and 0.00066 W/kg	Increased DNA damage in the hippocampus
Nittby et al. (2008)	Fischer 344 rats exposed to 1800 MHz GSM RFR for 6 h; SAR whole body average 0.013 W/kg, head 0.03 W/kg	Expression in cortex and hippocampus of genes connected with membrane functions.
Odaci et al. (2016)	Pregnant Sprague - Dawley rats exposed to 900 MHz RFR 1 h each day during days 13 - 21 of pregnancy; whole body average SAR 0.024 W/kg	Testis and epididymis of offspring showed higher DNA oxidation.
Pandey et al. (2017)	Swiss albino mice exposed to 900-MHz RFR for 4 or 8 h per day for 35 days; SAR 0.0054-0.0516 W/kg	DNA strand breaks in germ cells.
Pesnya and Romanovsky (2013)	Onion (Allium cepa) exposed to GSM 900-MHz RFR from a cell	Increased the mitotic index, the frequency of mitotic and chromosome abnormalities, and

	phone for 1 h/day or 9 h/day for 3 days; incident power density 0.0005 mW/cm^2	the micronucleus frequency in an exposure-duration manner.
Phillips et al. (1998)	Human Molt-4 T-lymphoblastoid cells exposed to pulsed signals at cellular telephone frequencies of 813.5625 MHz (iDEN signal) and 836.55 MHz (TDMA signal) for 2or 21 h. SAR 0.0024 and 0.024 W/Kg for iDEN and 0.0026 and 0.026 W/kg for TDMA)	Changes in DNA strand breaks
Qin et al. (2018)	Male mice exposed to 1800-MHz RFR 2 h/day for 32 days, SAR 0.0553 W/kg	Inhibition of testosterone synthesis might be mediated through CaMKI/RORα signaling pathway.
Rammal et al. (2014)	Tomato exposed to a 1250-MHz RFR for 10 days at 0.0095 mW/cm^2	Increased expression of two wound-plant genes.
Roux et al. (2006)	Tomato plants exposed to a 900-MHz RFR for 2-10 min at 0.0066 mW/cm^2	Induction of stress gene expression.
Roux et al. (2008)	Tomato plants exposed to a 900-MHz RFR for 10 min at 0.0066 mW/cm^2	Induction of stress gene expression.
Sarimov et al. (2004)	Human lymphocytes exposed to GSM 895-915 MHz signals for 30 min; SAR 0.0054 W/kg	Condensation of chromatin was observed.
Shahin et al. (2013)	Female mice (Mus musculus) exposed to continuous-wave 2.45 GHz RFR 2 h/day for 45v days; SAR 0.023 W/kg	Increased DNA strand breaks in the brain.

Sun Y. et al. (2017)	Human HL-60 cells exposed to 900 Hz RFR 5 h/day for 5 days; peak and average 0.00041 and 0.00025 W/kg, respectively.	Increased oxidative DNA damage and decreased mitochondrial gene expression.
Tkalec et al. (2013)	Earthworm (Eisenia fetida) exposed to comtinupus-wave and AM-modulated 900-MHz RFR for 2 - 4 h; SAR 0.00013, 0.00035, 0.0011, and 0.00933 W/kg	Increased DNA strand breaks.
Tsybulin et al. (2013)	Japanese Quail embryos exposed in ovo to GSM 900 MHz signal from a cell phone intermittently (48 sec ON/12 sec OFF) during initial 38 h of brooding or for 158 h (120 h before brooding plus initial 38 h of brooding): SAR 0.000003 W/kg	The lower duration of exposure decreased DNA strand breaks, whereas higher duration resulted in a significant increase in DNA damage.
Vian et al. (2006)	Tomato plants exposed to a 900-MHz RFR for 10 min at 0.0066 mW/cm^2	Induction of mRNA encoding the stress-related bZIP transcription factor.
Yakymenko et al. (2018)	Quail embryos exposed to GSM 1800 GHz signal from a smart phone (48 s ON/12 s OFF) for5 days before and 14 days during incubation, power density 0.00032 mW/cm^2	Increased DNA strand breaks and oxidative DNA damage.
Zong et al. (2015)	Mice exposed to 900 MHz RFR 4 h/day for 7 days; SAR 0.05 W/kg	Attenuated bleomycin-induced DNA breaks and repair,

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<u>Table 1</u>

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Part 2. Supplement 2.
Genetic Effects at Low Intensity Static/ELF EMF Exposure

Static and ELF EMF Studies	magnetic flux density	Effects observed
Agliassa et al. (2018)	Arabidopsis thaliana (thale cress) exposed to 0.00004 mT static magnetic field for 38 days after sowing	Changes in gene expression in leaf and floral meristem.
Baek et al. (2019)	Mouse embryonic stem cells exposed to hypomagnetic field (<0.005 mT) up to 12 days	Induced abnormal DNA methylation.
Bagheri Hosseinabadi et al. (2020)	Blood samples from thermal power plant workers; mean levels of exposure to ELF magnetic and electric fields were 0.0165 mT (±6.46) and 22.5 V/m (±5.38), respectively.	DNA strand breaks .in lymphocytes.
Baraúna et al. (2015)	Chromobacterium violaceum bacteria cultures exposed to ELF-EMF for 7 h at 0.00066 mT	Five differentially expressed proteins detected including the DNA-binding stress protein.
Belyaev et al. (2005)	Human lymphocytes exposed to 50 Hz magnetic field at 0.015 mT (peak) for 2 h (measurements made at 24 and 48 h after exposure).	Induced chromatin conformation changes.
Dominici et al. (2011)	Lymphocytes from welders (average magnetic field exposure from personal dosimeters 0.00781 mT (general environmental level 0.00003 mT)	Higher micronucleus frequency correlated with EMF exposure levels; decreased in sister chromatid exchange frequency.

Heredia-Rojas et al. (2010)	Human non-small cell lung cancer cells (INER-37) and mouse lymphoma cells (RMA E7) (transfected with a plasmid with hsp70 expression when exposed to magnetic field and contains the reporter for the luciferases gene) exposed to a 60-Hz magnetic field at 0.008 and 0.00008 mT for 20 min.	An increased in luciferase gene expression was observed in INER-37 cells.
Liboff et al. (1984)	Human fibroblasts dring the middle of S phaseexposed to 15 Hz-4 kHz sinusoidal MF	Enhanced DNA synthesis at between 5-25 μT
Sarimov et al. (2011)	Human lymphocytes exposed to 50-Hz magnetic field at 0.005-0.02 mT for 15-180 min	Magnetic field condensed relaxed chromatin and relaxed condensed chromatin.
Villarini et al. (2015)	Blood leukocytes from electric arc welders presumably exposed to 50-Hz EMF (mean 0.0078 mT; range: 0.00003-0.171 mT)	Decreased DNA strand beaks.
Wahab et al. (2007)	Human peripheral blood lymphocytes exposed to 50 Hz sinusoidal (continuous or pulsed) or square (continuous or pulsed) magnetic fields at 0.001 or 1 mT for 72 h.	Increase in the number of sister chromatid exchange/cell
Zendehdel et al. (2019)	Peripheral blood cells of male power line workers in a power plant. The median value of the magnetic	Increased in DNA strand breaks.

	field at the working sites was 0.00085 mT.	

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Part 2. Supplement 3
Biological Effects in Animals and Plants Exposed to Low-Intensity RFR

		SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Aitken et al. (2005)	Mice exposed to 900 MHz RFR, 12/day. 7 days	0.09		Genotoxic effect in sperm.
Akdag et al. (2016)	Rats exposed to 2400 MHz RFR from a Wi-Fi signal generator for a year	0.000141 (min)- 0.007127 (max)		DNA damage in testes.
Alimohammadi et al. (2018)	pregnant mice exposed to 915 MHz RFR; 8h/day, 10 days.		0.045	Offspring had increased fetal weight, enlarged liver and tail deformation
Alkis et al. (2019a)	Rtas exposed to 900; 1800; and 2100 MHz RFR; 2 h/day. 6 months	Brain SAR: 900 MHz - 0.0845; 1800 MHz- 0.04563; 210 MHz- 0.03957		DNA single strand break and oxidative damages in frontal lobe.
Alkis et al. (2019b)	Rats exposed to 900; 1800; and 2100 MHz RFR; 2 h/day. 6 months	maximum SAR over the rat body 0.017		DNA strand beaks and oxidative DNA damage in testicular tissue.
Atasoy et al. (2013)	Rats exposed to 2437 MHz (Wi-Fi) RFR; 24 h/day for 20 weeks	maximum SAR 0.091		Oxidative DNA damage in blood and testes.

Balmori et al. (2010)	Frog (Rana temporaria) exposed to 88.5 – 1873.6 MHz, cell phone base station emissions; 2 months from egg phase to tadpole		0.859-3.25 (1.5-3.8 V/m)	Retarded development and increased mortality rate.
Balmori et al (2015)	White stocks lived within 200 m of a Phone mast, GSM-900 MHz and DCS-1800 MHz signals		1.48	Affected reproduction rate.
Bartos et al. (2019)	Cockroach exposed to broadband RF noise		429 nT	Light-dependent slowing of circadian rhythm.
Beaubois et al. (2007)	Tomato plant exposed to 900-MHz RFR for 10 min		6.6	Increased expression of leucine-zipper transcription factor (bZIP) gene in leaves.
Bedir et al. (2018)	Rat exposed to 2100 MHz RFR, 6 or 19 h/day, 30 days	0.024		Oxidative stress-mediated renal injury.
Belyaev et al. (1992)	E. coli exposed to 51.62-51.84 and 41.25-41.50 GHz RFR, 5-15 min		1	Suppressed radiation-induced repair of genome conformation state.
Belyaev et al. (2005)	915 MHz GSM signal, 24 & 48 hr	0.037		Genetic changes in human white blood cells
Belyaev et al. (2009)	915 MHz, 1947 MHz; GSM, UMTS signals 24 & 72 hr	0.037		DNA repair mechanism in human white blood cells
Bourdineaud et al. (2017)	Earthworm (Eisenia fetida) exposed to 900 MHz RFR, 2 hr	0.00013-0.009		DNA modification.

Burlaka et al. (2013)	Japanese quail embryos exposed to GSM 900 MHz RFR; 158-360 hr		0.25	Oxidative DNA damage and free radical formation
Capri et al. (2004)	900 MHz, GSM signal, 1 hr/day, 3 days	0.07		Cell proliferation and membrane chemistry
Cammaerts and Johansson (2015)	Brassicaceae lepidium sativum (cress d'alinois) seed exposed to 900 and 1800 MHz RFR, 4, 7, and 10 days		0.007-0.01	Defect in germination.
Cammaerts et al. (2013)	Ants exposed to GSM signal for 180 h		0.1572	Affected food collection and response to pheromones.
Cammaerts et al. (2014)	Ants exposed to GSM signal for 10 min		0.5968	Affected social behavior.
Campisi et al. (2010)	Rat neocortical astroglial cells exposed to 50-Hz modulated 900 Mhz RFR, 5-20 min		26	Free radical production and DNA fragmentation.
Czerwinski et al. (2020)	Plant community exposed to cell phone base station radiation		0.01-0.1	Biological effects observed.
Chaturvedi et al. (2011)	Rat brain cells exposed to 2450 MHz RFR, 2 h/day for 30 days	0.03561		Increased DNA strand breaks.
Comelekoglu et al. (2018)	Rat sciatic nerve exposed to 1800 MHz RFR, 1 hr/day, 4 weeks	0.00421		Changes in electrical activity, increased catalase, and degeneration of myelinated fibers.

De Pomerai et al. (2003)	Protein exposed to 1 GHz RFR, 24 & 48 hr	0.015		Protein damages
Deshmukh et al. (2013)	Rats exposed to 900, 1800, and 2450 MHz RFR ; 30 days	0.0006-0.0007		DNA strand breaks in brain.
Deshmukh et al. (2015)	Rats exposed to 900, 1800, and 2450 MHz RFR; 180 days	0.0006-0.0007		Declined cognitive functions, increased brain HSP70 and DNA strand break.
Deshmukh et al. (2016)	Rats exposed 900, 1800, and 2450 MHz; 90 days	0.0006-0.0007		Declined cognitive functions, increased brain HSP70 and DNA strand break in rats
Dutta et al. (1984)	human neuroblastoma cells exposed to 915 MHz RFR, sinusoidal AM at 16 Hz	0.05		Increase in calcium efflux.
Dutta et al. (1994)	Escherichia coli cultures containing a plasmid with a mammalian gene for enolase were exposed for 30 min to 147 MHz RFR AM at16 or 60 Hz	0.05		Enolase activity in exposed cultures RFR at AM at 16 Hz showed enhanced activity enhanced, and AM at 60 Hz showed reduced activity. (Modulation frequencies. 16 and 60 Hz, caused similar effects.)
Eker et al. (2018)	Rats exposed to 1800 MHz RFR, 2 hr/day for 8 weeks	0.06		Increased caspase-3 and p38MAPK expressions in eye.
Fesenko et al. (1999)	Mice exposed to 8.15 – 18 GHz RFR, 5 hr to 7 days, direction of response depended on exposure duration		1	Changes in immunological functions.

Forgacs et al. (2006)	Mice exposed to 1800 MHz RFR, GSM- 217 Hz pulses, 576 µs pulse width; 2 hr/day, 10 days	0.018		Increase in serum testosterone.
Frątczak et al. (2020)	Ticks exposed to 900 MHz RFR		0.1	Ticks attracted to the RFR, particularly those infected with Rickettsia (spotted fever).
Friedman et al. (2007)	Rat and human cells exposed to 875 MHz RFR, 30 min		5	Activation of signaling pathways.
Furtado-Filho et al. (2014)	Pregnant rats exposed to 950 MHz RFR for 0.5 h/day for 51 days (21 days of gestation and 6-30 days old)	SAR pregnant rat 0.01-0.03 W/kg; neonate 0.88 W/kg, 6-day old 0.51 W/kg, 15-day old 0.18 W/kg, 30-day old 0.06 W/kg		Decreased DNA strand breaks in liver of 15-day old and increased breaks in 30-day old offspring.
Gandhi et al. (2015)	People who lived within 300 m of a mobile-phone base station.		1.15	Increased DNA damage in lymphocytes, more in female than in male subjects.
Garaj-Vrhovac et al. (2011)	Operators of two types of marine radars (3, 9.4, and 5.5 GHz); average time on job 2-16 yrs	0.0005-0.004 (time averaged)		Increased genetic damages in blood lymphocytes

Gremiaux et al. (2016)	Rose exposed to 900 MHz RFR, 3x 39min every 48 h at 2 stages of development	0.00072		Delayed and reduced growth.
Gulati et al. (2016)	People lived close (<400 meters) to a cell tower; 1800 MHz, , some subjects lived in the area for more than 9 yrs		Maximum power density (at 150 meters) 1.22	Increased DNA strand breaks in lymphocytes and micronucleus in buccal cells.
Gulati et al. (2020)	DNA damage in human lymphocytes	Cells exposed to UMTS signals at different frequency channels used by 3 G mobile phone (1923, 1947.47, and 1977 MHz) for 1 or 3 h; SAR 0.04 W/kg		DNA damage found only in cells exposed to 1977-MHz field.
Gupta et al. (2018)	Rtas exposed to 2450 MHz RFR; 1h/day 28 days	0.0616		Cognitive deficit, loss of mitochondrial functions, activation of apoptotic factors in hippocampus; affected cholinergic system.
Gurler et al. (2014)	Rats exposed to 2.45 GHz RFR, 1 h/day, 30 days		3.59	Increased DNA damage in brain.

Halgamuge et al. (2015)	Growth parameters of soybean seedlings	GSM 217 Hz-modulated (4.8 x 10^{-7}, 4.9 x 10^{-5}, and 0.0026 W/kg) SAR or CW (0.00039 and 0.02 W/kg) 900-MHz RFR for 2 h		Modulated and CW fields produced different patterns of growth effects. There was an amplitude effect and extremely low-level modulated field (4.8 x 10^{-7} W/kg) affected all parameters.
Hanci et al. (2013)	Pregnant rats exposed 1 h/day on days 13-21 of pregnancy to 900-MHz RFR		26.5	Testicular tissue of 21-day old offspring showed increased DNA oxidative damage.
Hanci et al. (2018)	Rats exposed to 900 MHz RFR, 1 h/day to postnatal day 60.	0.0067		Changes in morphology and increase in oxidative stress marker in testis.
Hassig et al. (2014)	Cows exposed to 916.5 MHz signal similar to GSM base station, 30 days 16 h 43 min per day		38.2	Changes in redox enzymes (SOD. CAT, GSH-px
He et al. (2016)	Mouse bone marrow stromal cells exposed to 900 MHz RFR 3 h/day for 5 days	2.5 x 10^{-4}		Increased expression of PARP-1 mRNA
Hekmat et al. (2013)	Calf thymus exposed to 940 MHz RFR, 45 min	0.04		Conformational changes in DNA.

Ivaschuk et al. (1997)	Nerve growth factor-treated PC12 rat pheochromocytoma cells 836.55 MHz TDMA signal, 20 min	0.026		Transcript levels for c-jun altered.
Ji et al. (2016)	Mouse bone-marrow stromal cells exposed to 900 MHz RFR, 4 hr/day for 5 days		120	Faster kinetics of DNA-strand break repair.
Keleş et al. (2019)	Rats exposed tp 900 MHz RFR; 1h/day, 25days	0.012		Higher number of pyramidal and granule neurons in hippocampus.
Kesari and Behari (2009)	Rats exposed to 50 GHz RFR; 2hr/day, 45 days	0.0008		Double strand DNA breaks observed in brain cells
Kesari and Behari (2010)	Rats exposed to 50 GHz RFR; 2 hr/day, 45 days	0.0008		Changes in oxidative processes and apoptosis in reproductive system.
Kesari et al. (2010)	Rats exposed to 2450 MHz RFR at 50-Hz modulation, 2 hr/day, 35 days	0.11		DNA double strand breaks in brain cells
Kumar et al. (2010a)	Rats exposed to 10 GHz RFR, 2h/day 45 days	0.014		Cellular changes and increase in reactive oxygen species in testes
Kumar et al. (2010b)	Rats exposed to 10 GHz RFR, 2 h/day, 45 days; or 50 GHz, 2h/day, 45 days	0.014 (10 GHz) 0.0008 (50 GHz)		Genetic damages in blood cells.

Kumar et al. (2013)	Rats exposed to 10 GHz RFR for 2 h a day for 45 days	0.014		Increased micronucleus in blood cells and DNA strand breaks in spermatozoa.
Kumar et al. (2015)	maize seedlings exposed to 1899 MHz RFR, 0.5-4 h		33.2	Retarded growth and decreased chlorophyll content.
Kumar et al. (2021)	Epigenetic modulation in the hippocampus of Wistar rats	Rats exposed to 900 MHz, 1800 MHz, and 2450 MHz RFR at a specific absorption rate (SAR) of 5.84×10^{-4} W/kg, 5.94×10^{-4} W/kg and 6.4×10^{-4} W/kg respectively for 2 h per day for 1-month, 3-month and 6-month periods.		Significant epigenetic modulations were observed in the hippocampus, larger changes with increasing frequency and exposure duration.
Kwee et al. (2001)	Transformed human epithelial amnion cells exposed to 960 MHz GSM signal, 20 min	0.0021		Increased Hsp-70 stress protein.
Landler et al. (2015)	Juvenile snapping turtle (c. serpentina) exposed to 1.43 MHz RFR, 20 min		20-52 nT	Disrupted magnetic orientation.

Lazaro et al. (2016)	50, 100, 200, 400 m from ten mobile telecommunication antennas		0.0000265 - 0.106	Distance-dependent effects on abundance and composition of wild insect pollinators
Lerchl et al. (2008)	383 MHz (TETRA), 900 and 1800 MHz (GSM) 24 hr/day, 60 days	0.08		Metabolic changes in hamster.
López-Martín et al. (2009)	Pulse-modulated GSM and unmodulated signals; 2 hr	0.03-0.26		c-Fos expression in brain of picotoxin-induced seizure-prone rats
Magras and Xenos (1997)	Mice in 'antenna park'-TV and FM-radio, exposure over several generations		0.168	Decrease in reproductive functions.
Marinelli et al. (2004)	Human leukemia cell exposed to 900 MHz CW RFR 2 - 48 hr	0.0035		Cell's self-defense responses triggered by DNA damage.
Makova et al. (2005)	human white blood cells exposed to 915 and 905 MHz GSM signal, 1 hr	0.037		Altered chromatin conformation.
Markova et al. (2010)	in human diploid VH-10 fibroblasts and human adipose-tissue derived mesenchymal stem cells exposed to GSM (905 MHz or 915 MHz) or UMTS (1947.4 MHz, middle channel) RFR for 1, 2, or 3 hr;	0.037-0.039		Inhibited tumor suppressor TP53 binding protein 1 (53BP1) foci that are typically formed at the sites of DNA double strand break location.

Megha et al. (2015a)	Rats exposed to 900 and 1800 MHz RFR for 30 days (2 h/day, 5 days/week)	0.00059 and 0.00058		Reduced levels of neurotransmitters dopamine, norepinephrine, epinephrine, and serotonin, and downregulation of mRNA of tyrosine hydroxylase and tryptophan hydroxylase (synthesizing enzymes for the transmitters) in the hippocampus.
Megha et al. (2015b)	Rats exposed to 900, 1800, and 2450 MHz RFR for 60 days (2 h/day, 5 days/week)	0.00059, 0.00058, and 0.00066		Increased DNA damage in the hippocampus.
Monselise et al. (2011)	Etiolated duckweed exposed to AM 1.287 MHz signal form transmitting antenna		0.859 (1,8-7.8 V/m)	Increased alanine accumulation in cells.
Navakatikian and Tomashevskaya (1994)	Rats exposed to 2450 MHz CW and 3000 MHz pulse-modulated 2 μs pulses at 400 Hz, Single (0.5-12 hr) or repeated (15-60 days, 7-12 hr/day)	0.0027		Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin. CW-no effect
Nittby et al. (2007)	Rats exposed to 900 MHz GSM signal, 2 hr/wk, 55wk	0.0006		Reduced memory functions.
Nittby et al. (2008)	Rats exposed to 915 MHz GSM signal, 6 hr	0.013 (whole body average); 0.03 (head)		Altered gene expression in cortex and hippocampus.

Novoselova et al. (1999)	Mice exposed to RFR from 8.15 -18 GHz, 1 sec sweep time-16 ms reverse, 5 hr		1	Changes in Functions of the immune system.
Novoselova et al. (2004)	Mice exposed to RFR from 8.15 -18 GHz, 1 sec sweep time-16 ms reverse, 1.5 hr/day, 30 days		1	Decreased tumor growth rate and enhanced survival.
Novoselova et al. (2017)	Mice exposed to 8.15 -18 GHz RFR, 1 Hz swinging frequency, 1 hr		1	Enhanced plasma cytokine.
Odaci et al. (2016)	Pregnant Sprague - Dawley rats exposed to 900 MHz RFR 1 h each day during days 13 - 21 of pregnancy	0.024		Testis and epididymis of offspring showed higher DNA oxidation.
Özsobacı et al. (2020)	Human kidney embryonic cells (HEK293) exposed to 3450 MHz RFR, 1 h		1.06	Changed oxidative enzyme activity and increased apoptosis.
Panagopoulos and Margaritis. (2010a)	Flies exposed to GSM 900 and 1800 MHz RFR, 6 min/day, 5 days		10	'Window' effect of GSM radiation on reproductive capacity and cell death.
Panagopoulos and Margaritis. (2010b)	Flies exposed to GSM 900 and 1800 MHz RFR, 1- 21 min/day, 5 days		10	Reproductive capacity of the fly decreased linearly with increased duration of exposure.
Panagopoulos et al. (2010)	Flies exposed GSM 900 and 1800 MHz RFR, 6 min/day, 5 days		1-10	Affected reproductive capacity and induced cell death.
Pandey et al. (2017)	Mice exposed to 900-MHz RFR for	0.0054-0.0516		DNA strand breaks in germ cells.

	4 or 8 h per day for 35 days			
Pavicic et al. (2008)	Chinese hamster V79 cells exposed to 864 and 935 MHz CW RFR, 1-3 hrs	0.08		Cell growth affected.
Perov et al. (2019)	Rats exposed to 171 MHz CW RFR, 6h/day, 15 days	0.006		Stimulation of adrenal gland activity.
Persson et al. (1997)	Rats exposed to 915 MHz RFR -CW and pulse-modulated (217-Hz, 0.57 ms; 50-Hz, 6.6 ms) 2-960 min.	0.0004		Increase in permeability of the blood-brain barrier. CW more potent.
Pesnya and Romanovsky (2013)	Onion exposed to GSM 900-MHz RFR from a cell phone for 1 h/day or 9 h/day for 3 days.		0.5	Increased mitotic index, frequency of mitotic and chromosome abnormalities, and micronucleus frequency.
Phillips et al. (1998)	Human leukemia cells exposed to 813.5625 MHz (iDEN); 836.55 MHz (TDMA) signals, 2 hr and 21 hr	0.0024		DNA damage observed.
Piccinetti et al. (2018)	Zebrafish exposed to 100 MHz RFR, 24-72 h post-fertilization	0.08		Retarded embroyonic development.
Postaci et al. (2018)	Rats exposed to 2600 MHz RFR, 1 h/day, 30 days	0.011		Cellular damages and oxidative damages in liver.

Pyrpasopoulou et al. (2004)	Rats exposed to 9.4 GHz GSM (50 Hz pulses, 20 μs pulse length) signal, 1-7 days postcoitum	0.0005		Exposure during early gestation affected kidney development.
Qin et al. (2018)	Mice exposed to 1800-MHz RFR, 2 h/day for 32 days	0.0553		Inhibition of testosterone synthesis.
Rafati et al. (2015)	Frog gastroenemius muscle exposed to cell phone jammers; 1 m away, 3x 10 min periods	For different jammers:0.01-0.05		Latency of contraction of prolonged.
Ranmal et al. (2014)	Tomato exposed to 1250-MHz RFR for 10 days.		9.5	Increased expression of two wound-plant genes.
Roux et al. (2006)	Tomatoes exposed to 900-MHz RFR for 2-10 min		6.6	Induction of stress gene expression in tomato.
Roux et al. (2008a)	Tomatoes exposed to 900 MHz RFR		6.6	Changes in Gene expression and energy metabolism.
Roux et al. (2008b)	Tomato plants exposed to 900 MHz RFR (>30 min)		6.6	Changes in energy metabolism in leave of tomato plant.
Salford et al. (2003)	Rats exposed to 915 MHz GSM, 2 hr	0.02		Nerve cell damage in brain.
Sarimov et al. (2004)	Human lymphocytes exposed to 895-915 MHz GSM signal, 30 min	0.0054		Chromatin affected similar to stress response.

Schwarz et al. (2008)	Human fibroblasts exposed to 1950 MHz UMTS signal, 24 hr	0.05		Changes in genes.
Shahin et al. (2013)	Mice exposed to 2450 MHz RFR, 2 h/day for 45 days	0.023		Increased DNA strand breaks in the brain.
Singh et al. (2012)	Hung beans exposed to 900 MHz RFR, 0.5-2 h		8.54	Reduced root length and number of roots per hypocotyls.
Sirav and Seyhan (2011)	Rats exposed to CW 900 MHz or 1800 MHz for 20 min	CW 900 MHz (0.00426 W/kg) or 1800 MHz (0.00146 W/kg)		Increased blood-brain barrier permeability in male rats, no significant effect on female rats.
Sirav and Seyhan (2016)	Rats exposed to pulsed-modulated (217 Hz, 517 µs width) 900 MHz or 1800 MHz 6 RFR for 20 min	0.02		In male rats, both frequencies increased blood-brain barrier permeability, 1800 MHz is more effective than 900 MHz; in female rats, only 900 MHz filed caused an effect.
Somosz et al. (1991)	Rat embryo 3T3 cells exposed to 2450-MHz 16-Hz square modulated RFR	0.024		Increased the ruffling activity of the cells, and caused ultrastructural alteration in the cytoplasm. CW was less effective.
Soran et al. (2014)	Plants exposed to GSM and WLAN signals		10 (GSM) 7 (WLAN)	Enhanced release of terpene from aromatic plants; essential oil contents in leaves enhanced by GSM radiation but reduced by WLAN radiation in some plants.

Stagg et al. (1997)	Glioma cells exposed to 836.55 MHz TDMA signal, duty cycle 33%, 24 hr	0.0059		Glioma cells showed significant increases in thymidine incorporation, which may be an indication of an increase in cell division.
Stankiewicz et al. (2006)	Human white blood cells exposed to 900 MHz GSM signal, 217 Hz pulses-.577 ms width, 15 min	0.024		Immune activities of human white blood cells affected.
Sun Y. et al. (2017)	Human HL-60 cells exposed to 900 Hz RFR, 5 h/day for 5 days	peak and average SAR 4.1 x 10^{-4} and 2.5 x 10^{-4} W/kg		Increased oxidative DNA damage and decreased mitochondrial gene expression.
Szymanski et al. (2020)	Human cells exposed to Pulse-modulated 900 MHz RFR, two 15-min exposure	0.024		Human blood mononucleus cells demonstrated high immunological activity of monocytes and T-cell response to concanavalin A.
Tkalec et al. (2013)	Earthorm exposed to continuous-wave and AM-modulated 900- MHz RFR for 2 - 4 h	0.00013, 0.00035, 0.0011, and 0.00933		Increased DNA strand breaks.
Tsybulin et al. (2012)	Japanese Quail embryos exposed to GSM 900 MHz signal during first 38 h or 14 days of fertilization		0.2	Enhanced development and survival in Japanese Quail embryos probably via a free radical-induced mechanism.
Tsybulin et al. (2013)	Japanese Quail embryos exposed to GSM 900 MHz signal, 48 sec on/12 sec off; 38 or 158 h	0.003		Decreased DNA strand break at 38 h and increased in 158h exposure in cells.

Vargová et al. (2017)	Ticks exposed to 900 MHz RFR		0.07	Ticks showed greater movement activity, with jerking movement of whole body or first pair of legs.
Vargová et al. (2018)	Ticks exposed to 900 MHz and 5000 MHz RFR		0.105	In a tube with half shielded for RFR, ticks exposed to 900 MHz concentrated on exposed side, and escaped to shielded side when exposed to 5000 MHz
Velizarov et al. (1999)	Human epithelial amnion cells exposed to 960 MHz GSM signal, 217 Hz square-pulse, duty cycle 12%, 30 min	0.000021		Decreased proliferation
Veyret et al. (1991)	Exposure to 9.4 GHz 1 μs pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM modulation, direction of response depended on AM frequency	0.015		Changes in functions of the mouse immune system.
Vian et al. (2006)	Tomato plants exposed to 900 MHz RFR		6.6	Stress gene expression in plant.

Vilić et al. (2017)	Oxidative effects and DNA damage in honey bee (Apis mellifera) larvae		Honey bee larvae were exposed to 900-MHz at unmodulated field at 27 $\mu W/cm^2$ and modulated (80% AM 1 kHz sinusoidal) field at 140 $\mu W/cm^2$, for 2 hr.	Oxidative effect with exposure to unmodulated field. DNA damage increased after exposure to modulated field.
Waldmann-Salsam et al. (2016)	Mobile phone mast, long-term exposure		>0.005	Damages to trees
Wolke et al. (1996)	Heart muscle cells of guinea pig exposed to 900, 1300, 1800 MHz, square-wave modulated at 217 Hz; Also 900 MHz with CW, 16 Hz, 50 Hz and 30 KHz modulations	0.001		Changed calcium concentration in heart muscle cells.
Yakymenko et al. (2018)	Quail embryos exposed to GSM 1800 GHz signal from a smart phone (48 s ON/12 s OFF) for5 days before and 14 days during incubation		0.32	Increased DNA strand breaks and oxidative DNA damage.

Yurekli et al. (2006)	945 MHz GSM, 217 Hz pulse-modulation 7 hr/day, 8 days	0.0113		Free radical chemistry.
Zong et al. (2015)	Mice exposed to 900 MHz RFR, 4 h/day for 7 days	0.05		Attenuated bleomycin-induced DNA breaks and repair.

Author Note: *Many of the biological studies are acute, mostly one-time, exposure experiments, whereas exposure to ambient environmental man-made EMF is chronic. Acute and chronic exposures will likely end up with different consequences. Living organisms can compensate for the effect at the beginning of exposure and growth promotion in plants could be a result of over-compensation. After prolonged exposure, a breakdown of the system could occur, leading to detrimental effects. This sequence of response is basically how a living organism responds to stressors. The timeline of response depends on the physiology of an organism and also the intensity of exposure*

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Supplement 4. Effects of EMF on plant growth

	Experimental conditions	Results
STATIC MAGNETIC FIELD		
Abdani Nasiri et al.(2018)	medicinal sage;15-30 mT, 5 min	enhanced growth
Baghel et al. (2016)	soybean; 200 mT, 1h,	increased growth
Bahadir et al. (2018)	sweet pea ; 125 mT, 24-72 h	promoted germination
Bhardwaj et al. (2012)	cucumber; 100-250 mT, 1-3 h	increased germination rate, length of seedling and dry weight
Ćirković et al. (2017)	wheat ; 340 mT, 16 h	increased growth rate
Florez et al. (2007)	maize;125 and 250 mT, 1 min to 10 days	increased growth rate
Jovičić-Petrović et al. (2021)	White mustard seed, 90 mT, 5 or 15 min	suppressed germination, but synergistic with a plant growth-promoting bacterial strain Bacillus amyloliquefaciens D5 ARV
Kataria et al. (2020)	soybean; 200 mT, 1 h	stimulated germination and promoted growth
Kim et al. (2016)	agricultural plants ; 130-250 mT, 4 days	increased stem and root lengths
Patel et al. (2017)	maize; 200 mT, 1 h	enhanced germination
Payez et al. (2013)	wheat; 30 mT, 4 days	promoted growth
Razmioo andAlinian (2017)	Cumin seed; 150, 250 500 mT or 1T for min	improved germination, growth and oil and essential contents
Shabrangy et al. (2021)	barley seeds, 7 mT, 1,3, or 6 h	Improved seed germination rate, root and shoot lengths, and biomass weight
Vashisth and Joshi (2017)	maize; 50-250 mT, 1-4 h	enhanced seed growth
Vashisth and Nagarajan (2008)	chickpea; 0-250 mT, 1-4 h	increased speed of germination, seedling length and dry weight
Xu et al. (2013)	rock cress, removal of the local geomagnetic field (~45 μT)	suppressed growth
PULSED MAGNETIC FIELD		

Bhardwaj et al. (2016)	green pea; 100 mT, 1 h, 6-min on/off	enhanced germination and growth
Bilalis et al. (2012)	corn; 3 Hz; 12.5 nT, 1 x 10^{-6} wave duration, 0-15 min	promoted plant growth and yield
Efthimiadou et al. (2014)	tomato; 3 Hz, 12.5 mT, 1 x 10^{-6} s duration, 0-15 min	enhanced plant growth
Radhakrishnan et al. (2012a)	soybean; 1 Hz, 1.5 µT, 5 h/day for 20 days	improved plant growth
Radhakrishnan et al. (2012b)	soybean; 10 Hz, 1.5 µT, 5 h/day for 20 days	improved plant growth
ELF MAGNET FIELD		
De Souza et al. (2008)	lettuce; 60-Hz, 120-160 mT, 1-5 min	enhanced growth and final yield
Fischer et al. (2004)	sunflower and wheat; 16.67 Hz; 20 µT, 12 days	increased fresh and dry weights and growth rate
Huang and Wang (2008)	Mung bean; 10-60 Hz modulated, 12 h, 6.38-16.20 µT	20 and 60 Hz, enhanced growth; 30, 40 and 50 Hz inhibited growth
Leelapriya et al. (2003)	cotton;10 Hz, 0.1 mT, 5 h/day for 20 days	enhanced germination
Naz et al. (2012)	okra; 50 Hz, 99 mT, 3 and 11 min	increased germination
Novitskii et al. (2014)	radish; 50 Hz, 500 µT,5 days	stimulated lipid formation
Shine et al. (2011)	soybean; 50 Hz, 0-300 mT, 30-90 min	improved germination parameters and biomass
Yano et al. (2004)	radish; 60 Hz, 50 µT plus a parallel 48-µT static magnetic field, 10-15 days	decreased CO_2 uptake , fresh and dry weights and leaf area
RFR		
Cammaerts and Johansson (2015)	Garden cress; 900 and 1800 MHz, 0.007-0.01 µW/cm^2, 10 days	decreased germination
Grémiaux et al. (2016)	rose, 900 MHz, 0.00072 W/kg, 3 hr once or 3 times, every 48 hr	delayed and reduced growth
Halgamuge et al. (2015)	Soybean seedling. 900 MHz GSM pulsed or CW, 0.45 mW/cm^2, 2 h	GSM radiation reduced outgrowth of epicotyls; CW exposure reduced outgrowth of roots and hypocotyls.
Kumar et al. (2015)	maize;1800 MHz, 0.5-4 h, 33.2 µW/cm^2	retarded growth and reduced chlorophyll content

Mildažienė et al. (2019)	sunflower seed; 5.28 MHz, 5, 10, 15 min 0.74 mT	changes in phytohormone balance, development and leaf protein expression
Payez et al. (2013)	wheat; 10 KHz, 4 days, 25 mW/cm^2	reduced water intake, increased speed of growth, reduced seeding vigor index I
Senavirathna et al. (2014)	Parrot feather (Myriophyllum aquaticum), 2000 MHz, 0.142 mW/cm^2, 1 h	Reduction in growth
Singh et al. (2012)	Mung bean; 900 MHz, 8.54 μW/cm^2, 0.5-2 h	reduced root length and number of roots per hypocotyls
Tkalec et al. (2009)	Onion; 400 and 900 MHz, 2h, 446 μW/cm^2	induced mitotic aberrations due to impairment of the mitotic spindle

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To Whom It May Concern:

Dear Sirs/Madams:

I am Scientist Emeritus and Former Director of the National Institute of Environmental Health Sciences and National Toxicology Program of the National Institutes of Health. I am currently a Scholar in Residence at the Nicholas School of the Environment at Duke University.

Wireless networks, cell towers and cell phones create radiofrequency radiation emissions. U.S. FCC limits for human exposure to radiofrequency were last reviewed in 1996 and based on the assumption that heating is the only harmful effect. Aware that the FCC's 1996 limits lacked the underpinning of solid scientific data regarding long term health effects, the FDA requested large-scale studies by the National Toxicology Program (NTP) and in 2018 the NTP studies found clear evidence of an association with cancer in male rats. Additionally, the NTP found heart damage and DNA damage, despite the fact that the animals were carefully exposed to non-heating RFR levels long assumed to be safe. The Ramazzini Institute animal studies used even lower RFR lower exposures to approximate cell tower emissions and also found increases of the same tumor type. The NTP studies were carefully controlled to ensure exposures did not significantly heat the animals. The animal study findings in combination with human studies indicate adverse effects from non heating levels of radiofrequency.

I document the importance of the NTP findings of effects from non thermal exposures in my declaration in an Amicus Brief for the case Environmental Health Trust et al v. the FCC. The August 13, 2021 judgment ordered the FCC to address several issues including the health implications of long term exposures.

A mounting body of published studies associates radiofrequency radiation with adverse negative health effects. FCC limits need to be strengthened to protect the public, especially children and vulnerable populations, from long term exposures.

Linda S. Birnbaum, PhD
Scientist Emeritus and Former Director
National Institute of Environmental Health Sciences and National Toxicology Program
Scholar in Residence, Duke University, Former President, Society of Toxicology
Adjunct Professor, Yale University and UNC, Chapel Hill, Visiting Professor, Queensland University (Australia)

National Toxicology Program Radiofrequency Radiation
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Massachusetts Joint Committee on Consumer Protection
Massachusetts Joint Committee on Advanced Information Technology, the Internet and Cybersecurity Committee
24 Beacon St. Room 506
Boston, MA 02133

Subject: In Support of Technology Safety Bills S. 186, S. 187, H. 115, H. 105-114

Dear Esteemed Legislators,

I am writing in support of legislation that which reduces RFR exposure, especially for children who are more vulnerable.

I am Professor Emeritus of Pediatrics and of Environmental & Occupational Health George Washington University School of Medicine and Health Sciences and George Washington University Milken Institute School of Public Health. I am also past chair of the Council on Environmental Health of the American Academy of Pediatrics, and also served on the Children's Health Protection Advisory Committee for the US EPA.

We assume that our federal health and environmental agencies regularly review the latest research and ensure that cell phones and wireless devices are safe. However, U.S. agencies which regulate cell phone radiation have not shown they have evaluated the research on children's unique vulnerability to ensure long term safety.

The reality is that US safety regulations for cell phone radiation were last set twenty-five years ago based on science that is now outdated. The Federal Communications Commission (FCC) is the primary agency responsible for regulating wireless radiation. The FCC has no expertise related to human health topics. Moreover, federal agencies like the Environmental Protection Agency or the National Cancer Institute or the Food and Drug Administration have not carried out up-to-date full scientific review of this growing technology. Just like the thousands of chemicals in our environment today, wireless radiation has not had appropriate oversight. It has slipped through the cracks.

The one agency which has carried out studies on the impact of long term exposure to electromagnetic fields and human health is the National Toxicology Program (NTP), a component of the National Institute of Environmental Health Sciences. The NTP found:

- **Clear evidence of an association with tumors in the hearts of male rats.** The tumors were malignant schwannomas.
- **Some evidence of an association with tumors in the brains of male rats.** The tumors were malignant gliomas.
- **Some evidence of an association with tumors in the adrenal glands of male rats.** The tumors were benign, malignant, or complex combined pheochromocytoma.

Pediatricians have long called for an update to this outdated cell phone radiation test method because research finds children can absorb up to 10 or more times higher wireless radiation than adults into their brain, eyes and bone marrow. Children are not little adults. As we sadly learned with early childhood lead exposures leaving long-lasting impairments, the developing brain is particularly susceptible. Unlike my generation, today's youth will be exposed for years and years.

Please support legislation that reduces children's radiofrequency radiation exposure and call on the federal government to strengthen human exposure limits to protect children. I am glad to answer any questions that you have.

Sincerely,

Jerome A Paulson, MD FAAP

Jerome Paulson MD FAAP

January 28, 2021

Chairman Don Serotta
Town of Chester
1786 Kings Highway
Chester, NY 10918

Dear Chairman Don Serotta,

Cell antennas and cell towers should not be placed near schools and homes.

On August 13, 2021, the United States Court of Appeals for the District of Columbia Circuit ruled in our case against the FCC that the decision by the Federal Communications Commission (FCC) to retain its 1996 safety limits for human exposure to wireless radiation (which includes cell tower emissions) was “arbitrary and capricious.” Once of the important aspects of the court decision was that the ruling found the FCC did not adequately explain why it ignored the impacts of long term wireless exposure, especially for children, who are more vulnerable to wireless radiation. This ruling highlights how no federal health agency has reviewed the full body of research to develop proper safety standards.

Extensive published scientific evidence indicates that radiofrequency radiation *at levels far below FCC limits* can cause cancer, increased oxidative stress, genetic damage, structural and functional changes of the reproductive system, memory deficits, behavioral problems, and neurological impacts. We consider radiofrequency radiation (RFR) to be a human carcinogen based on the current body of evidence.

At this time we have not identified a safe level of exposure. Although radiation levels decrease as you increase your distance from a particular antenna/tower, the reality is that adding a tower or base station to a community will definitely *increase* the radiation exposure in that area and at any distance within the surrounding coverage area.

We recommend policies to reduce human exposure to RFR, especially for children. Schools are where children spend the majority of their daytime hours. Therefore we strongly recommend against installing cell towers near schools, daycares, parks, homes, or hospitals.

Recent research on people living near cell antennas has found increases in molecular markers in the blood that predict cancer. This study evaluated effects in the human blood of individuals living near mobile phone base stations (for study purposes, they chose a distance of 80 meters) compared with healthy controls living more than 300 meters from a base station. The study measured higher RFR levels in the homes of people living in homes within 80 meters from the cell antennas (documenting the impact of increased RFR radiation from the antenna installations) and found statistically significant differences in their blood. The group living closer to the antennas had statistically significant higher frequency of micronuclei and a rise in lipid peroxidation in their blood; these changes are considered biomarkers predictive of cancer (Zothansiama et al, 2017).

Please note the following facts about cell towers and cell phone radiation:

- In 2011, radiofrequency radiation was classified as a Class 2B possible carcinogen by the World Health Organization's International Agency for Research on Cancer. Between then and now, the published peer-reviewed scientific evidence has significantly increased. Now, many scientists are of the opinion that the weight of current peer-reviewed evidence supports the conclusion that radiofrequency radiation should be regarded as a human carcinogen (Hardell and Carlberg 2017, Peleg et al. 2018, Miller et al 2018).
- The US National Toxicology Program $25 million animal study on long-term exposure to radiofrequency radiation found DNA Damage, heart damage, increased brain tumors, and increased heart tumors deemed "clear evidence of cancer." Importantly, this study was launched almost two decades ago by the FDA because the US government had not performed research on the long-term effects of RFR exposure and the FDA wanted data on long-term safety. In 1996, the EPA was defunded from developing proper safety standards, and since then there has been no systematic review of the science by any US agency.
- Researchers with the renowned Ramazzini Institute in Italy published findings that lab animals exposed to levels of RFR below FCC limits developed the same types of cancerous cancers as the US National Toxicology Program found in their large-scale animal study.
- An Australian study looked at RFR levels to which kindergarten children were exposed, depending on how close their school was to base stations/cell towers. Researchers equipped the children with RFR measuring devices. Researchers found that kindergartens located nearby base stations/cell towers (closer than 300 meters or approximately 330 yards) had total exposure to radiofrequency radiation (RFR or RF-EMF) more than 3 times higher than children at schools where base stations were further away than 300 meters.
- A 2018 study measured radiofrequency radiation exposures in the environment including emissions from cell phone towers, TV and FM radio broadcast antennas, cell phone

handsets, and Wi-Fi—in several countries including the United States. The researchers concluded that cell phone tower (base station) radiation emissions are the dominant contributor to RFR exposure in most outdoor areas.

- A 2015 review found that in 93 out of 100 studies, RFR exposure caused oxidative stress (Yakymenko 2015). A 2021 review again confirmed non ionizing radiation has oxidative effects (Schuermann 2021). Many well-known causes of cancer in humans (such as asbestos and arsenic) are understood to induce oxidative stress.
- Studies also show that when combined with lead or a known carcinogen, RFR has magnified the carcinogen's effects. For example, RFR at levels far below FCC limits more than doubled the numbers of liver and lung tumors in carcinogen-exposed mice (Lerchl 2015).
- The International Association of Firefighters has officially opposed cell towers on their stations since 2004 after a study found neurological damage in firefighters with antennas on their fire station. In 2017, when 5G "small cells" were coming to California via a 5G streamlining bill (SB 649), firefighter organizations came out in strong opposition to the bill and requested that towers not be installed on firehouses. They were successful and SB649 was amended to exempt their stations from the deployment due to their health concerns.
- Published research finds the frequencies impact wildlife. For example, studies have found that the radiation alters bird navigation and disturbs honeybee colonies. Research also shows adverse impacts on trees and plants. (Research on EMF and Bees, Research on Wildlife Research on Trees)
- A 2019 study of students in schools near cell towers found their higher RF exposure was associated with impacts on motor skills, memory, and attention (Meo 2019). Examples of other effects linked to cell towers in research studies include neuropsychiatric problems, elevated diabetes, headaches, sleep problems, and genetic damage. Such research continues to accumulate after the 2010 landmark review study on 56 studies that reported biological effects found at very low intensities of wireless radiation, including impacts on reproduction, permeability of the blood-brain barrier, behavior, cellular changes, and metabolic changes, and increases in cancer risk (Lai and Levitt 2010).

- The International EMF Scientist Appeal was submitted to the United Nations urging immediate protective policy action in light of the scientific evidence that has found adverse biological effects from electromagnetic radiation, including radiofrequency radiation, and, as of January 2019, this Appeal is signed by 247 scientists from 42 nations; these are scientists who have published peer-reviewed articles about electromagnetic fields. They state, "numerous recent scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines. Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being."

The exposure limits of the US Federal Communications Commission are totally outdated and do not protect the health of the public, especially not the health of children. The Los Angeles School District has banned cell towers on their District's school grounds.

Please note that in several countries, governments have set policies to protect children, pregnant women, and medically fragile persons by classifying areas with homes, hospitals, and schools as "sensitive areas." Some examples include:

- In India the government has set RFR limits to 1/10th of ICNIRP and the Brihanmumbai Municipal Corporation, Zilla Parishad, Rajasthan, and Mumbai have banned cell antenna/tower installations on schools.
- Greece has banned the installation of mobile phone base stations at the premises of schools, kindergartens, hospitals, or eldercare facilities.
- Chile's "Antenna Law" prohibits cell antennas/towers in "sensitive areas" (educational institutions, nurseries, kindergartens, hospitals, clinics, nursing homes).
- Several countries have lower allowable RFR limits in "sensitive" areas.

EHT's position is that children require special protections from radiofrequency radiation and their exposures should be reduced to as low as possible. We strongly recommend against cell tower/antenna placements at schools or near homes as this would increase daily RFR exposure.

Please feel free to contact us with more questions.

Sincerely,

Devra Davis, PhD, MPH
President and Founder, Environmental Health Trust
Visiting Professor, Hebrew University Hadassah Medical Center
https://ehtrust.org

Anthony B. Miller, MD
Professor Emeritus at the Dalla Lana School of Public Health, University of Toronto
Senior Advisor to Environmental Health Trust

Dr. Hugh Scully Testimony to the City of Toronto

(Past-President of Ontario Medical Association, Past-President of Canadian Medical Association, Past-President of Canadian Cardiovascular Society.)

As a physician leader in Canada with a great commitment to the health of Canadians, I am very concerned about the increasing evidence internationally that EMR is creating increasing health problems in our population as its use increases exponentially. This is particularly true among children and young Canadians, and teachers and nurses who are continuously exposed to WiFi routers in schools [and hospitals].

As a cardiac specialist, I am concerned that approximately 20% of people have detrimental cardiac rhythm sensitivity to EMR.

This issue is under active consideration by the Health and Public Policy Committee of the Royal College of Physicians and Surgeons of Canada, the Health Policy and Public Health Committees of the Canadian Medical Association and the Council of Family Physicians of Canada, the Canadian Pediatric Society and the Canadian Cardiovascular Society.

There is an abundance of evidence from around the world that EMR can be harmful to health. Many countries...not Canada or the United States...have initiated policies to mitigate the risks. We, in Canada, need to do the same or more.

It is imperative that City of Toronto does not install WiFi's in public parks and spaces. I ask you to vote against Councillor Matlow's proposal.

Sincerely,

Dr. Hugh Scully, BA,MD,MSc,FRSC[C],FACS

Professor of Surgery and Health Policy, University of Toronto, Past-President, OMA, CMA, CCS, Former Member of Council [Board], RCPSC and WMA, Member, Health Policy Advisory Council, American College of Surgeons.

HARVARD MEDICAL SCHOOL

Martha R. Herbert, Ph.D., M.D.
Assistant Professor, Neurology
Director, TRANSCEND Research Program
www.transcendresearch.org
transcend@partners.org

MASSACHUSETTS GENERAL HOSPITAL

Martinos Center for Biomedical Imaging
149 13th Street, Room 10.043
Charlestown (Boston), Massachusetts 02129
martha.herbert@mgh.harvard.edu
https://connects.catalyst.harvard.edu/profiles/display/Person/47629

December 12, 2015

Montgomery County Schools
Carver Educational Services Center
850 Hungerford Drive
Rockville, MD 20850

cc Montgomery County City Council

Dear Montgomery County School District,

I am a pediatric neurologist and neuroscientist on the faculty of Harvard Medical School and on staff at the Massachusetts General Hospital. I am Board Certified in Neurology with Special Competency in Child Neurology, and Subspecialty Certification in Neurodevelopmental Disorders.

I have an extensive history of research and clinical practice in neurodevelopmental disorders, particularly autism spectrum disorders. I have published papers in brain imaging research, in physiological abnormalities in autism spectrum disorders, and in environmental influences on neurodevelopmental disorders such as autism and on brain development and function.

A few years ago I accepted an invitation to review literature pertinent to a potential link between Autism Spectrum Disorders and Electromagnetic Frequencies (EMF) and Radiofrequency Radiation(RFR). I set out to write a paper of modest length, but found much more literature than I had anticipated to review. I ended up producing a 60 page single spaced paper with over 550 citations. It is available at http://www.bioinitiative.org/report/wp-content/uploads/pdfs/sec20_2012_Findings_in_Autism.pdf and it was published in a revised and somewhat shortened form in two parts in the peer reviewed indexed journal *Pathophysiology (2013)*with the title: Áutism and EMF? Plausibility of a pathophysiological link." Please also see the appendix to this letter which contains a summary of this material and includes substantial scientific citations.

More recently I published an article entitled “Connections in Our Environment: Sizing up Electromagnetic Fields,” in *Autism Notebook Spring 2015* edition in which I summarized and personalized the information in the . In this article I describe how here is a whole series of problems at the cellular, sub-cellular and metabolic levels and immune levels that have been identified in autism. And interestingly, for every single one of those problems, there’s literature about how EMFs can create those kinds of problems.

The argument I made in these articles is not that EMF is proven to cause autism, but rather, that EMF can certainly contribute to degrading the physiological integrity of the system at the cellular and molecular level” – and this in turn appears to contribute to the pathogenesis/causation not only of autism but of many highly common chronic illnesses, including cancer, obesity, diabetes and heart disease.. Please see this article on page 24-25 at the link http://virtualpublications.soloprinting.com/publication/?i=252361

In fact, there are thousands of papers that have accumulated over decades –and are now accumulating at an accelerating pace, as our ability to measure impacts become more sensitive – that document adverse health and neurological impacts of EMF/RFR. Children are more vulnerable than adults, and children with chronic illnesses and/or neurodevelopmental disabilities are even more vulnerable. Elderly or chronically ill adults are more vulnerable than healthy adults.

Current technologies were designed and promulgated without taking account of biological impacts other than thermal impacts. We now know that there are a large array of impacts that have nothing to do with the heating of tissue. The claim from wifi proponents that the only concern is thermal impacts is now definitively outdated scientifically.

Radiofrequency electromagnetic radiation from wifi and cell towers can exert a disorganizing effect on the ability to learn and remember, and can also be destabilizing to immune and metabolic function. This will make it harder for some children to learn, particularly those who are already having learning or medical problems in the first place. And since half of the children in this country have some kind of chronic illness, this means that a lot of people are more vulnerable than you might expect to these issues.

Powerful industrial entities have a vested interest in leading the public to believe that EMF/RFR, which we cannot see, taste or touch, is harmless, but this is not true. Please do the right and precautionary thing for our children.

I urge you to opt for wired technologies in Montgomery County classrooms, particularly for those subpopulations that are most sensitive. It will be easier for you to make a healthier decision now than to undo misguided decisions later.

Thank you.

Martha Herbert, PhD, MD

Selected pertinent publications

Connections in our Environment: Sizing up Electromagnetic Fields by M.R. Herbert (published in Autism Notebook Spring 2015, pp.. 24-25) reviews in two pages key points of the more technical Herbert & Sage Autism-EMF paper

Herbert, M.R. and Sage, C. "Autism and EMF? Plausibility of a Pathophysiological Link". Part 1: *Pathophysiology* , 2013, Jun;20(3):191-209, epub Oct 4, PMID 24095003. Pubmed abstract for Part 1. Part II: *Pathophysiology,* 2013 Jun;20(3):211-34. Epub 2013 Oct 8, PMID 24113318. Pubmed abstract for Part II.

APPENDIX: MORE DETAILED SUMMARY OF THE PATHOPHYSIOLOGY

I became interested in the health and brain effects of electromagnetic frequency (EMF) and radiofrequency radiation (RFR) exposures in relation to my brain research because I was interested in how such exposures might alter brain function. In order to familiarize myself in more detail existing literature on the pathophysiological impacts of EMF/RFR, I coauthored a 40,000 word chapter in the 2012 update of the Bioinitiative, [1] and published an updated 30,000 word version of that paper ("Autism and EMF? Plausibility of a Pathophysiological Link") in 2013 in two parts in the peer reviewed journal *Pathophysiology.* [2, 3] My intention was to assess the plausibility of an association between increasing incidence of autism spectrum disorder and increasing EMF/RFR exposures. Rather than directly address the epidemiological issues, I looked at the parallels between the pathophysiological features documented in autism and the pathophysiological impacts of EMF/RFR documented in the peer-reviewed published scientific literature.

I will include here a brief summary of the paper (prepared for a lay audience) of the features of EMF/RFR that I reviewed (with citations at the end of this letter):

- EMF/RFR stresses cells. It lead to cellular stress, such as production of heat shock proteins, even when The EMF/RFR isn't intense enough to cause measurable heat increase. [4-6]
- EMF/RFR damages cell membranes, and make them leaky, which makes it hard for them to maintain important chemical and electrical differences between what is inside and outside the membrane. This degrades metabolism in many ways – makes it inefficient. [7-15]
- EMF/RFR damages mitochondria. Mitochondria are the energy factories of our cells. Mitochondria conduct their chemical reactions on their membranes. When those membranes get damaged, the mitochondria struggle to do their work and don't do it so well. Mitochondria can also be damaged through direct hits to steps in their chemical assembly line. When mitochondria get inefficient, so do we. This can hit our brains especially hard, since electrical communication and synapses in the brain demands huge amounts of energy.
- EMF/RFR creates "oxidative stress." Oxidative stress is something that occurs when the system can't keep up with the stress caused by utilizing oxygen, because the price we pay for using oxygen is that it generates free radicals. These are generated in the normal course of events, and they are "quenched" by antioxidants like we get

in fresh fruits and vegetables; but when the antioxidants can't keep up or the damage is too great, the free radicals start damaging things.

- EMF/RFR is genotoxic and damages proteins, with a major mechanism being EMF/RFR-created free radicals which damage cell membranes, DNA, proteins, anything they touch. When free radicals damage DNA they can cause mutations. This is one of the main ways that EMF/RFR is genotoxic – toxic to the genes. When they damage proteins they can cause them to fold up in peculiar ways. We are learning that diseases like Alzheimer's are related to the accumulation of mis-folded proteins, and the failure of the brain to clear out this biological trash from its tissues and fluids.
- EMF/RFR depletes glutathione, which is the body's premier antioxidant and detoxification substance. So on the one hand EMF/RFR creates damage that increases the need for antioxidants, and on the other hand they deplete those very antioxidants.[1, 16]
- EMF/RFR damages vital barriers in the body, particularly the blood-brain barrier, which protects the brain from things in the blood that might hurt the brain. When the blood-brain barrier gets leaky, cells inside the brain suffer, be damaged, and get killed. [1, 16, 17]
- EMF/RFR can alter the function of calcium channels, which are openings in the cell membranes that play a huge number of vital roles in brain and body. [18-27]
- EMF/RFR degrades the rich, complex integration of brainwaves, and increase the "entropy" or disorganization of signals in the brain – this means that they can become less synchronized or coordinated; such reduced brain coordination has been measured in autism. [28-40]
- EMF/RFR can interfere with sleep and the brain's production of melatonin. [41-43]
- EMF/RFR can contribute to immune problems. [44-50]
- EMF/RFR contribute to increasing stress at the chemical, immune and electrical levels, which we experience psychologically. [51-57] [17, 58-62] [63-68]

Please note that:

1. There are a lot of other things that can create similar damaging effects, such as thousands of "xenobiotic" substances that we call toxicants. Significantly, toxic chemicals (including those that contain naturally occurring toxic elements such as lead and mercury) cause damage through many of the same mechanisms outlined above.
2. In many of the experimental studies with EMF/RFR, damage could be diminished by improving nutrient status, particularly by adding antioxidants and melatonin. [69-72]

I understand that the concept of electromagnetic hypersensitivity is not always well understood in the medical and scientific communities. Indeed, the inter-individual variability is perplexing to those who would expect a more consistent set of features.

But given the range of challenges I have listed that EMF/RFR poses to core processes in biological systems, and given the inter-individually variable vulnerability across these symptoms, it is really not surprising that there would be subgroups with different combinations of symptom clusters.

It also appears to be the case that the onset and duration of symptoms or even brain response to EMR/RFR can be variable. This again is to be expected given the mediation of these symptoms through a variety of the above-listed pathophysiological processes, many of which differ in scale (ranging from molecular to cellular to tissue and organ) and time course of impact. The different parts of the body also absorb this energy differently, both because of their biophysical properties and as a function of their state of health or compromise thereof.

Here is a list of subgroups of symptom clusters identified by a group of German physicians, t exemplifies these variability issues:

Group 1	no symptoms
Group 2	sleep disturbance, tiredness, depressive mood
Group 3	headaches, restlessness, dazed state, irritability, disturbance of concentration, forgetfulness, learning difficulties, difficulty finding words
Group 4	frequent infections, sinusitis, lymph node swellings, joint and limb pains, nerve and soft tissue pains, numbness or tingling, allergies
Group 5	tinnitus, hearing loss, sudden hearing loss, giddiness, impaired balance, visual disturbances, eye inflammation, dry eyes
Group 6	tachycardia, episodic hypertension, collapse
Group 7	other symptoms: hormonal disturbances, thyroid disease, night sweats, frequent urge to urinate, weight increase, nausea, loss of appetite, nose bleeds, skin complaints, tumors, diabetes

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3 August 2016

Petaluma City Schools
District Office
200 Douglas Street
Petaluma, California 94952

Dear Sirs/Madams:

I am a public health physician who served as the Co-Editor of the Bioinitiative Report, published in 2007 as a comprehensive review of the adverse health effects of radiofrequency electromagnetic fields.

There is strong and consistent evidence that excessive exposure to radiofrequency electromagnetic fields has adverse human health effects. Of particular concern is the clear evidence that children are more vulnerable than adults. The best-documented adverse effects are an increase in risk of cancer, but cancers do not appear immediately upon exposure but rather come years later. The National Toxicology Program has within the past couple of months reported that even rats exposed to radiofrequency radiation develop brain cancer! Within a school setting there is increasing evidence that excessive exposures reduce learning ability, which is the last thing one wants in a school. Some children will also develop a syndrome of electrohypersensitivity, where they get headaches and reduced ability to pay attention and learn. While these effects are not nearly as well documented as those relating to cancer, they are particularly important within a school. This is especially the case in a wireless computer classroom, where exposure can be very high. However there will be essentially no exposure in a wired computer classroom.

The exposure levels of the Federal Communications Commission are totally outdated and do not protect the health of the public, especially of children. I urge you to abandon any plans for wireless communication within schools. It is of course critical that all children have access to the Internet, but when this is done through wired connections they will not be exposed to excessive electromagnetic fields.

Yours sincerely,

David O Carpenter

David O. Carpenter, M.D.
Director, Institute for Health and the Environment
University at Albany

District Office
200 Douglas Street
Petaluma, California
94952
USA

4 August, 2016

Dear Petaluma City Schools;
Superintendent Gary Callahan and Board of Trustees

Regarding: Wireless technology should not be used in schools or pre-schools due to health risks for children and employees

We have been asked to declare our opinion about wireless technology in schools by parents that are concerned about their children.

Based on current published scientific studies, we urge your administration to educate themselves on the potential risks from wireless technologies in schools, and to choose wired teaching technologies. The well-being and educational potential of children depends on it.

High-speed connectivity to schools is important but it can be a wired connection instead of Wi-Fi. Wireless classroom infrastructure and wireless devices for schoolchildren should be avoided for these reasons:

- Wireless radiofrequency (RF) radiation emissions were classified as a Possible Human Carcinogen (group 2B) by the World Health Organization International Agency for Research on Cancer (IARC) in May 2011. One of the signers, Dr Hardell, was part of the evaluation group.
- The IARC classification holds for *all forms of radio frequency radiation* including RF-EMF emissions from wireless transmitters (access points), tablets and laptops.
- Epidemiological studies show links between RF radiation exposure and cancer, neurological disorders, hormonal changes, symptoms of electrical hypersensitivity (EHS) and more. Laboratory studies show that RF radiation exposure increases risk of cancer, abnormal sperm, learning and memory deficits, and heart irregularities. Foetal exposures in both animal and human studies may result in altered brain development in the young offspring, with disruption in learning, memory and behaviour.
- Recently a report was released from The National Toxicology Program (NTP) under the National Institutes of Health (NIH) in USA on the largest ever animal study on cell phone RF radiation and cancer (http://biorxiv.org/content/biorxiv/early/2016/05/26/055699.full.pdf). An increased incidence of glioma and malignant schwannoma in the heart was found. Interestingly our research group and others have in epidemiological studies shown that persons using wireless phones (both mobile phones and cordless phones; DECT) have an increased risk for glioma and acoustic neuroma. Acoustic neuroma or vestibular schwannoma is the same type of tumour as the one found in the heart, although benign.
- The research showing increased brain cancer risk in humans *has strengthened* since the IARC 2011 classification as new research has been published which repeatedly shows a significant association after RF radiation exposure. In addition, tumour

promotion studies have now been replicated showing cancer promotion after exposures at low levels.
- It is our opinion and that of many colleagues that the current IARC cancer risk classification should move to an *even higher* risk group. The carcinogenic effect has been shown in human and animal studies. Several laboratory studies have shown mechanistic effects in carcinogenesis such as oxidative stress, down regulation of mRNA, DNA damage with single strand breaks.
- In summary RF radiation should be classified as Carcinogenic to Humans, Group 1 according to the IARC classification. This classification should have a major impact on prevention.

The evidence for these statements is based on hundreds of published, peer-reviewed scientific studies that report adverse health effects at levels much lower than current ICNIRP and FCC public safety limits. Compliance with government regulations does not mean that the school wireless environment is safe for children and staff (especially pregnant staff).

As researchers in cancer epidemiology and RF radiation exposures, we have published extensively in this area and it is our opinion that schools should choose wired Internet connections. Multiple epidemiological research studies show that exposures equivalent to 30 minutes a day of cell phone use over ten years results in a significantly increased brain cancer risk.

What will be the health effect for a child exposed all day long in school for 12 years? Wireless networks in schools result in full body low level RF radiation exposures that can have a cumulative effect on the developing body of a child. No safe level of this radiation has been determined by any health agency and therefore we have no safety assurances. Cancers can have long latency periods (time from first exposure until diagnosis) and it will take decades before we know the full extent of health impacts from this radiation. The statistics and effects will be borne by the children you serve.

Wi-Fi in schools, in contrast to wired Internet connections, will increase risk of neurologic impairment and long-term risk of cancer in students. Promoting wireless technology in schools disregards the current health warnings from international science and public health experts in this field.

We recommend that your school district install wired Internet connections and develop curriculum that teaches students at all ages safer ways to use their technology devices. If cell phones and other wireless devices are used in the school curriculum (as many schools are now doing with Bring your Own Device Policy) then there should be educational curriculum in place and well posted instructions in classrooms so that the students and staff use these devices in ways that reduce exposure to the radiation as much as possible.

Supporting wired educational technologies is the safe solution in contrast to potentially hazardous exposures from wireless radiation.

Respectfully submitted

Lennart Hardell, MD, PhD
Department of Oncology,
Örebro University Hospital,

Michael Carlberg, MSc
Department of Oncology,
Örebro University Hospital,

SE-701 85 Örebro, Sweden
E-mail: lennart.hardell@regionorebrolan.se

SE-701 85 Örebro, Sweden
michael.carlberg@regionorebrolan.se

Lena Hedendahl, MD
Östra Skolgatan 12,
SE-972 53 Luleå, Sweden
E-mail: lenahedendahl@telia.com

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Dr. Anthony B. Miller

3800 Yonge Street, Suite 406,
Toronto, ON, M4N 3P7
Telephone 416 487 5825
Email: ab.miller@sympatico.ca

August 4, 2016

Petaluma City Schools
District Office
200 Douglas Street
Petaluma, California
94952

Re: Adverse Effects of Radiofrequency fields

I am writing to express my concern over the increasing exposure of children in schools to Radiofrequency Fields (e.g. from wi-fi, as required for cell phones and iPads, and emitted by cell towers) and the lack of concern expressed by many councils, governments and School Boards on this issue. In particular, justification for the "safety" of radiofrequency fields is placed upon the use of outdated safety standards, based upon tissue heating, whereas it has now been well demonstrated that adverse biological effects occur at far lower levels of radiofrequency fields that do not induce tissue heating, including a recent animal study performed by the National Toxicology Program in the United States which found an increased incidence of brain cancers and other cancers in rats exposed to prolonged Radiofrequency fields.

I am a physician and epidemiologist specializing in cancer etiology, prevention, and screening, expert in epidemiology, and particularly causes of human cancer. I have performed research on ionizing radiation and cancer, electromagnetic fields and cancer, and have served on many committees assessing the carcinogenicity of various exposures, including working groups of the International Agency for Research on Cancer (IARC), widely regarded as providing unbiased assessment on the carcinogenicity of chemicals and other exposure to humans.

In 2011, an IARC working group designated radiofrequency fields as a class 2B carcinogen, a <u>possible</u> human carcinogen. Since that review a number of additional studies have been reported. One of the most important was a large case-control study in France, which found a doubling of risk of glioma, the most malignant form of brain cancer, after two years of exposure to cell phones. After five years exposure the risk was five-fold. They also found that in those who lived in urban environments the risk was even higher. In my view, and that of many colleagues who have written papers on this issue, these studies provide evidence that radiofrequency fields are not just a <u>possible</u> human carcinogen but a <u>probable</u> human carcinogen, i.e. IARC category 2A. It would be impossible to ignore such an assessment in regulatory approaches.

It is important to recognize that there are no safe levels of exposure to human carcinogens. Risk increases with increasing intensity of exposure, and for many carcinogens, even more with increasing duration of exposure. The only way to avoid the carcinogenic risk is to avoid exposure altogether. This is why we ban known carcinogens from the environment and why much effort is taken to get people, particularly young people, not to smoke. We now recognize that exposure to carcinogens in childhood can increase the risk of cancer in adulthood many years later. Further, people vary in their genetic makeup, and certain genes can make some people more susceptible than others to the effect of carcinogens. It is the young and those who are susceptible we should protect.

As an epidemiologist who has done a great deal of work on breast cancer, I have been concerned by a series of case reports from California and elsewhere of women who developed unusual breast cancers in the exact position where they kept cell phones in their bras. These are unusual cancers. They are multifocal, mirroring where the cell phone was kept. Thus in these relatively young women the radiofrequency radiation from very close contact with a cell phone has caused breast cancer.

Not only brain and breast cancers but parotid gland tumors, tumors of the salivary gland, have been associated with prolonged exposure to cell phones.

Given the long natural history of cancer and the fact that human populations have not been exposed for a sufficient length of time to reveal the full adverse effects of radiofrequency fields, it is extremely important to adopt a precautionary approach to the exposure of humans to such fields. An individual, if appropriately informed, can reduce her or his exposure to radiofrequency fields from devices that use wi-fi, but in the case of cell towers, smart meters and wi-fi in schools, the exposure they receive is outside their control. Then, with the people who manufacture these devices and those who promote wi-fi failing to issue adequate health warnings, we are reaching a situation where schools, work places and homes are being saturated with radiofrequency fields.

Thus to avoid a potential epidemic of cancer caused by radiofrequency fields from wi-fi and other devices, we should introduce means to reduce exposure as much as reasonably achievable, use hard wire connections to the internet and strengthen the codes that are meant to protect the public.

Yours sincerely

Anthony B. Miller, MD, FRCP(C), FRCP, FACE
Professor Emeritus
Dalla Lana School of Public Health, University of Toronto, Ontario, Canada

Karolinska Institutet
Department of Neuroscience
Experimental Dermatology Unit

Stockholm, December 8, 2015

To:
MCPS CEO Dr. Andrew Zuckerman [Andrew_Zuckerman@mcpsmd.org]
MCPS Superintendent Mr. Larry Bowers [Larry_Bowers@mcpsmd.org]
MCPS Chief Technology Officer Mr. Sherwin Collette [Sherwin_Collette@mcpsmd.org]
MCPS Board of Education [boe@mcpsmd.org]
840 Hungerford Drive
Rockville, MD 20850, USA

cc:
Montgomery County Council [county.council@montgomerycountymd.gov]

Dear Madame or Sir,

My name is Olle Johansson, and I am an associate professor, heading the Experimental Dermatology Unit at Sweden's Karolinska Institute in the Department of Neuroscience. I understand you have recently made public pronouncements regarding the safety of Wi-Fi. As a neuroscientist who has been studying the biophysical and epidemiological effects of electromagnetic fields (EMFs) for over 30 years, I believe this designation is short-sighted.

Wireless communication is now being implemented in our daily life in a very fast way. At the same time, it is becoming more and more obvious that the exposure to electromagnetic fields not only may induce acute thermal effects to living organisms, but also non-thermal effects, the latter often after longer exposures. This has been demonstrated in a very large number of **non-ionizing radiation** studies and includes cellular DNA-damage, disruptions and alterations of cellular functions like increases in intracellular stimulatory pathways and calcium handling, disruption of tissue structures like the blood-brain barrier, impact on vessel and immune functions, and loss of fertility. Whereas scientists can observe and reproduce these effects in controlled laboratory experiments, epidemiological and ecological data derived from long-term exposures in well-designed case-control studies reflect this link all the way from molecular and cellular effects to the living organism up to the induction and proliferation of diseases observed in humans. It should be noted that we are not the only species at jeopardy; practically all animals, plants and bacteria may be at stake. Although epidemiological and ecological investigations as such never demonstrate causative effects, due to the vast number of confounders, they confirm the relevance of the controlled observations in the laboratories.

Many times since the early 1980s I have pointed out that the public's usage of cell phones has become the largest full-scale biological and medical experiment ever with mankind, and I was also the first person to firmly point out that this involuntary exposure violates the Nuremberg Code's principles for human experimentation, which clearly states that voluntary

Mailing address	Visiting address	Telephone	
Experimental Dermatology Unit	Retziuslaboratoriet	Direct	468-52 48 70 58
Department of Neuroscience	Retzius väg 8	Switchboard	468-52 48 64 00
Karolinska Institutet	Solna	Fax	468-30 39 04
171 77 Stockholm		Fax (KI)	468-31 11 01
Sweden			

consent of human subjects is absolutely essential. Among many effects seen, the very serious one is the deterioration of the genome. Such an effect - if seen in a food item under development or in a potential pharmaceutical drug - immediately would completely ban it from further marketing and sale; genotoxic effects are not to be allowed or spread. For these reasons above, we, scientists, can not accept that children undergo an enormous health risk for their present and future, by being exposed to WI-FI in kindergardens or schools (even if the WI-FI masts/routers are not in the children's classroom). The precautionary principle has to be respected. Furthermore, when men place cell phones in their front pocket, or laptops on their laps, it should be noted that experimental studies have demonstrated that after similar exposures there is a decrease in sperm count as well as in the quality of sperm, which is a phenomenon that could affect society's overall ability to procreate in the future. Experiments in mice point to that it may be true already in 5 generations time.

Many other states including France, Russia, Israel and Germany, have employed various precautionary steps and their responses (including labelling cell phones and other transmitting devices with SAR ratings, discouraging the use of cell phones and other wireless gadgets by children, warning parents of the risks, and removing or restricting WiFi in schools and replacing it with hard-wired ethernet) as a result of the *WHO/IARC classification of radiofrequency electromagnetic radiation in 2011 as a Class 2B carcinogen as well as the earlier classification of power-frequent magnetic fields in 2001 also as a Class 2B carcinogen*, the information summarized in the Bioinitiative Reports of 2007 and 2012, and the other considerable international and independent research and reviews, that show adverse biological effects from electromagnetic fields, including heart palpitations, headaches, skin rashes, damage to DNA, mental health effects, impaired concentration, decreased problem-solving capacity, electrohypersensitivity, etc., are about to set a new standard for educational quality with due respect to children's and staff's health.

In the case of "protection from exposure to electromagnetic fields", it is thus of paramount importance to act from a prudence avoidance/precautionary principle point of view. Anything else would be highly hazardous. Total transparency of information is the key sentence here, as I believe the public does not appreciate having the complete truth revealed years after a certain catastrophe already has taken place. For instance, it shall be noted, that today's recommended values for wireless systems, such as the SAR-values, are just recommendations, and not safety levels. Since scientists observe biological effects at as low as 20 microWatts/kg, can it truly be stated that it is safe to allow irradiation of humans at SAR 2 W/kg, or at 100,000 times stronger levels of radiation?

IMBALANCED REPORTING
Another misunderstanding is the use of scientific publications (as the tobacco industry did for many years) as 'weights' to balance each other. But one can NEVER balance a report showing a negative health effect with one showing no effect. This is a misunderstanding which, unfortunately, is very often used both by the industrial representatives as well as official authorities to the detriment of the general public. True balance would be reports showing negative health effects against *exact replications* showing no or positive effects. However, this is not what the public has been led to believe.

Mailing address	Visiting address		Telephone
Experimental Dermatology Unit	Retziuslaboratoriet	Direct	468-52 48 70 58
Department of Neuroscience	Retzius väg 8	Switchboard	468-52 48 64 00
Karolinska Institutet	Solna	Fax	468-30 39 04
171 77 Stockholm		Fax (KI)	468-31 11 01
Sweden			

Karolinska Institutet
Department of Neuroscience
Experimental Dermatology Unit

NEED FOR INDEPENDENT RESEARCH
In many commentaries, debate articles and public lectures - for the last 20-30 years – I have urged that completely independent research projects must be inaugurated immediately to ensure our public health. These projects must be entirely independent of all types of commercial interests; public health can not have a price-tag! It is also of paramount importance that scientists involved in such projects must be free of any carrier considerations and that the funding needed is covered to 100%, not 99% or less. This is the clear responsibility of the democratically elected body of every country.

WHO/INTERNATIONAL AGENCY FOR RESEARCH ON CANCER (IARC), 2011
Very recently (in Lyon, France, May 31, 2011) the WHO/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer. This should be added to the previous (2001) 2B classification of power-frequent (ELF) electromagnetic fields – emitted at high levels from handheld gadgets, such as eReaders and mobile phones – as a risk factor for childhood leukemia. Given the 2001 very close votes (9 to 11) for moving it to 2A and all the new knowledge that has accumulated since 2001, today the association between childhood leukemia and power-frequent (ELF) electromagnetic fields would definitely be signed into the much more serious 2A ("probably carcinogenic") category. So, the 'red flag' is – unfortunately – flying very high.

INVOLUNTARY EXPOSURE
According to Article 24 of the UNICEF's Child Convention "children have the right to … a clean and safe environment, and information to help them stay healthy". We must all ensure that this article never is violated. This is about our social responsibility, and is very much a public health issue.

In summary, electromagnetic fields may be among the most serious and overlooked health issues today, and having these fields checked and reduced/removed from schools and kindergardens may be essential for health protection and restoration, and is a must for persons with the functional impairment electrohypersensitivity as for children who are more fragile (cf. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Johansson O, Kern M, Kundi M, Lercher P, Mosgöller W, Moshammer H, Müller K, Oberfeld G, Ohnsorge P, Pelzmann P, Scheingraber C, Thill R, "EUROPAEM EMF Guideline 2015 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses", Rev Environ Health 2015; 30: 337–371). In addition, as recently discussed in a think-tank group here in Stockholm, it is very important to constantly educate oneself and participate in the general debate and public discussions to keep the information build-up active. Thus, it is of paramount importance to keep the "kettle boiling", never blindly trusting or accepting given 'facts', but only read and think for yourself and for your loved ones. Only so you can arrive at a genuinely working precautionary principle.

Mailing address
Experimental Dermatology Unit
Department of Neuroscience
Karolinska Institutet
171 77 Stockholm
Sweden

Visiting address
Retziuslaboratoriet
Retzius väg 8
Solna

Telephone
Direct 468-52 48 70 58
Switchboard 468-52 48 64 00
Fax 468-30 39 04
Fax (KI) 468-31 11 01

Karolinska Institutet
Department of Neuroscience
Experimental Dermatology Unit

CONCLUSION

In conclusion, wireless systems, such as Wi-Fi routers or cell towers, and their electromagnetic fields, can not be regarded as safe in schools, but must be deemed highly hazardous and unsafe for the children as well as for the staff.

I encourage governments and local health and educational bodies to adopt a framework of guidelines for public and occupational EMF exposure that reflect the Precautionary Principle. As noted, the Precautionary Principle states when there are indications of possible adverse effects, though they remain uncertain, the risks from doing nothing may be far greater than the risks of taking action to control these exposures. The Precautionary Principle shifts the burden of proof from those suspecting a risk to those who discount it — as some nations have already done. Precautionary strategies should be based on design and performance standards and may not necessarily define numerical thresholds because such thresholds may erroneously be interpreted as levels below which no adverse effect can occur.

Some 100 years back, we learned the hard lessons of ionizing radiation and the need for strict health protections – now we must openly face the possibility that we must take a seat in life's school and learn again. This time it is about non-ionizing radiation.

Based on all of the above, I strongly urge you to reconsider your public stance on the safety of Wi-Fi, cell towers, and similar systems in schools as their non-ionizing radiation emissions very likely are hazardous and unsafe for students, staff and teachers.

With my very best regards
Yours sincerely
Olle Johansson

(Olle Johansson, associate professor
The Experimental Dermatology Unit
Department of Neuroscience
Karolinska Institute
171 77 Stockholm
Sweden)

Mailing address
Experimental Dermatology Unit
Department of Neuroscience
Karolinska Institutet
171 77 Stockholm
Sweden

Visiting address
Retziuslaboratoriet
Retzius väg 8
Solna

Telephone
Direct 468-52 48 70 58
Switchboard 468-52 48 64 00
Fax 468-30 39 04
Fax (KI) 468-31 11 01

Martin L. Pall, Professor Emeritus
Biochemistry and Basic Medical Sciences,
Washington State University,
638 NE 41st Ave., Portland, OR
97232-3312
503-232-3883
martin_pall@wsu.edu

MCPS COO Dr. Andrew Zuckerman
MCPS Interim Superintendent Larry Bowers
MCPS Board of Education
MCPS Office of Technology
Montgomery County Schools
Carver Educational Services Center
850 Hungerford Drive
Rockville, MD 20850

January 3, 2016

Dear Montgomery County COO Dr. Andrew Zuckerman, Interim Superintendent Larry Bowers, Board of Education and Office of Technology;

I have been asked to comment on the MCPS Statement Concerning Deployment of Wireless Computing Technologies. I am happy to do so.

The first paragraph in that statement is not relevant to the issue at hand because it is perfectly possible to use wired communication for such education. This document is being produced on a computer on which I only use wired communication, connecting to the internet, connecting to my printer and for other purposes, as well.

The 2nd and 3rd paragraphs of your statement may well be technically correct. However these give us no assurance whatsoever of safety of Wi-Fi fields. The FCC guidelines as are many other such guidelines, are based on the assumption that only heating effects of microwave/lower frequency EMFs can have biological effects. However that assumption has been falsified by thousands of studies published from the 1950s to the present, each showing that non-thermal levels of exposure often produce biological effects. For example, in 1971, the U.S. Office of Naval Medical Research produced a document reporting over 100 different non-thermal effects [1], listing 40 apparent neuropsychiatric changes produced by non-thermal microwave frequency exposures, including 5 central/peripheral nervous system (NS) changes, 9 central NS effects, 4 autonomic system effects, 17 psychological disorders, 4 behavioral changes and 2 misc. effects [1]. It also listed cardiac effects including ECG changes and cardiac necrosis as well as both hypotension and hypertension, and also 8 different endocrine effects.

Changes affecting fertility included tubular degeneration in the testis, decreased spermatogenesis, altered sex ratio, altered menstrual activity, altered fetal development, programmed cell death (what is now known as apoptosis) and decreased lactation. Many other non-thermal changes were also listed for a total of over 100 non-thermal effects. They also provided [1] approximately 2000 citations documenting these various health effects. That was almost 45 years ago and is only the beginning of the evidence for the existence of non-thermal effects. My own recent paper [2] shows that widespread neuropsychiatric effects are caused by non-thermal exposures to many different microwave frequency electromagnetic fields (EMFs).

Tolgskaya and Gordon [3] in 1973 published a long and detailed review of effects of microwave and lower frequency EMFs on experimental animals, mostly rodents. They report that non-thermal exposures impact many tissues, with the nervous system being the most sensitive organ in the body, based on histological studies, followed by the heart and the testis. They also report effects of non-thermal exposures on liver, kidney, endocrine and many other organs. The nervous system effects are very extensive and include changes many changes in cell structure, disfunction of synaptic connections between neurons and programmed cell death and are discussed in Refs. [2,3] and more modern studies reporting extensive effects of such non-thermal EMF exposures on the brain are also cited in [2]. There are also many modern studies showing effects of non-thermal exposures on fertility in animals.

The Raines 1981 National Aeronautics and Space Administration (NASA) report [4] reviewed an extensive literature based on occupational exposures to non-thermal microwave EMFs. Based on multiple studies, Raines [4] reports that 19 neuropsychiatric effects are associated with occupational microwave/ radiofrequency EMFs, as well as cardiac effects, endocrine including neuroendocrine effects and several other effects.

I reviewed many other scientific reviews on this topic, each of which clearly supports the view that there are various non-thermal health impacts of these EMFs [5]. In 2015, 206 international scientists signed a statement sent to the United Nations Secretary General and to member states, stating that international safety guidelines and standards are inadequate to protect human health [6]. Each of these 206 scientists from 40 countries had scientific publications on biological effects of such EMFs and therefore each is well qualified to judge this. ***It can be seen from this statement to the UN, that there is a strong scientific consensus that current safety guidelines and standards are inadequate because they do not take into consideration all of the non-thermal health effects produced by various EMF exposures.***

That scientific consensus also rejects, therefore, the FCC EMF guidelines, guidelines that cannot be defended despite your own attempt to do so in MCPS Statement Concerning Deployment of Wireless Computing Technologies.

It can be seen from the previous paragraphs, that the following non-thermal effects of EMF exposures are well documented:

Ø Widespread neuropsychiatric effects
Ø Several types of endocrine (that is hormonal) effects
Ø Cardiac effects impacting the electrocardiogram (Note: these are often associated with occurrence of sudden cardiac death)
Ø Male infertility
However, there are many additional types of biological changes produced by non-thermal EMF exposures (reviewed in 5,7] including:
Ø Oxidative stress
Ø Changes in calcium fluxes and calcium signaling
Ø Several types of DNA damage to the cells of the body, including single strand and double strand DNA breaks and 8-OH-guanine in DNA
Ø Cancer (which is undoubtedly caused, in part, by such DNA damage)
Ø Female infertility
Ø Lowered melatonin; sleep disruption
Ø Therapeutic effects of EMFs when they are highly controlled and focused on a specific part of the body

It can be seen from the above, that each of the things that we most value as individuals and as a species are being attacked by non-thermal microwave frequency EMFs [5.7]:
§ **Our Health**
§ **Our brain function**
§ **The integrity of our genomes**
§ **Our ability to produce healthy offspring**

I want to emphasize that the specific health effects listed above are **not** the only things that are likely to be impacted by non-thermal EMF exposures, they are however the best documented such effects.

While it has been clear for many years that there are many non-thermal health effects of microwave frequency EMFs, it has not been clear until about 2 ½ years ago, how these effects are produced by such exposures. I stumbled onto the mechanism in 2012 and published on it in mid-2013. This 2013 paper [8] was honored by being placed on the Global Medical Discovery web site as one of the most important medical papers of 2013. At this writing, it has been cited 61 times according to the Google Scholar database, with over 2/3rds of those citations during 2015. So clearly it is having a substantial and rapidly increasing impact on the scientific literature. I have given 26 professional talks, in part or in whole on EMF effects in 10 different countries over the last 2 1/4 years. So it is clear that there has been a tremendous amount of interest in this research.

What the 2013 study showed [8], was that in 24 different studies (and there are now 2 more that can now be added [2]), effects of low-intensity EMFs, both microwave frequency and lower frequency EMFs could be blocked by calcium channel blockers, drugs that block what are called voltage-gated calcium channels (VGCCs). There were a total of 5 different types of calcium channel blocker drugs used in these studies, with each type acting on a different site on the VGCCs and each thought to be highly specific for blocking VGCCs. What these studies tell us is that these EMFs act to produce non-thermal effects by activating the VGCCs. Where several effects were studied, when one of them was blocked or greatly lowered, each other effect studied was also blocked or greatly lowered. This tells us that the role of VGCC activation is quite wide – many effects go through that mechanism, possibly even all non-thermal effects in mammals. There are a number of other types of evidence confirming this mechanism of action of microwave frequency EMFs [2,]. Each of the 11 health impacts caused by non-thermal EMF exposures can be explained as being produced by indirect effects of VGCC activation [5,7].

It is now apparent [7] that these EMFs act directly on the voltage sensor of the VGCCs, the part of the VGCC protein that detects electrical changes and can open the channel in response to electrical changes. The voltage sensor (and this is shown on pp. 102-104 in [7]) is predicted, because of its structure and its location in the plasma membrane of the cell, to be extraordinarily sensitive to activation by these EMFs, about 7.2 million times more sensitive than are single charged groups elsewhere in the cell. What this means is that arguments that EMFs produced by particular devices are too weak to produce biological effects, are immediately highly suspect because the actual target, the voltage sensor of the VGCCs is extremely sensitive to these EMFs. **Because heating is mostly produced by forces on these singly charged groups elsewhere in the cell, limiting safety guidelines to heating effects means that these guideline allow exposures that are something like 7.2 million times too high**.

Why then does the FCC stick with these totally unscientific safety guidelines? That is the 64 billion dollar question. The FCC has been shown, in a long detailed document published by Harvard University Center for Ethics, to be a “captured agency”, that is captured by the telecommunications industry that the FCC is supposed to be regulating [9; can be obtained full text from web site listed in 9]. So perhaps the failure of the FCC to follow the extensive science in this important area, can be understood. Of course, what that means is that the FCC is completely failing in its role of protecting the public and it is a major blunder, therefore for either you or any other organization to depend on the FCC guideline as a reliable predictor of impacts of EMFs in humans.

So what is known about health impacts of Wi-Fi EMFs?

Table 1. The following Table summarizes various health impacts of Wi-Fi EMF exposures:

Citation(s)	**Health Effects**
[10,11,12,13,14,15,16]	Sperm/testicular damage, male infertility
[10,15,17,18,19,20]	Oxidative stress
[20]	Calcium overload

[11,12,20]	Apoptosis (programmed cell death)
[17]	Melatonin lowering; sleep disruption
[10,13]	Cellular DNA damage
[21]	MicroRNA expression (brain)
[18]	Disrupts development of teeth
[22]	Cardiac changes, blood pressure disruption; erythrocyte damage; catecholamine elevation
[23,24]	Neuropsych changes including EEG
[25]	Growth stimulation of adipose stem cells (role in obesity?)

Each of the effects reported above in 2 to 7 studies have an extensive literature for their occurring in response to various other microwave frequency EMFs so it should be clear that these observations on Wi-Fi exposures are highly probable to be correct. These include (see Table 1) findings that Wi-Fi exposures produce impacts on the testes leading to lowered male fertility; oxidative stress; intracellular calcium overload; apoptosis (a process that has an important causal role in neurodegenerative diseases); cellular DNA damage; neuropsychiatric changes including EEG changes. Each of these are very serious and oxidative stress has causal roles in many different human diseases; intracellular calcium overload has many different consequences – for example, it has a central role in causing neurodegenerative diseases; cellular DNA damage can cause cancer and produce mutations that impact future generations (if there are any). Other Wi-Fi effects each only documented by a single study are also effects where a variety of other non-thermal microwave EMFs also cause these, as shown by extensive literature on each of them. These include: melatonin lowering and sleep disruption; and the effects reported by Saili et al [22] cardiac changes, blood pressure disruption; erythrocyte damage; catecholamine elevation. So these may well be correct observations as well despite having only a single Wi-Fi specific study for each.

Summary:

1. The EMF safety guidelines supported by the FCC and others assume that only heating effects need be of concern. These assumptions have been known to be false for at least 45 years and there is a scientific consensus on this, that has lead to the petition by 206 highly qualified international scientists to the UN stating that current safety guidelines are inadequate.
2. We now know that low intensity non-thermal exposures work via VGCC activation and that indirect effects of such VGCC activation can produce each of the health effects that have been widely reported to occur in response to such EMF exposures for something like 60 years. These attack:

    a. **Our health**

  b. **Our brain function**
  c. **The integrity of our genomes**
  d. **Our ability to produce healthy offspring**

3. The voltage sensor of the VGCCs is stunningly sensitive to such low intensity EMFs, about 7.2 million times more sensitive than are singly charge groups elsewhere in our cells. The consequence of this is that safety guidelines allow exposures that are very roughly 7.2 million times too high.
4. The FCC has been shown, in a detailed Harvard University study, to be a Captured Agency, captured by the industry that it is supposed to be regulating. This provides an additional reason to be very highly skeptical about all FCC safety guidelines.
5. 15 studies have each shown health effects of Wi-Fi, most of which have also been shown to occur in response to low intensity exposures to other types of microwave frequency EMFs. These are likely to have massive health effects by producing male infertility (female infertility has not been studied in response to Wi-Fi), oxidative stress (involved in dozens of human diseases), cellular DNA damage (possibly leading to both cancer and mutations in future generations), life threatening cardiac effects, cellular apoptosis and also intracellular calcium overload (with both of these possibly leading to neurodegenerative diseases), various neuropsychiatric changes and many others.

It is my view that it is sheer insanity to fail to see the threat to our and to all human civilization by continuing to ignore the threats from such EMFs, starting with Wi-Fi.

Martin L. Pall, Professor Emeritus
Biochemistry and Basic Medical Sciences,
Washington State University,
martin_pall@wsu.edu

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Columbia University, College of Physicians and Surgeons
Department of Physiology and Cellular Biophysics

Board Member
Los Angeles Unified School District,
Board of Education

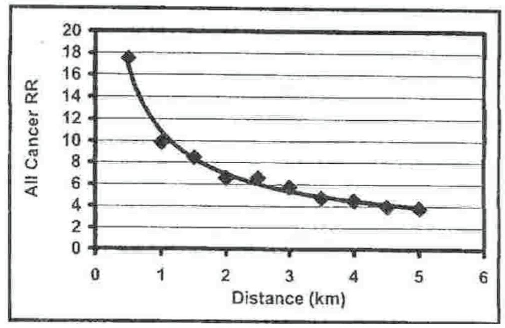
Re: Health effects of cell tower radiation

As an active researcher on biological effects of electromagnetic fields (EMF) for over twenty five years at Columbia University, as well as one of the organizers of the 2007 online Bioinitiative Report on the subject, I am writing in support of a limit on the construction of cell towers in the vicinity of schools.

There is now sufficient scientific data about the biological effects of EMF, and in particular about radiofrequency (RF) radiation, to argue for adoption of precautionary measures. We can state unequivocally that EMF can cause single and double strand DNA breakage at exposure levels that are considered safe under the FCC guidelines in the USA. As I shall illustrate below, there are also epidemiology studies that show an increased risk of cancers associated with exposure to RF. Since we know that an accumulation of changes or mutations in DNA is associated with cancer, there is good reason to believe that the elevated rates of cancers among persons living near RF towers are probably linked to DNA damage caused by EMF. Because of the nature of EMF exposure and the length of time it takes for most cancers to develop, one cannot expect 'conclusive proof' such as the link between helicobacter pylori and gastric ulcer. (That link was recently demonstrated by the Australian doctor who proved a link conclusively by swallowing the bacteria and getting the disease.) However, there is enough evidence of a plausible mechanism to link EMF exposure to increased risk of cancer, and therefore of a need to limit exposure, especially of children.

EMF have been shown to cause other potentially harmful biological effects, such as leakage of the blood brain barrier that can lead to damage of neurons in the brain, increased micronuclei (DNA fragments) in human blood lymphocytes, all at EMF exposures well below the limits in the current FCC guidelines. Probably the most convincing evidence of potential harm comes from living cells themselves when they start to manufacture stress proteins upon exposure to EMF. The stress response occurs with a number of potentially harmful environmental factors, such as elevated temperature, changes in pH, toxic metals, etc. This means that ***when stress protein synthesis is stimulated by radiofrequency or power frequency EMF, the body is telling us in its own language that RF exposure is potentially harmful.***

There have been several attempts to measure the health risks associated with exposure to RF, and I can best summarize the findings with a graph from the study by Dr. Neil Cherry of all childhood cancers around the Sutro Tower in San Francisco between the years 1937 and 1988. Similar studies with similar results were done around broadcasting antennas in Sydney, Australia and Rome, Italy, and there are now studies of effects of cellphones on brain cancer. The Sutro tower contains antennas for broadcasting FM (54.7 kW), TV (616 kW) and UHF (18.3 MW) signals over a fairly wide area, and while the fields are not uniform, and also vary during the day, the fields were measured and average values estimated, so that one could associate the cancer risk with the degree of EMF exposure.



The data in the figure are the risk ratios (RR) for a total of 123 cases of childhood cancer from a population of 50,686 children, and include a 51 cases of leukaemia, 35 cases of brain cancer and 37 cases of lymphatic cancer. It is clear from the results that the risk ratio for all childhood cancers is elevated in the area studied, and while the risk falls off with radial distance from the antennas, as expected, it is still above a risk ratio of 5 even at a distance of 3km where the field was 1μW/cm^2. This figure is what we can expect from prolonged RF exposure. In the Bioinitiative Report, we recommended 0.1μW/cm^2 as a desirable precautionary level based on this and related studies, including recent studies of brain cancer and cellphone exposure.

As I mentioned above, many potentially harmful effects, such as the stress response and DNA strand breaks, occur at nonthermal levels (field strengths that do not cause a temperature increase) and are therefore considered safe. It is obvious that the safety standards must be revised downward to take into account the nonthermal as well as thermal biological responses that occur at much lower intensities. Since we cannot rely on the current standards, it is best to act according to the precautionary principle, the approach advocated by the European Union and the scientists involved in the Bioinitiative report. In light of the current evidence, the precautionary approach appears to be the most reasonable for those who must protect the health and welfare of the public and especially its most vulnerable members, children of school-age.

Sincerely yours,

Martin Blank, Ph.D.
Associate Professor of Physiology and Cellular Biophysics

6840 Seaview Road, Sechelt, BC V0N 3A4
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MCPS COO Dr. Andrew Zuckerman
MCPS Interim Superintendent Larry Bowers
MCPS Board of Education
MCPS Office of Technology
Montgomery County Schools
Carver Educational Services Center
850 Hungerford Drive
Rockville, MD 20850

December 13, 2015

Dear Montgomery County COO Dr. Andrew Zuckerman, Interim Superintendent Larry Bowers, Board of Education and Office of Technology;

In my capacity as a pediatric occupational therapist, biologist, international speaker, and author on the subject of the impact of technology on child development and learning, I'm writing to you on behalf of students, teachers, and parents requesting you reconsider the use of devices which operate using wireless radiation.

Please find below guiding principles regarding managed balance between technology and healthy activity, as well as information on wireless radiation. More judicious use of educational based technologies is a safe manner, will serve to ensure sustainable futures for all children. Reversion to Ethernet or fiber optic cable devices, until such time as the World Health Organization deems wireless to not be harmful to young children, is recommended.

Guiding principles for the use of educational based technology in school environments.

Minimize Risk and Maximize Safety.

- Wireless radiation has not been proven safe (WHO 2011).
- Recent research indicates wireless radiation causes harmful effects to adult humans (Avendano 2012, Hardell 2013).
- Long term effects of wireless radiation on children are unknown at this time (AAP 2013).
- Children have thinner skulls, more aqueous bodies, and have rapidly developing cells, indicating they are exceedingly more vulnerable to harmful effects from wireless radiation than adults (AAP 2013, C4ST 2015).
- The American Academy of Pediatrics and the Canadian Pediatric Society recommends no more than 1-2 hours total technology use per day, including

educational technology. Many schools exceed these expert guidelines (AAP 2014).

Weigh Risk vs. Benefit.

- Education technology is not evidence based and is laden with conflict of interest e.g. manufacturers claims are financially motivated, and are not substantiated by university level research.
- Traditional and standardized teaching methods have substantive research support and evidence, yet are being rapidly replaced with education technology.

Ensure adequate foundational skills prior to use of technology.

Children need to balance the following 4 critical factors with technology, to optimize development and learning. Time spent with technology adversely affects these factors.

- *Movement:* stimulates vestibular, proprioceptive and cardiovascular systems.
- *Touch:* stimulates parasympathetic system for lowered cortisol and adrenalin.
- *Human Connection:* activates parasympathetic system; a life sustaining force.
- *Nature:* attention restorative, improves learning, erases effects of technology.
- *See video:* Message to Schools on EdTech

Risks associated with the use of technology by children are as follows:

- *Sedentary nature* of technology use is causally related to the recent rise in obesity/diabetes, developmental delay and learning difficulties (Tremblay 2011, HELP EDI Mapping 2009/13, Ratey 2008, PISA 2012).
- *Isolating factor* of technology use is associated with escalation in social impairments, mental illnesses (including adhd and autism), and self-regulation difficulties (Houtrow 2014).
- *Overstimulation* from technology use is a causal factor in rise in attention deficit, aggression, sleep disturbance, and chronic stress from hyper-arousal of the sympathetic nervous system (Christakis 2004, Gentile 2009, Markman 2010, Bristol University 2010).
- *Neglect* of students by teachers and support staff who are engaged in their own personal technology, is unfortunately common.
- Consequently, the risks associated with using education technology far outweigh the dubious benefits.

When In Doubt, Act With Caution.

- Existing research on harmful effects of wireless radiation on *adults*, indicates taking a cautionary approach when considering same radiation exposure to *children* (AAP 2014).

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- Rapid cell turnover in children creates particular concern regarding potential DNA damage from wireless radiation, and consequent susceptibility to cancer. While rise in cancer incidence is becoming more apparent, rise in rates of cancer in children will not be observable until adulthood.
- Removal of wireless radiation and reversion to Ethernet cabled devices, will ensure immediate and long term safety to all students, teachers, and support staff.
- Defaulting to a remote authority regarding removing wireless radiation from schools, is not acting in the best interests of students and staff, and may not be defensible in a court of law.

Montgomery County's statement that the radiofrequency levels in schools "is compliant" with federal regulations *does not* assure safety to the students in your care. The current proposed technology plan to further increase the use of screens in classrooms on a daily basis, clearly does not support children's healthy development.

The implications of failure of schools to act with caution now regarding wireless radiation and technology, could potentially be horrific in both scope and magnitude, and may constitute neglect of children. Please act now to safeguard your children's future.

Respectfully,

CRowan

Cris Rowan, BScBi, BScOT, SIPT, AOTA Approved Provider
CEO Zone'in Programs Inc. and Sunshine Coast Occupational Therapy Inc.
crowan@zonein.ca email
Websites: www.zonein.ca, www.suncoastot.com, www.virtualchild.ca;
Blog: www.movingtolearn.ca

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P.O. Box 58
Teton Village, WY 83025
www.ehtrust.org

Montgomery County Board of Education
Montgomery County Schools
Carver Educational Services Center
850 Hungerford Drive
Rockville, MD 20850

January 20, 2016

Dear Montgomery County Board of Education,

Concerned parents in your school district have asked me to write to you regarding the health risks of wireless radiofrequency radiation exposure in the classroom. Based on what I have been told, I want to urge you to halt programs that currently have students use their own phones in ways that expose their eyes and brains to levels of radiation that have never been tested for safety.

I was Founding Director of the Board on Environmental Studies and Toxicology of the U.S. National Research Council, and Founding Director of the Center for Environmental Oncology at the University of Pittsburgh Cancer Institute. President Clinton appointed me to the Chemical Safety and Hazard Investigation Board, and I am former Senior Advisor to the Assistant Secretary for Health in the Department of Health and Human Services. I founded the non-profit Environmental Health Trust in 2007 to provide basic research and education about environmental health hazards. Our scientific team is currently focusing on the health risks of radiofrequency radiation as an important public health issue.

Many people are unaware that cell phones and wireless laptops and tablets function as two-way microwave radios. A typical classroom might have the following scenario: every student has a laptop--which is typically tested for use 8 inches from an adult male body--a cell phone in the pocket--which is also tested at a minimum distance from an adult male body-- and a network transmitter on the ceiling and possibly a cell tower outside next to the sports field. All these devices emit microwave radiation which can be readily absorbed into children's bodies and brains.

Manufacturers specifically recommend that cell phones be used "as tested"—at this little-known minimum distance from the body. Recently, *Consumer Reports* in November advised that people should not keep phones in the pocket—advice that few children or adults appreciate. *These devices have never been tested for safety with children.* Accumulating research indicates that long-term exposure to low levels over long lifetimes could pose a serious risk to our health.

Regarding tested distances for using laptops, the Federal Communications Commission (FCC) states that laptops and computers are “mobile devices are transmitters designed to be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.” The body in this instance refers to a large male weighing more than 200 pounds and standing six feet tall.

As the county is preparing to increase student use of Chromebooks, please be aware that the Samsung Chromebook manual states:
“United States of America USA and Canada Safety Requirements and Notices

- Do not touch or move antenna while the unit is transmitting or receiving.
- Do not hold any component containing the radio such that the antenna is very close or touching any exposed parts of the body, especially the face or eyes, while transmitting.
- Regardless of the power levels, care should be taken to minimize human contact during normal operation.
- This device should be used more than 20 cm (8 inches) from the body when wireless devices are on and transmitting.
- FCC Statement for Wireless LAN use: *“While installing and operating this transmitter and antenna combination the radio frequency exposure limit of 1mW/cm2 may be exceeded at distances close to the antenna installed. Therefore, the user must maintain a minimum distance of 20cm from the antenna at all times.”*

As one of the leaders in educational policy of this nation, your school district has an opportunity to set an example for school districts nationwide by installing safer technology in classrooms and educating students, teachers and staff about tested distances that devices should be used to reduce radiation. A number of public and private schools have already implemented such policies. Just as we provide children with seat belts and bike helmets, a precautionary approach to wireless is recommended by many scientists and governments worldwide.

For more information about all of these issues, please read cell phone instructions for various models at http://showthefineprint.org. Our newly posted Ebook also details fine print safety instructions in wireless device user manuals.

When children use these devices close to their bodies, they are exceeding these safety instructions, and exposing themselves to radiofrequency (RF) radiation levels which can exceed our government FCC RF radiation exposure limits. The FCC RF exposure limit was designed to protect the public from the thermal (heating) effects of acute exposure to RF energy. The FCC states, “Tissue damage in humans could occur during exposure to high RF levels because of the body's inability to cope with or dissipate the excessive heat that could be generated. Two areas of the body, the eyes and the testes, are particularly vulnerable to RF heating because of the relative lack of available blood flow to dissipate the excess heat load.”

CHILDREN ABSORB MORE RADIATION THAN ADULTS

Our recently published research in the IEEE *Spectrum* with investigators at the Federal Universities of Brazil provides new state-of-the-art radiation exposure brain modeling which confirms that substantially higher radiofrequency radiation doses occur in younger children as compared to adults even where products comply with tested guidelines developed for adults.

FCC REGULATIONS ARE OUTDATED

FCC exposure limits were set more than 19 years ago and were based on decades-old research. The Government Accountability Office published a 2012 Report that calls on the FCC to formally reassess their current RF energy (microwave) exposure limits, stating that the "FCC RF energy exposure limit *may not* reflect the latest research." I encourage you to read scientific submissions to FCC Proceeding Number 13-84 at http://bit.ly/1aGxQiq. It is unknown when the FCC will make a ruling, however, *until that time* the current outdated FCC limits are *not reflective* of the current state of science.

FCC REGULATIONS DO NOT PROTECT THE PUBLIC FROM BIOLOGICAL EFFECTS

As the California Medical Association states in their 2014 Resolution calling for updated FCC Regulations, "peer reviewed research has demonstrated adverse biological effects of wireless EMF [electromagnetic fields] including single and double stranded DNA breaks, creation of reactive oxygen species, immune dysfunction, cognitive processing effects, stress protein synthesis in the brain, altered brain development, sleep and memory disturbances, ADHD, abnormal behavior, sperm dysfunction, and brain tumors."

In May 2015, over 200 scientists who have authored more than 2,000 articles on this topic appealed to the United Nations to address "the emerging public health crisis" related to cellphones and other wireless devices, urging that the United Nations Environmental Programme (UNEP) initiate an assessment of alternatives to current exposure standards and practices that could substantially lower human exposures to non-ionizing radiation. These scientists state that "the ICNIRP guidelines do not cover long-term exposure and low-intensity effects, " and are " insufficient to protect public health." They also state that "the various agencies setting safety standards have failed to impose sufficient guidelines to protect the general public, particularly children who are more vulnerable to the effects of EMF." Please see their website at https://emfscientist.org.

INCREASED CANCER RISK

Wireless radiofrequency radiation was classified as a Class 2B "Possible Human Carcinogen" by the World Health Organization's International Agency for Research on Cancer in 2011. According to many scientists, evidence *has increased* since 2011, indicating that cell phone and wireless radiation should be classified as a "probable carcinogen." Those exposed at younger ages show four to eight times increased cancer risk. Replicated research just published in Biochemical and Biophysical Research Communications indicates that radiofrequency acts as a *tumor promoter* at low to moderate levels.

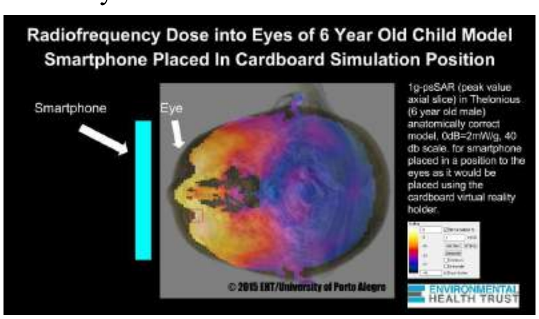
CONCERN FOR PREGNANT STUDENTS AND STAFF

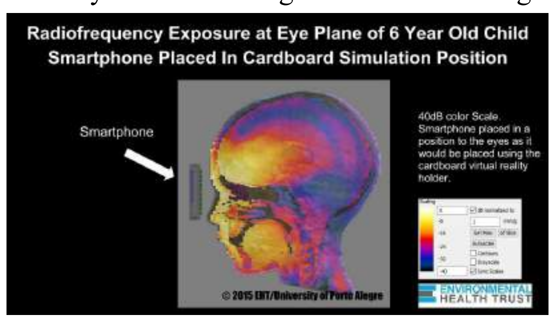
Pregnant students and staff are especially at risk from wireless because the fetus is the most vulnerable to toxic exposures. Several experimental studies are showing irreversible changes after prenatal exposure to cell phone and wireless radiation such as altered brain functioning, decreased brain cells and altered reproductive organ development. More than 100 physicians, scientists and public health professionals joined together to express their concern about the risk that wireless radiation poses to pregnancy and now *urge pregnant women to limit their exposures*. Please read these scientists BabySafe Joint Statement

VIRTUAL TECHNOLOGY RESULTS IN HIGHER EXPOSURES TO THE EYE AND BRAIN

Most recently, I was contacted by a parent in your district about the virtual reality devices now used in MCPS classrooms to go on a virtual "field trip." As indicated by online instructions, this experience involves using smartphones placed directly in front of the child's eyes so that they can directly watch a fascinating video of faraway lands. The smartphone is streaming radiation throughout the classroom from the teacher's iPad for the entire "field trip."

Please be aware that FCC regulations set decades ago did not utilize science that looks at the effects from cell phones on different body tissues such as the eyes. Upon hearing about this issue, I contacted EHT-associated scientists at federal universities of Brazil who do state-of-the-art computer modeling. I asked them to position the phone as it would be in the virtual reality cardboard for use in front of the child's eyes and assess the microwave radiation. The yellow and orange color show the highest exposures.





My colleagues and I are sharing this work with you today because we believe you should have more information about microwave radiation exposures that will take place through this system.

This research image above utilizes a sophisticated computer system that the U.S. Food and Drug Administration (FDA) currently applies to evaluate medical devices. It simulates the radiation absorption into *anatomically correct models*--something that currently used systems for testing phones and devices cannot do. In a study from Memorial Sloan-Kettering Cancer Center, radiation physicist David Gultekin, working with Bell Labs electrical engineer Lothar Moeller, reported that normal working cell phones can create tiny hotspots within brain tissue. Unlike other organs, eyes do not have circulation to effectively carry away heat.

In addition to the impact from the microwave radiation, there could also be impacts to a child's retina from the blue light emitted by the screen. Youths under the age of 20, and especially very young children, have little or no yellowing of the lens (which helps protect the adult eye). Therefore, blue light (or UV) which enters the eye is unfiltered in children and strikes the retina at full-strength exposing not only the retina, but the lens to possible damage over the long time. Such injury may not be evident until later in time.

In 2010, Andreas Christ and team reported that children's hippocampus and hypothalamus absorbs 1.6–3.1 times higher and the cerebellum absorbs 2.5 times higher microwave radiation compared to adults; children's bone marrow of the skull absorbs 10 times higher microwave radiation than in adults, *and children's eyes absorb much higher microwave radiation than adults.* A recent Deans' Lecture I delivered to University of Melbourne provides an overview on this research.

SIMPLE STEPS WILL PROTECT CHILDREN

Compelling research raises the possibility of very serious harm to children from radiofrequency radiation exposures well below "FCC compliant" levels. Legal does not mean safe. Based on the preliminary work that I share with you here, I urge you to forgo the use of such devices such as virtual reality cardboard as there is no research that has considered their impact on children's eyes. At this time, the smart choice for school decision makers is to act now and reduce radiofrequency wireless exposures. In fact, many countries (over 20) and health authorities worldwide recommend reducing radiofrequency radiation to children.

More recently, the Cyprus Government's National Committee on Environment and Children's Health released a video about reducing wireless and I invite you to watch this excellent example of responsible action at this link https://www.youtube.com/watch?v=H43IKNjTvRM .

I understand that your county has a Bring Your Own Device policy whereby cell phones are not only allowed *in* the classroom but are actively used in the curriculum. As I have been told, students in film class might use their cell phones to take footage to create a movie, and in some math classes they use their cell phones as a calculator. Advice should be routinely provided to any student using a wireless device at school about *how to reduce exposures*. For example, if phones are used on airplane mode, and wireless is turned off on computers then these devices will neither send nor receive microwave radiation.

When powered on, phones undergo short bursts of microwave radiation up to 900 times per minute, *whether or not the phone is being used for talking.* Once teachers and students are educated on how they can simply turn their phone onto airplane mode, then they can use the phone in the classroom *without* being exposed to unnecessary radiofrequency radiation.

Likewise, laptops such as Chromebooks are also emitting constant radiation and at much higher levels when a student is streaming video or using cloud based applications. Laptops can easily be hardwired to ethernet so that students can safely use the internet without radiation emissions. Please review the Best Practices for Low EMF in Schools developed by the Northeast Collaborative For High Performing Schools which details how schools can reduce exposure to radiofrequency fields and still have full internet connectivity.

Along with the recommendation of over 200 scientists (see https://emfscientist.org) and health authorities worldwide, I recommend that the best course of action is to take simple precautions—as many nations already currently advise. *Children's exposures to wireless radiation should be reduced as much as possible.* We have a responsibility to act now to reduce children's exposure to radiofrequency radiation. Children's nervous, immune and reproductive systems are rapidly developing and, along with pregnant women, children deserve an abundance of caution.

As several colleagues and I wrote in a letter to the U.S. Secretary of Education just a few months ago, we recommend your school district do the following:

1. **Raise school community awareness through new educational curriculum:** Students, teachers and their families should be given information on wireless health risks and simple precautionary steps they can take to protect their health. It is important to teach children how to use technology both safely and more responsibly in order to protect their health and wellbeing.

2. **Install a safe communication and information technology infrastructure in schools to meet educational needs:** Solutions exist to reduce exposures to wireless emissions and mitigate the health risk. Low-EMF Best Practices have been developed, allowing educational needs to be met with safer, hard-wired Internet connections, which are also faster and more secure.

Low-EMF Best Practices are the solution that allows for full communication, information access and learning tools use in the classroom while minimizing unnecessary health risks. Your district can thoughtfully integrate safe technology into every classroom while responsibly safeguarding the health of every generation.

I fully understand that this information has not been widely understood. I would be happy to provide or develop an online technical briefing to your senior staff to assist you as you make decisions today that will affect the health of students for the rest of their lives.

Yours respectfully,

Devra Davis

Devra Davis, PhD MPH
President and Founder
Environmental Health Trust
Visiting Professor of Medicine
The Hebrew University, Hadassah Medical Center
Associate Editor, Frontiers in Radiation and Health
ehtrust.org

UNIVERSITY AT ALBANY
State University of New York

Institute for Health and the Environment
WHO Collaborating Center in Environmental Health

July 28, 2014

Board of Trustees
Fay School
48 Main Street
Southborough, MA 01772

Re: Advisability of WiFi in schools

Dear Sirs/Madams:

This is concerning potential adverse health effects associated with exposure to radiofrequency/microwave (RF/MW) radiation, specifically that from wireless routers and wireless computers. I am writing to express concern that students at your school are experiencing electrosensitivity symptoms from these technologies.

I am a public health physician who has been involved in issues related to electromagnetic fields (EMFs) for several decades. I served as the Executive Secretary for the New York Powerline Project in the 1980s, a program of research that showed that children living in homes with elevated magnetic fields coming from powerlines suffered from an elevated risk of developing leukemia. I served as Director of the Wadsworth Laboratory of the New York State Department of Health, as well as Dean of the School of Public Health at the University at Albany/SUNY. I have edited two books on effects of EMFs, ranging from low frequency fields to radiofrequency/ microwave radiation, or the kind emitted by WiFi routers, cell phones, neighborhood antennas and wireless computer equipment. I served as the co-editor of the BioInitiative Report 2012 (Bioinitiatve.org), a comprehensive review of the literature showing biological effects at non-thermal levels of exposure, much of which has since been published in the peer-reviewed journal, *Pathophysiology* (attached). Also, I served on the President's Cancer Panel that examined radiation exposures as they relate to cancer risk, in 2009, and a report from that testimony is also attached. Thus, this is a subject which I know well, and one on which I take a public health approach rooted in the fundamental principle of the need to protect against risk of disease, even when one may not have all the information that would be desirable.

There is clear and strong evidence that intensive use of cell phones increases the risk of brain cancer, tumors of the auditory nerve and cancer of the parotid gland, the salivary gland in the cheek by the ear. The evidence for this conclusion is detailed in the attached publications. The WHO's International Agency for Research on Cancer has also classified the radiation from both cell phones and WiFi as a Class 2B "Possible Carcinogen" (2011). WiFi uses similar radio-frequency radiation as cell phones (in the 1.8 to 5.0 GHz range). The difference between a cell phone and a WiFi environment, however, is that while the cell phone is used only intermittently, and at higher power, a WiFi environment is continuous, and transmitting even when not being used. In addition, WiFi transmitters are indoors, where people (and in this case, children) may be very close by, or certainly close to devices using the WiFi, such as wireless computers, iPads and smart boards, the radiation from which can be intolerable to sensitive people.

Furthermore, commercial routers, like those in schools, operate at much higher wattage than consumer routers. They are designed to penetrate through materials like cement, wood and brick, to handle dozens to hundreds of users, and to reach into outdoor areas, so industrial grade routers are of much greater concern.

An additional consideration to appreciate is that it is not only the power of wireless radiation that causes biological dysregulation, but the frequencies, pulsing, amplitude, and the quantity and kind of information being transmitted that can have effects as well. These 'non-thermal effects' have been shown in thousands of studies to be biologically active, and may be more important than the effects from the power. Thus, while a router may be in the ceiling, or not right next to a student, teacher or administrator, the known biological and health effects, particularly the non-thermal ones, are still very much occurring.

Finally, while acute electrosensitivity symptoms, like the ones I understand your students are experiencing, are of course of great concern (such as cognitive effects impairing attention, memory, energy levels, and concentration; cardiac irregularities, including in children; or, headaches or other symptoms in students wearing braces), the full effects for society from chronic and cumulative exposures are not known at this time. Given what we do know, however, including the DNA effects, I must, as a public health physician, advise minimizing these exposures as much as possible. Indications are that cell phones and wireless technologies may turn out to be a serious public health issue, comparable to tobacco, asbestos, DDT, PCBs, pesticides and lead paint, or possibly worse given the ubiquitous nature of the exposures. While unfortunately we must wait for federal regulation to catch up with the science, the prudent thing to do in the interim would be to exercise precaution at every opportunity.

Computers and the world-wide web have tremendous value in education, but the value also depends on how these are used in numerous respects. As wired internet connections do not pose radiation risk, are readily available, are faster and more secure than WiFi, and are now even available for certain tablets, I highly recommend you factor the risks I have described into your technology planning. At the same time, I would urge you to take the complaints of your students very seriously, and potentially involve the school nurse and teachers in helping to assess the extent of the electrosensitivity problem among students at the school.

An excellent reference on the EMF and electrosensitivity science is "Electrosensitivity and Electrohypersensitivity—A Summary" (2013) authored by M.J. Bevington and available through Electrosensitivy-U.K. (www.es-uk.info/)

If I can be of further help, please do not hesitate to call.

Yours sincerely,

David O Carpenter

David O. Carpenter, M.D.
Director, Institute for Health and the Environment
University at Albany

Enclosures

Martin Blank, PhD
Department of Physiology and Cellular Biophysics
Columbia University
New York, NY 10032

July 25, 2014

Mr. Thomas McKean, President, Board of Trustees
Mr. James Shay, President-Elect, Board of Trustees
Fay School
48 Main Street
Southborough, MA01772

To the Board of Trustees,

It has been brought to my attention that school children have become symptomatic at your school after installation of WiFi. I am writing to express my concern and to encourage you to review the independent science on this matter.

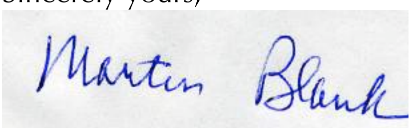
I can say with conviction, in light of the science, and in particular in light of the cellular and DNA science, which has been my focus at Columbia University for several decades, putting radiating antennas in schools (and in close proximity to developing children) is an uninformed choice. Assurances that the antennas are within 'FCC guidelines' is meaningless today, given that it is now widely understood that the methodology used to assess exposure levels only accounts for one type of risk from antennas, the thermal effect from the power, not the other known risks, such as non-thermal frequencies, pulsing, signal characteristics, etc. They fail also to consider multiple simultaneous exposures from a variety of sources in the environment, and cumulative exposures over a lifetime. Compliance with FCC guidelines, thus, unfortunately, is not in any way an assurance of safety today, as the guidelines are fundamentally flawed. Until the guidelines and advisories in the U.S. are updated, the intelligent thing for your Board of Trustees to do is to exercise the Precautionary Principle and hard wire all internet connections.

I know this might be disappointing to hear, as I understand you have invested in the WiFi. But there is no amount of money that could justify the added physiological stress from wireless antenna radiation and its many consequences, most in particular for children. Our research has shown that the cellular stress response, a protective reaction that is indicative of cellular damage, occurs at levels that are deemed 'safe'. Many other harmful reactions have been reported, such as the impairment of DNA processes that can account for the observed increased risk of cancer, as well as the potential cognitive decline, and sleep effects that may be due to impairment of the blood brain barrier. The DNA effects are of particular concern for future generations, an area of research that is just beginning to raise alarms. As with other environmental toxic exposures, children are far more vulnerable than adults, and they will have longer lifetimes of exposure.

The science showing reasons for concern about the microwave radiation emitted by antennas is abundant and there will be a day of reckoning. As I explain in my recent book, *Overpowered*, The Precautionary Principle instructs us that in the face of serious threats, a lack of scientific 'certainty' never justifies inaction. The changes occurring at the molecular level, and known associations with many diseases, are sufficient at this time to give us pause and to recommend minimizing exposures to these fields, in our homes, schools, neighborhoods and workplaces. There is significant potential for risk, and to very large numbers of people, and the effects are occurring nonetheless whether or not we are noticing them.

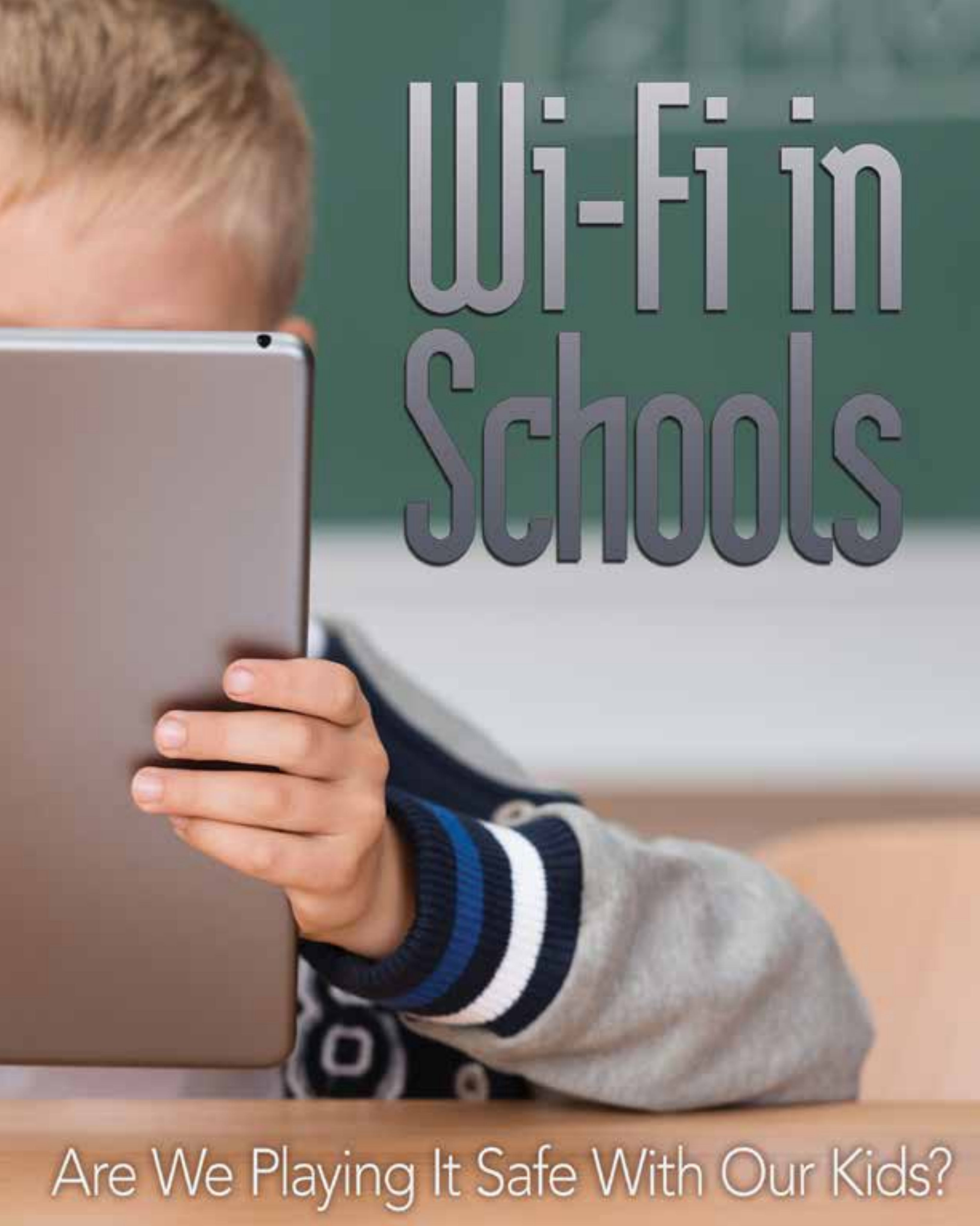
I recommend you hardwire the internet connections at your school, and also encourage students to use hard wired connections at home for internet access, as well as for all computer equipment connections and voice communications.

Sincerely yours,



Martin Blank, PhD
mb32@columbia.edu,

Martin Blank, PhD, Special Lecturer and (ret.) Associate Professor, Columbia University, Department of Physiology and Cellular Biophysics. Dr. Blank is a leading expert in the effects of electromagnetic fields on DNA and biology, and Past President of the Bioelectromagnetics Society. He holds two PhDs, in physical chemistry and in colloid science, an interdisciplinary field involving chemistry, physics and nanoscience. Dr. Blank was author of the BioInitiative Report's section on the impact of electromagnetic fields on Stress Proteins; Editor of the journal *Pathophysiology*'s special issue on Electromagnetic Fields (2009); and co-author of "Electromagnetic fields and health: DNA based dosimetry" (2012), which recommends a new way of assessing the biological impact of electromagnetic fields across the spectrum, using DNA. Dr. Blank's book, *"Overpowered—What Science Tells Us About the Dangers of Cell Phones and Other WiFi-Age Devices"*, was published in 2014.



Wi-Fi in Schools

Are We Playing It Safe With Our Kids?

“Current FCC standards do not account for the unique vulnerability and use patterns specific to pregnant women and children. It is essential that any new standard for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded throughout their lifetimes.” American Academy of Pediatrics Letter to FCC August 29, 2013 (20)

By Cindy Russell, MD

VP of Community Health, SCCMA

Industry has been quite successful in creating magically useful wireless technologies such as cell phones, Ipads, Wi-Fi, and now wearable tech devices such as Google glasses, we all love. Many of these handy gadgets have now reached the typical classroom across the globe. It has become apparent, however, that there are substantial downsides to being too connected to technology and as safety concerns mount, governments such as France and Israel are backing away from the blind adoption of wireless technology in schools, especially for young children.

These devices are cool and convenient, however there remains nagging questions of overuse and safety as the application of these devices has increased to the point we are literally exposed 24 hours a day to this radiation. Wireless microwaves come from many sources both at work and at home.

An increasing number of physicians, scientists, and parents are concerned about long term health effects from Wi-Fi in schools. (42)(43)(44)(49) As any parent knows, computers now are as ubiquitous in schools as they are at work. From kindergarteners on up kids are required to learn computer skills in order to take core testing online. There is a push to enable students to be connected to the internet 24/7 to take photos, email documents, and research a topic. In schools, wired connections for computers have been rapidly being eliminated to install wireless systems that connect students both indoors and outdoors on campus.

Europe and some schools in the U.S. are taking a different more precautionary approach and going back to the future with wired plug in computers. Studies have also cast doubt on some of the benefits of classroom computers and warned of the new age of “Digital Dementia” which has now crept into Korean youth due to the heavy use of electronic gadgets. (17)(48)

Professors in college are banning computers during lectures and finding students learn more. (38) (39)

CHILDREN ARE MORE VULNERABLE THUS NEED MORE PROTECTION

Children have several organ systems that are immature at birth and are thus much more sensitive to toxic exposures. The human brain, one of the top vital organs, is far from being a finished product in youth. Long-term structural maturation of the nervous system is required for successful development of cognitive, motor, and sensory functions. Neuronal axons – long thin projections from the nerve cell – act as electronic transmission lines. Axons in major pathways of the brain continue to develop throughout childhood and adolescence. Myelin is the insulation surrounding individual nerves protecting it from outside electrical charges. The process of myelination is much faster the first two years but continues into adulthood. (16) Children have thinner skulls (29), their immune systems are undeveloped, their cells are dividing more rapidly, thus, they are more vulnerable to EMF radiation and other carcinogens. They also have a longer cumulative exposure to all toxins including EMF radiation.

CURRENT WIRELESS SAFETY STANDARDS AND MICROWAVING POTATOES

Wireless devices work on high frequency microwaves similar to the microwave you use to cook food with. It is with less power but substantial research (1)(2)(3)(4) demonstrates that even at low power within the current safety standards these microwaves can cause biologic harm to plants, animals, and cellular structures. Current Federal Communications Commission (FCC) standards are based only on heat generated by the device, not on adverse biological effects seen in hundreds of studies and at much lower levels.

Our own CMA supports reassessment of EMF standards. The California Medical Association, in 2014, passed a resolution as follows:

> “Resolved 1:That CMA supports efforts to re-evaluate microwave safety exposure levels associated with wireless communication devices, including consideration

Continued on page 18

of adverse nonthermal biologic and health effects from non-ionizing electromagnetic radiation used in wireless communications and be it further

Resolved 2: That CMA support efforts to implement new safety limits for wireless devices to levels that do not cause human or environmental harm based on scientific research.

ADVERSE EFFECTS DEMONSTRATED IN PEER REVIEWED PUBLISHED RESEARCH (2)

- DNA with single and double stranded breaks
- Leakage of the blood brain barrier (two hours of cell phone exposure causes 7+ days of albumin leakage)
- Stress protein production in the body indicating injury
- Infertility/reproductive harm
- Neurologic harm with direct damage to brain cells
- Lowering of melatonin levels
- Immune dysfunction
- Inflammation/oxidation.

PLAUSIBLE MECHANISM FOUND FOR EMF MICROWAVE EFFECTS

Dr. Martin Pall, Professor Emeritus of Biochemistry, Washington State University has studied how electromagnetic fields impact the cells of our bodies. His 2013 paper on this subject highlights a major biological mechanism of action of EMF microwave radiation on cell structure. His work, along with two dozen prior studies, demonstrated that EMF microwave radiation effects cellular calcium channels and this can be inhibited with calcium channel blockers. "A whole series of biological changes reportedly produced by microwave exposures can now be explained in terms of this new paradigm of EMF actions via Voltage Gated Calcium Channels (VGCC) activation." (14)(15)

In May 2011, the International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B).(30)

EMF AFFECTS ON WILDLIFE: BIRDS, BEES, AND TOMATO PLANTS

Bird researchers in Germany found that their migratory European Robins lost their sense of navigation when in the city. (5) This was found to be due to the EMF radiation interfering with the bird's special internal magnetic compass. They replicated the experiment over seven years before publishing the results in the prestigious journal *Nature*.

John Phillips and others have found that newts, sea turtles, and migratory birds use a magnetic compass to navigate long distances and this can be interrupted by low levels of EMF. (6)(7) A review of effects on cell towers and wireless devices showed that beehives can have rapid colony collapse with exposure to cell phone radiation. (8)

Plants have been shown to have stress response to EMF from wireless devices. (9)(10) (22) In tomatoes exposed for short duration, the stress response seen by exposure to EMF was prevented by administration of calcium counteracting drugs. (11) Even simple high school science experiments document abnormal seed growth near Wi-Fi routers. (19) There appear to be adverse biological effects of this seemingly harmless radiation.

HUMAN ELECTROSENSITIVITY: IS IT REAL?

There is varied opinion about those who state they are sensitive to EMF. Scientific research has not given a definitive answer, nevertheless, many seem to suffer from vague and often disabling symptoms they feel in the presence of EMF. Exposure to EMF radiation in some people reportedly causes headaches, memory problems, fatigue, sleep disorders, depression. This is so significant for some people that they have to live in a very low EMF environment to feel normal. (25)

Sweden recognizes electro-sensitivity as a functional impairment and estimates that about 3% of the population suffers from this. (23)(24) Dr. Magda Havas found in replicated studies that some EMF sensitive individuals heart rates increased with wireless devices turned on in double blind study. (12)(26) Researchers at Louisiana State University, in 2011, studied a self reported EMF sensitive physician and found "In a double-blinded EMF provocation procedure specifically designed to minimize unintentional sensory cues, the subject developed temporal pain, headache, muscle twitching, and skipped heartbeats within 100 s after initiation of EMF exposure ($p < .05$)." They concluded that "EMF hypersensitivity can occur as a bona fide environmentally inducible neurological syndrome." (27)

Genius and Lipp reviewed the current literature on EHS, in 2011, and point to several explanations for this multisystem phenomenon, including toxicant induced loss of tolerance as many with EHS symptoms had high levels of PCB's possibly causing immune dysfunction. Scientific research also identifies an inflammatory response with cytokine production. Another aspect of research points to catecholamine and adrenal gland dysfunction. In addition, heavy metal toxicity has also been proposed as contributing to EHS. (28)

The Austrian Medical Association feels Electrohypersensitivity is a real phenomenon and in 2012 published Guidelines for EMF and Electro-hypersensitivity. They state the primary method of treatment should consist in the prevention or reduction of EMF exposure, taking care to reduce or eliminate all sources of EMF if possible. (32)

GOVERNMENT ACTIONS ON WI-FI IN SCHOOLS

While much of the U.S. is marching forward with Wi-Fi in schools, Europe is changing direction, as indicated by the policies listed below. (45) Internationally there is wide disagreement in standards. The U.S. and Canadian limits are 1000 microwatts/cm2. China and Russia are 10 microwatts/cm2. Belgium is 2.4 microwatts/cm2, and Austria is 0.001 microwatts/cm2. The Bioinitiative Report 2012 recommendation for "No Observable Effect" is 0.0003 microwatts/cm2. Cosmic background EMF we evolved with is <0.00000000001 microwatts/cm2. (2)

COUNCIL OF EUROPE PARLIAMENT ASSEMBLY 2011 EMF MICROWAVE POLICY : "THE POTENTIAL DANGERS OF ELECTROMAGNETIC FIELDS AND THEIR EFFECT ON THE ENVIRONMENT"

The report notes "other non-ionizing frequencies, whether from extremely low frequencies, power lines or certain high frequency waves used in the fields of radar, telecommunications, and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects, and animals, as well as the human body, even when exposed to levels that are below the official threshold values."

The Council calls for a number of measures to protect humans and the environment, especially from high-frequency electromagnetic fields. One of the recommendations is to "take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumors". (37)

IN FRANCE: A NEW NATIONAL LAW BANS WI-FI IN NURSERY SCHOOLS

In January 2015, France passed a landmark law that calls for precaution with wireless devices for children and the general public. (34)(35) It calls for:

1. Wi-Fi banned in nursery schools.
2. Wi-Fi routers should be turned off in school when not in use.
3. Schools are informed when new tech equipment is installed.
4. Citizens will have access to environmental cell tower radiation measurements near homes.
5. There will be continued research conducted into health effects of wireless communications.
6. Information on reducing exposure to EMF radiation is mandatory in the contents of the cell phone package.
7. Wi-Fi hotspots are labeled.

ISRAELI MINISTRY OF EDUCATION ISSUE GUIDELINES TO LIMIT WI-FI IN SCHOOLS

On August 27, 2013, the Israeli Ministry of Education issued new guidelines regarding Wi-Fi use in schools. (33) The guidelines will:

1. Stop the installation of wireless networks in classrooms in kindergarten.
2. Limit the use of Wi-Fi between first and third grades. In the first grade, students will be limited to use Wi-Fi to study for one hour per day and no more than three days per week. Between the first and third grades, students will be limited to use Wi-Fi up to two hours per day for no more than four days per week.
3. To limit unnecessary exposure teachers will be required to turn off mobile phones and Wi-Fi routers when they are not in use for educational purposes.
4. All Wi-Fi equipment be tested for compliance with safety limits before and after installation in an Israeli school.
5. Desktop computers and power supplies be kept at least 20 cm from students.

2012 THE RUSSIAN COMMITTEE ON NON-IONIZING RADIATION PROTECTION OFFICIALLY RECOMMENDED THAT WI-FI NOT BE USED IN SCHOOLS.

2011 THE RUSSIAN COMMITTEE ON NON-IONIZING RADIATION PROTECTION (RNCNIRP) RELEASED THEIR RESOLUTION ENTITLED "ELECTROMAGNETIC FIELDS FROM MOBILE PHONES: HEALTH EFFECTS ON CHILDREN AND TEENAGERS."

According to the opinion of the Russian National Committee on Non-Ionizing Radiation Protection, the following health hazards are likely to be faced by the children mobile phone users in the nearest future: disruption of memory, decline of attention, diminishing learning and cognitive abilities, increased irritability, sleep problems, increase in sensitivity to the stress, increased epileptic readiness. (36)

Expected (possible) remote health risks: brain tumors, tumors of acoustical and vestibular nerves (in the age of 25-30 years), Alzheimer's

Continued on page 20

Wifi In Schools, continued from page 19

disease, “got dementia”, depressive syndrome, and the other types of degeneration of the nervous structures of the brain (in the age of 50 to 60).

PLAYING IT SAFE FOR OUR KIDS

A healthy and safe learning environment is a cornerstone of education. Current FCC standards are obsolete and inappropriate as they are based only on heat effects, not biological effects. They give us a false sense of security. There may be higher EMF levels at school than at home as routers are more powerful. Cumulative Effects on DNA or cell structures are not taken into consideration in any safety standard. Because of the long-term exposure to EMF microwave radiation this generation is experiencing, they will be at higher risk for potential health problems. We will not know what happens to our progeny’s DNA until our grandchildren are born.

Considering there has been a more precautionary approach internationally to microwave radiation exposure and the trend is toward less exposure in schools, especially to vulnerable populations such as children, it makes sense to re-evaluate our wireless schools. We buckle our seat belts and wear a helmet when we ride bikes even though we don’t know if we will get in an accident. Although not all the issues of wireless microwaves are understood, there is enough science to understand it acts as a toxicant at even low levels that fall within current safety standards. We also know that decades of research precedes meaningful regulation in the area of toxins, thus the only reasonable approach is precautionary.

In addition, we need to be thoughtful about how much our kids should use computers and what this is doing not only to them, but to our society as a whole. We get starry eyed with every new wireless gadget, however, in “Alone Together” Sherry Turkle expertly addresses the rise in isolation, loneliness, lack of privacy, and increasing pressure on students in this age of invasive technology. Her thorough and non-judgmental scientific investigation of the psychological effects of computers makes us aware that we need to take care that we do not replace real human connection with a “virtual reality” that will redirect us in an unhealthy direction.

As physicians and parents, we understand that decisions we make today may have far reaching consequences in the future for our kids. Let’s play it safe for them right now.

> *“Certain high frequency waves used in the fields of radar, telecommunications, and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects, and animals, as well as the human body, even when exposed to levels that are below the official threshold values.”*

RECOMMENDATIONS FOR SCHOOLS

1. **Wired internet connections** like we used to have are the safest and possibly cheapest option – all the benefits of the internet without the risk.
2. **Wireless devices**, but with an on/off switch in each room so teachers can use only when needed for educational purposes.
3. **Limit Wi-Fi** use, especially in younger grades.
4. **Cell phones stay off and in the backpacks during class** and on the campus during school hours.
5. **Have EMF and electrical measurements done by one or more qualified, experienced consultants before and after any installation**. Understand you may need to increase your knowledge of low and high frequency electromagnetic fields and limits to accurately interpret the reports. The Bioinitiative Report is a very useful compendium that has recommendations for safer levels.
6. **Support efforts by governments to provide independent standardized transparent research to define safe limits in all the different wireless frequencies used commercially.** This could lead to less EMF emissions and safer wireless devices.

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STEPHEN T. SINATRA M.D., F.A.C.C.
F.A.C.N., C.N.S., C.B.T.,
Integrative Metabolic Cardiology

July 16, 2014

Chairman and Trustees
Fay School
48 Main Street
Southborough, MA 01772

RE: Wi-Fi in Schools

Dear Chairman and Trustees:

I am writing this letter on behalf of concerned parents of children who are attending schools with Wi-Fi technology. I'm a cardiologist and co-founder of Doctors for Safer Schools, an organization dedicated to informing teachers, parents and superintendents about the uncertainty and possible environmental health hazards of Wi-Fi technologies.

The heart is a delicate and complex electromagnetic organ that can be adversely affected by exogenous signals from wireless technology and microwave radiation. For this reason it is unwise to expose students and teachers to Wi-Fi radiation for internet access, especially when safer alternative wired options are available. Children are particularly vulnerable to this radiation and the incidents of cardiovascular events including sudden cardiac arrest, seems to be increasing, especially among young athletes (up to the age of 19). In some cases this is due to undetected heart defects, blunt trauma to the heart in contact sports, and heat stress during strenuous exercise, but in instances these irregularities may be exacerbated by or due to microwave signals interfering with the autonomic nervous system that regulates the heart.

I know this because I am a board certified cardiologist and have been a Fellow of the American College of Cardiology since 1977. At the Manchester Memorial Hospital in Connecticut, I served in several roles, including Chief of Cardiology, Director of Cardiac Rehabilitation, and Director of Medical Education.

In both Canada and the United States a large number of students are complaining that they feel unwell in classrooms that have Wi-Fi technology. These complaints have been investigated and what emerges is the following:

1. Symptoms common among these students include headaches, dizziness, nausea, feeling faint, pulsing sensations or pressure in the head, chest pain or pressure, difficulty

The Optimum Health Building • 257 East Center Street • Manchester, CT 06040 • TELEPHONE: 860-647-9729 • FAX: 860-643-2531
www.opthealth.com

concentrating, weakness, fatigue, and a racing or irregular heart accompanied by feelings of anxiety. These symptoms may seem diverse but they indicate autonomic dystonia or dysfunction of the autonomic nervous system.

2. Symptoms do not appear in parts of the school that do not have this technology (Wi-Fi-free portables) and they do not appear in homes that do not have wireless technology.

3. We know that the heart is sensitive to and can be adversely affected by the same frequency used for Wi-Fi (2.4 GHz) at levels a fraction of federal guidelines (less than 1%) and at levels that have been recorded in two Ontario schools with Wi-Fi technology.

4. The incidence of sudden cardiac arrests (SCA) among young athletes is increasing and doctors don't know why. In one small Ontario community, the number of students experiencing SCA is disturbingly high. Whether WiFi and nearby cell phone antennas exacerbate SCA needs to be investigated further before students are subjected to these fields.

In conclusion it is unwise to install wireless technology (WiFi) in schools. We do not know what the long-term effects of low-level microwave radiation are on students and teachers. The safety of this technology on children has not been tested and I would advise that you follow the precautionary principle that states the following:
"*In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*"
(Rio Conference 1992).

The principle implies that we have a social responsibility to protect the public from exposure to harm, when scientific investigations have found a plausible risk. That "plausible risk" exists for microwave radiation at very low levels. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result. In some legal systems the application of the precautionary principle has been made a statutory requirement.

Sincerely,

Steph T. Sinatra

Stephen T. Sinatra, M.D., F.A.C.C., F.A.C.N., C.N.S

Karolinska Institutet
Department of Neuroscience
Experimental Dermatology Unit

Stockholm, July 24, 2014

Mr. Thomas McKean, President, Board of Trustees
Mr. James Shay, President-Elect, Board of Trustees
Fay School
48 Main Street
Southborough, MA 01772

Ladies and Gentlemen,

It has been brought to my attention that children in your school are physically being impacted by radiation from WiFi antennas, and that some of the student's reactions have been severe. I was concerned to learn this. It is unwise to chronically expose children to this type of radiation, as their bodies are more sensitive than adults and the radiation has been shown to impair not just physiological functioning but cognitive function and learning.

Radiation of the kind emitted by WiFi transmitters impacts attention, memory, perception, learning capacity, energy, emotions and social skills. There is also diminished reaction time, decreased motor function, increased distraction, hyperactivity, and inability to focus on complex and long-term tasks. In some situations, children experience cardiac difficulties. In one Canadian school district, incidence of cardiac arrest in children was 40x the expected rate, and defibrillators have had to be placed at each school. Online time, particularly multi-tasking in young children, has been linked with a chronically distracted view of the world preventing learning critical social, emotional and relational skills. There is a physiological as well as psychological addiction taking place. I am sure, that as stewards of the lives of the children in your charge, you would not wish any of these outcomes.

Given the large and growing body of science indicating biological and health effects from the radiation emitted by antennas, it would be most imprudent at this time to permit wireless antennas on—or inside—your property. Understand the FCC exposure guidelines only protect against the acute power density, or acute thermal, effects, and they do nothing to protect against the other aspects of the radiation's risk, such the frequencies, amplitude, pulsing, intensity, polarity and biologically disruptive information content. Thus, until the FCC establishes guidelines for the non-thermal effects, any reliance by your school on current FCC guidelines, based solely on *thermal effects* would necessarily be incomplete. I urge a school of your caliber to be a leader on this issue, and appreciate that two wrongs do not make a right.

I enclose for your review the transcript of the Seletun Scientific Statement laying out the key concerns on this topic. If I can be of further help, please, do not hesitate to be in touch.

Yours truly,

Olle Johansson, Associate Professor
The Experimental Dermatology Unit,
Department of Neuroscience,
Karolinska Institute, 171 77 Stockholm, Sweden

Mailing address	Visiting address		Telephone
Experimental Dermatology Unit	Retziuslaboratoriet	Direct	468-52 48 70 58
Department of Neuroscience	Retzius väg 8	Switchboard	468-52 48 64 00
Karolinska Institutet	Solna	Fax	468-30 39 04
171 77 Stockholm		Fax (KI)	468-31 11 01
Sweden			

From: jmm@berkeley.edu
To: john.sterritt@lausd.net, monica.garcia@lausd.net, marguerite.lamotte@lausd.net, tamar.galatzan@lausd.net, steve.zimmer@lausd.net, sarah.bradshaw@lausd.net, nury.martinez@lausd.net, richard.vladovic@lausd.net, enrique.boullt@lausd.net, pta31dist@aol.com, ronald.chandler@lausd.net, lhc8767@lausd.net, bcohen@lausd.net, superintendent@lausd.net, john.deasy@lausd.net, tim.delia@lausd.net, senglish@advanceproj.com, wfletcher@utla.net, smfolsom@aol.com, bforrester@utla.net, mark.hovatter@lausd.net, Daniel.hwang@lausd.net, ainouye@utla.net, michelle.king@lausd.net, dlyell@utla.net, yolanda.pujol@lausd.net, lrojas@lausd.net, azayas@SEIU99.org
CC: cheemf@lists.healthandenvironment.org
Sent: 2/8/2013 2:21:54 P.M. Pacific Standard Time
Subj: [cheemf] Adoption of Wi-Fi in Los Angeles USD classrooms

TO: Los Angeles Unified School District (LAUSD)

FROM: Joel M. Moskowitz, Ph.D.
Director, Center for Family and Community Health
School of Public Health
University of California, Berkeley

RE: Adoption of Wi-Fi in Classrooms

DATE: February 8, 2013

Based upon my review of the research of the health effects associated with exposure to radiofrequency (RF) electromagnetic radiation (EMR), especially microwave radiation, I feel compelled to register my concern that adoption of Wi-Fi in LAUSD classrooms is likely to put at risk the health of many students and employees in the District.

In December, Dr. Gayle Nicoll of URS Corporation asked me to serve as an expert reviewer for a report that URS prepared for the LAUSD regarding the adoption of Wi-Fi in classrooms. Since Ms. Nicoll could not assure me that URS has no conflicts of interest, I turned down her request and sent her references to recent studies about Wi-Fi radiation. I cc:ed Board members and key staff as I was concerned about the health risks of unnecessarily subjecting 660,000 children to 13,000 hours of Wi-Fi microwave radiation during their K-12 school years.

Although I have not seen the URS report, I imagine it is based on the FCC's outmoded 1996 safety standards which only protect the public from the **thermal risk of RF EMR exposure** (i.e., from heating of tissue). For the past three years, in numerous media interviews I have been calling on the FCC to strengthen its standards and testing procedures to protect the public and workers from the low-intensity, **non-thermal risks of RF EMR exposure** that have been reported in hundreds, if not thousands, of research studies. These include increased risk of neurological and cardiovascular problems, sperm damage and male infertility, reproductive health risks, and cancer.

The **precautionary principle** should be applied to this critical policy decision. This principle, developed at a U.N. environmental conference in 1992 states that in the absence of scientific consensus if an action has a suspected risk of causing harm, the burden of proof it is not harmful falls on those taking the action, and all reasonable measures to reduce the risk must be taken.

Internet access can be provided to students through wires or optical fiber without installing Wi-Fi in the classrooms.

For further information, please see my **Electromagnetic Radiation Safety web site** at http://saferemr.blogspot.com where I have archived news releases and links to recent reports by major scientific groups and political agencies.

Sincerely,

Joel M. Moskowitz, Ph.D.

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Joel M. Moskowitz, Ph.D.
Director
Center for Family and Community Health
The UC Berkeley Prevention Research Center
School of Public Health
University of California, Berkeley
50 University Hall
Berkeley, CA 94720-7360

Phone: 510-643-7314
E-mail: jmm@berkeley.edu

CFCH Web Site: http://cfch.berkeley.edu
EMR Safety Web Site: http://saferemr.blogspot.com

December 1, 2015

Montgomery County Schools
Carver Educational Services Center
850 Hungerford Drive
Rockville, MD 20850

Attention: Dr. Andrew Zuckerman, Chief Operating Officer
MCPS Board of Education Members

This letter of comment has been prepared after reviewing the *Montgomery County Public Schools Radiofrequency (RF) Summary Monitoring Report* dated July 2015 produced by AECOM Environment.

1) The instrument cited as being used for the peak measurements in section 7, a Narda SRM-3006, is not suitable to measure the very short (1 millisecond) spikes typically found in WiFi 802.11n communication. As stated on page 7-1, each data sweep takes 550 milliseconds, making the instrument unsuitable for reliably logging the short bursts typical in 802.11n WiFi communications. Palit et al conclude that 50% of the uplink traffic will be in bursts shorter than 2 milliseconds. The peak levels of those packets will not be reliably logged by a device with a 550 millisecond sweep time.

Palit et al, 2012. Anatomy of WiFi Access Traffic of Smartphones and Implications for Energy Saving Techniques. International Journal of Energy, Information and Communications, Vol. 3, Issue 1.

2) Even the average-level tests seem inconsistent with engineering reality. Figure 7.1 shows a background noise level mostly flat between 2.4GHz and 5.8Ghz. That noise (typically -70dBm) is generally consistent with the internal thermal noise in a quality wide-band measuring instrument. Two tiny peaks out of that noise are represented to be the "*average electric field generated at one foot away from an AP in use at Beverly Farms Elementary School*." Even with just the 802.11n beacon-frame idling, the peak field a foot away from an access point should be a million times higher than the levels of figure 7.1. Why do we just see a blip on the chart? Clearly some unusual 'averaging' has occurred, yet the parameters of that averaging, and the potential clinical implications of that averaging, are not noted in the annotation to the Figures. Further, Figure 7.2 shows a background noise level some 10dB higher than figure 7.1, something that would be very unusual in measurements at these Gigahertz frequencies.

3) The RF exposure estimates are additionally inadequate because, in reality, there is no way to meet the distancing that AECOM's report bases it's measurements on for an individual student. In normal use, kids hover over devices. They hug them to the body. They put them in their laps at lunchtime, on the couch and in bed doing homework. It is entirely unrealistic to expect teachers and parents to guarantee that students always keep their Chromebooks at some arbitrary distance during use.

4) The report concludes with classroom RF measurement comparisons to an outdated 2007 BioInitiative Report recommendation of 0.1 uW/cm2. (Section 7). Graphics need to be re-drawn with comparisons to the 2012 recommended BioInitiative level, and do so not only for a 12" spacing, but also for the one-inch distance measured from the Chromebook (Figure 7-3 and 7-4). Using an arbitrary 12" distance to report and compare to either the 2007 or 2012 BioInitiative recommendations will seriously underestimate RF exposures since students don't always (or even typically) maintain a foot of distance. Their 'leaning in' and having to place their faces close to the device is common usage, and is unavoidable.

5) The methodology is not specific as to the number of operating devices and clustering of students at work – which is necessary to characterize exposures from a room full of operational wireless devices. Figure 2.1 shows multiple wireless devices connected to one wireless router. Measuring one or several Chromebooks rather than one Chromebook for each of the 25-35 students plus router isn't how a normal classroom operates. It **does not** produce RF measurements of a typical class using many wireless devices at once, so this is a fundamental flaw. It will underestimate RF exposures.

6) There is also a comment to be made here about the setup – how does this methodology reasonably reflect how smaller or younger children with short arms and torsos actually use tablets? What RF exposures they can expect to receive? The likely consequence to the measurements is greater exposure. Unless the students are using chopsticks instead of their fingers, or are using wired keyboards that increase the distance to the wireless device, RF exposures will be worse for the younger or smaller-stature students.

7) This Report appears to legitimize MCSD's use of wireless in the classroom by asserting compliance with the 2007 BioInitiative Report recommendation, yet the report does not mention the significant revision of that threshold in the years between 2007 and 2012. Both BioInitiative Reports clearly state that their recommendations are interim and 'that they may have to go lower.' Recent studies of students reporting headache, irritability, concentration and behavior problems at levels as low as 0.003-0.006 uW/cm2, indicate that neither BioInitiative Report threshold may be low enough to assure safety. As the co-editor of the BioInitiative Reports, and a founding member of the BioInitiative Working Group, the way in which our work has been invoked is not consistent with the findings of the BioInitiative Reports overall. The conclusions of this report cannot be said to give a positive assertion of safety because of the degree of uncertainty over whether the testing equipment was adequate (we believe it was not); the lack of comparison data; and the failure to measure RF exposures at realistic distances from the student(s).

8) Correct BioInitiative citations are:

BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation at www.bioinitiative.org, December 31, 2012.

BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF) at www.bioinitiative.org, August 31, 2007

CONCLUSION

The data in this report cannot therefore be used to infer safety, or lack of safety, of children in any of the tested locations.

Respectfully submitted,

Cindy Sage. MA
Sage Associates
Co-Editor, BioInitiative 2007 and 2012 Reports
sage@silcom.com

Prof. Trevor Marshall, PhD
Director, Autoimmunity Research Foundation,
Senior Member IEEE,
Founding chair (retired) IEEE EMBS (Buenaventura Chapter)
Fellow, European Association for Predictive, Preventive and Personalised Medicine (Brussels)
International Expert Council, Community of Practice: Preventative Medicine (Moscow)
trevor.m@trevormarshall.com

September 22, 2014

On behalf of the BioInitative Working Group, we are writing to express our concern about the views expressed by CEOs from Google, Dell, Apple, Adobe, eBay, Facebook, the George Lucas Educational Foundation and others to the FCC supporting wireless technologies in schools.

Your letter to the FCC dated July 7, 2014 titled Education Superhighway, states:

> *"Today, we are writing to you to urge swift bi-partisan action at your July 11, 2014 meeting to adopt the E-Rate modernization proposal set forth by Chairman Wheeler."*
> *"By responsibly investing $2 billion of unused funds and providing predictable ongoing support for Wi-Fi, the plan will make dramatic progress in bringing high-speed connectivity to our classrooms."*

No one denies that bringing high-speed connectivity to our classrooms is important. But it can be a wired connection and does not have to be WiFi. It does not reflect well on the ethics of your corporations to encourage the FCC to provide $2 billion dollars for new wireless classroom infrastructure and devices for school children, knowing that wireless emissions have been classified as a Possible Human Carcinogen by the World Health Organization's International Agency for Research on Cancer (2011). To promote wireless technologies in schools is to deliberately and knowingly disregard current health warnings from international science and public health experts.

Saturating schools with wireless technology will likely create unnecessary liability for municipalities and result in a loss of public trust and confidence in the corporations that push their wireless products with a blind eye toward health concerns.

Epidemiological studies show links between radiofrequency radiation (RFR) exposure and cancers, neurological disorders, hormonal changes, symptoms of electrical hypersensitivity (EHS) and more. Laboratory studies show that RFR exposure increases risk of cancer, abnormal sperm, learning and memory deficits, and heart irregularities. Fetal exposures in both animal and human studies result in altered brain development in the young offspring, with disruption in learning, memory and behavior. The brain development of a fetus can be impaired by in-utero exposure to a pregnant woman. The evidence for these statements is based on hundreds of published, peer-reviewed scientific studies that report adverse effects at levels much lower than current FCC public safety limits. WiFi is schools, in contrast to wired internet connections, will increase risk of neurologic impairment and long-term risk of cancer in students. Corporations cannot avoid responsibility simply by asserting compliance with existing legal, but outdated and inadequate FCC public safety limits.

Today, corporations that deal with educational technology should be looking forward and helping school administrators and municipal leaders to access safe, wired solutions. Your corporations can reasonably foresee and offer alternatives to potentially hazardous exposures to wireless radiation by choosing to support wired educational technologies.

Thank you for your attention to this letter.

Cindy Sage, MA, Tel: (805) 969-0557 Email: sage@silcom.com
David O. Carpenter, MD, Tel: 518-525-2660 Email: dcarpenter@albany.edu
Co-Editors, BioInitiative 2012 Report
For the BioInitiative Working Group

Copies: CEOs signing Education Superhighway letter to the FCC
Federal Communications Commission
The White House, President Obama
US Secretary of Education Secretary Arne Duncan

Contributing Authors of the the 2007 and 2012 BioInitiative Working Groups

Jitendra Behari, PhD, India
Carlo V. Bellieni, MD, Italy
Igor Belyaev, Dr.Sc., Slovak Republic
Carl F. Blackman, PhD, USA
Martin Blank, PhD, USA
Michael Carlberg, MSc, Sweden
David O Carpenter, MD, USA
Zoreh Davanipour, DVM, PhD USA
Adamantia F. Fragopoulou, PhD, Greece
David Gee, Denmark
Yuri Grigoriev, MD, Russia
Kjell Hansson Mild, PhD, Sweden
Lennart Hardell, MD, PhD, Sweden
Martha Herbert, PhD, MD, USA
Paul Héroux, PhD, Canada
Michael Kundi, PhD, Austria
Henry Lai, PhD, USA
Ying Li, PhD, Canada
Abraham R. Liboff, PhD, USA
Lukas H. Margaritis, PhD, Greece
Henrietta Nittby, MD, PhD, Sweden
Gerd Oberfeld, MD, Austria
Bertil R. Persson, PhD, MD, Sweden
Iole Pinto, PhD, Italy
Paulraj Rajamani, PhD, India
Cindy Sage, MA, USA
Leif Salford, MD, PhD, Sweden
Eugene Sobel, PhD, USA
Amy Thomsen, MPH, MSPAS, USA

American Academy of Environmental Medicine

6505 E Central • Ste 296 • Wichita, KS 67206
Tel: (316) 684-5500 • Fax: (316) 684-5709
www.aaemonline.org

May 13, 2013

Open Letter to the Superintendents
of the School Districts of the United States

The American Academy of Environmental Medicine (AAEM) strongly supports the use of wired Internet connections.

The AAEM comprises Medical Doctors, Osteopaths, and PhD researchers focusing on the effects of environmental agents on human health. For forty years the Academy has trained Physicians to treat the most difficult patients who are often overlooked by our medical system, because the cause of their illness, rather than being caused by an infection or traditionally understood cause, is related to more basic underlying causes such as chemical, toxic metal, food or radiation exposures.

In May 2011 the World Health Organization elevated exposure to wireless radiation, including WiFi, into the Class 2b list of Carcinogens.

There is consistent emerging science that shows people, especially children who are more vulnerable due to developing brains, and thinner skulls, are affected by the increasing exposure to wireless radiation. In September 2010, the Journal of the American Society for Reproductive Medicine-Fertility and Sterility, reported that only four hours of exposure to a standard laptop using WiFi caused DNA damage to human sperm.

In December 2012 the American Academy of Pediatrics- representing 60,000 pediatricians, wrote to Congress requesting it update the safety levels of microwave radiation exposure especially for children and pregnant women.

In a school setting, children are exposed to WiFi for an unprecedented period of time, for their entire childhood. Some of these signals will be much more powerful than is received at home, due to the need for the signals to go through walls, and serve multiple computers simultaneously. The school signals are dozens of times more powerful than the café and restaurant systems.

To install this system in your school district risks a widespread public health hazard that the medical system is not yet prepared to address. Statistics show that you can expect to see an immediate reaction in 3% and delayed effects in 30%, including teachers.

It is better to exercise caution and substitute with a safe alternate such as a wired connection, which is not classified as a possible Carcinogen. While more research is being conducted children must be protected. Wired technology is not only safer, it also stronger and more secure.

While the debate ensues about the dangers of WiFi, cell phone towers and cell phones, it is the doctors who must deal with the after affects. Until we can determine why some get sick and others do not, and some are debilitated for indeterminate amounts of time, we implore you to not take the risk, with the health of so many children who have entrusted you to keep them safe while at school.

Respectfully,

The Executive Committee of the American Academy of Environmental Medicine

Message to Schools and Colleges about Wireless Devices and Health

If wireless devices, such as Wi-Fi, are used in your schools and colleges, then the health of your students, your faculty, and your staff can be at risk. This is a difficult problem but an addressable one if you act.

Background: Wireless devices transmit information using radiofrequency/microwave radiation. The international biomedical research community has been studying the biological impact of such radiation for decades, but more intensely in recent years. Thousands of peer-reviewed studies published in biomedical research journals have contributed to our understanding of this impact. So many serious biological effects have been found that immediate responsive action is warranted. Further, these biological effects are occurring at levels of radiation far lower than earlier understood. Simply stated, a worldwide health crisis is emerging and is becoming a hallmark of the 21st Century. The international biomedical research community is trying to warn us; but we, in the USA, are not yet listening. I hope this message will help to change that.

As a scientist, I urge you to look into the **health impact of the radiofrequency/microwave radiation** produced by wireless devices. Examples of wireless devices of concern in our environment are Wi-Fi in all of its forms; cell phones and cell towers (especially those located on school grounds); cordless phones; wireless computers, whether desktop, laptop, or tablet versions; wireless baby monitors; wireless smart electricity meters; emerging wireless smart appliances; and microwave ovens (because they always leak radiation).

This crisis is the consequence of many factors. Here are some of them:

- All living things are bioelectrical in nature. That is why electrocardiograms and electroencephalograms work. They, of course, measure the tiny electrical signals that operate the heart and the brain. The critical tasks performed by these tiny electrical signals, and so many other electrical signals in all living things, can be disrupted by radiofrequency/microwave radiation.

- The levels of manmade radiofrequency/microwave radiation in our environment are increasing exponentially and already exceed, by many orders of magnitude, the levels at which all life on Earth evolved. Simply stated, we are drowning in a rising sea of manmade radiofrequency/microwave radiation.

- The invisible nature of radiofrequency/microwave radiation leaves the public and the decision-makers unaware of the rising levels of radiation around them.

- The genuine usefulness of wireless devices promotes denial of the risks.

- The intense advertising, the economic power, and the political power of profitable wireless industries enable them to dominate the public dialogue and to hold sway over government regulators and legislators.

- Current Federal standards for limiting the exposure of the public to radiofrequency/microwave radiation are outdated and overly permissive. Those standards are based on thermal heating alone. In effect, the Government claims that if you are not cooked too much by the radiation, then you are fine. Those Federal standards ignore the many biological effects that occur at much lower levels of radiation, leaving the public unprotected.

- Federal and state governments are advocating unlimited expansion of wireless technology, and are even co-funding such expansion and mandating the acceptance of wireless technology by the public. Such actions reflect a widespread lack of understanding of, or willful blindness to, the underlying science and its consequences for public health.

- Some of the more serious consequences of exposure to radiofrequency/microwave radiation (such as DNA damage, cancer, and infertility) are especially nefarious because they give no early warning signs.

- Other consequences of exposure do give early warning signs (such as sleep disruption, headaches, fatigue, ringing in the ears, memory loss, dizziness, heart arrhythmia, and many others); but those signs are too often dismissed because they can have other causes as well, complicating identification of the true cause.

- The absence of routine training of physicians in the biological effects of radiofrequency/microwave radiation makes it difficult for physicians to identify the causes and to provide responsive guidance.

- Even aware individuals cannot control their exposure in any environment shared with others, because the radiation around them, much like second-hand smoke, is forced on them by unaware individuals. Only governments can fully solve this problem, but they are currently part of the problem. For now the public will have to protect itself, and that will require public education and action.

Fortunately, many of the services that wireless devices offer can be realized with much safer wired devices. The wired devices achieve connectivity with fiber-optic, coaxial, or Ethernet cables. The wired devices are faster, more reliable, and more cyber secure. They are, however, less mobile, often less convenient, and somewhat more expensive to install. But those drawbacks pale in comparison to the benefits of good health.

Simply stated, schools and colleges can protect their students, staff, and faculty from the health risks posed by wireless devices, including Wi-Fi, by converting to safe wired connectivity. If your institution lacks the resources to convert now, do consider shutting down your wireless devices anyway and converting as soon as you can. You can advance learning without leaving a trail of illness behind you, some of which can be lifelong.

As a suggested starting place for exploring the concerns about the radiation from wireless devices, I have appended an “Annotated List of References” and an “Annotated List of Videos”. Please view, especially, video (1) called “Wi-Fi in Schools, the Facts”, made in Australia, on page 6.

Regards,

Ronald M. Powell, Ph.D.
20316 Highland Hall Drive
Montgomery Village, MD 20886-4007
Telephone: 301-926-7568
Email: ronpowell@verizon.net

My background

I am a retired U.S. Government scientist (Ph.D., Applied Physics, Harvard University, 1975). During my Government career, I worked for the Executive Office of the President, the National Science Foundation, and the National Institute of Standards and Technology. For those organizations, respectively, I addressed Federal research and development program evaluation, energy policy research, and measurement development in support of the electronics and electrical-equipment industries and the biomedical research community. I currently interact with other scientists and with physicians around the world on the impact of the environment – including the radiofrequency/microwave environment – on human health.

ANNOTATED LIST OF REFERENCES

The international biomedical research community has conducted thousands of studies seeking to identify the biological effects of exposure to both low frequency and radiofrequency electromagnetic fields, extending into the microwave region. So many serious biological effects have been found from such fields, at levels earlier thought to be low enough to be safe, that immediate action is needed to alert and protect the public.

The most massive review of this biomedical literature is the 1479-page BioInitiative 2012 Report which considered about ***1800*** biomedical research publications, most issued in the previous five years. The BioInitiative 2012 Report was prepared by an international body of 29 experts, heavy in Ph.D.s and M.D.s, from 10 countries, including the USA which contributed the most experts (10). The review concludes that "The continued rollout of wireless technologies and devices puts global public health at risk from unrestricted wireless commerce unless new, and far lower*[,]* exposure limits and strong precautionary warnings for their use are implemented."

> BioInitiative Working Group, Cindy Sage, M.A. and David O. Carpenter, M.D., Editors, BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation, December 31, 2012
> http://www.bioinitiative.org

A group of six doctors in Oregon, led by Paul Dart, M.D., released, in June 2013, a 74-page review of ***279*** biomedical research publications. This review makes the health case against "cell phones, base stations, Wi-Fi, Smart Meters and other RF *[radiofrequency]* or ELF *[extremely low frequency]* -emitting devices". The review notes that "The current levels of exposure need to be reduced rather than increased further. The FCC *[Federal Communications Commission]* must especially protect vulnerable groups in the population including children and teenagers, pregnant women, men of reproductive age, individuals with compromised immune systems, seniors, and workers." This review is posted on the website of the FCC at the link entitled "Health Effects of RF - Research Review (87)".

> Biological and Health Effects of Microwave Radio Frequency Transmissions, A Review of the Research Literature, A Report to the Staff and Directors of the Eugene Water and Electric Board, June 4, 2013
> http://apps.fcc.gov/ecfs/comment/view?id=6017465430

Michael Bevington, in 2013, published a book that summarizes the findings of ***1828*** international biomedical research publications. The book describes the symptoms caused by exposure to electromagnetic radiation, the many diseases associated with such exposure, and the relative risk levels associated with specific sources of electromagnetic radiation. The citations of papers include the PMID index numbers for easy location on the PubMed.gov website of the National Institutes of Health. This website provides the largest index to the biomedical research literature in the world.

> Electromagnetic Sensitivity and Electromagnetic Hypersensitivity: A Summary by Michael Bevington
> NEW EDITION: March 2013
> http://www.es-uk.info

About 200 scientists from 39 countries around the world submitted an international appeal to the United Nations and to the World Health Organization in May 2015. These scientists seek improved protection of the public from harm from the radiation produced by many wireless sources, including "cellular and cordless phones and their base stations, Wi-Fi, broadcast antennas, smart meters, and baby monitors" among others.

Together, these scientists have published over 2000 peer-reviewed research papers on this subject.

https://www.emfscientist.org/index.php/emf-scientist-appeal

The International Agency for Research on Cancer, of the World Health Organization, has already classified radiofrequency electromagnetic fields as a Class 2B carcinogen ("possible carcinogen"), based primarily on the increased risk of brain cancer. That decision was made in 2011. Since then, the research supporting a higher classification of risk ("probable carcinogen", or even "known carcinogen") has continued to build.

http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

The American Academy of Environmental Medicine (AAEM), which trains physicians in preparation for Board Certification in Environmental Medicine, states: "The AAEM strongly supports the use of wired Internet connections, and encourages avoidance of radiofrequency such as from WiFi, cellular and mobile phones and towers, and 'smart meters'." AAEM further states that "The peer reviewed, scientific literature demonstrates the correlation between RF *[radiofrequency]* exposure and neurological, cardiac, and pulmonary disease as well as reproductive and developmental disorders, immune dysfunction, cancer and other health conditions. The evidence is irrefutable." The AAEM concludes: "To install WiFi in schools plus public spaces risks a widespread public health hazard that the medical system is not yet prepared to address."

AAEM, Wireless Radiofrequency Radiation in Schools, November 14, 2013
http://www.aaemonline.org/pdf/WiredSchools.pdf

The American Academy of Pediatrics (AAP), whose 60,000 doctors care for our children, supports the development of more restrictive standards for radiofrequency radiation exposure that would better protect the public, particularly the children. The AAP, in a letter to the Federal Communications Commission (FCC) and the Food and Drug Administration (FDA), dated August 29, 2013, states that "Children are not little adults and are disproportionately impacted by all environmental exposures, including cell phone radiation. Current FCC standards do not account for the unique vulnerability and use patterns specific to pregnant women and children. It is essential that any new standard for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded throughout their lifetimes."

http://apps.fcc.gov/ecfs/document/view?id=7520941318

The U.S. Government bears a major responsibility for the exponential growth in the levels of radiation from wireless devices in the environment. In 1996, the U.S. Congress passed, and the President signed, the Telecommunications Act of 1996. Under pressure from the cell phone industries, this law included this provision: "No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities *[cell towers]* on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the *[Federal Communications]* Commission's regulations concerning such emissions." Because the Federal Communications Commission's regulations on radiation exposure are so permissive, this provision prevents state and local governments from protecting their people from radiation from cell towers, based on health concerns.

Telecommunications Act of 1996
https://transition.fcc.gov/Reports/tcom1996.pdf

The Federal Communications Commission (FCC) has acted in partnership with the wireless industries by permitting wireless radiation levels far higher than the biomedical research literature indicates are necessary to protect human health. The success of the wireless industries in capturing the FCC, the committees in the U.S. Congress that oversee the FCC, and the Executive Branch is detailed in a new monograph from the Center for Ethics at Harvard University. As an example of that capture, the President recently appointed, as head of the FCC, the former head of the CTIA – The Wireless Association, which is the major lobbying organization for the wireless industry. This, of course, is the infamous "revolving door".

Norm Alster, Captured Agency: How the Federal Communications Commission is Dominated by the Industries It Presumably Regulates (2015)
http://ethics.harvard.edu/news/new-e-books-edmond-j-safra-research-lab

Further, the U.S. Government's "American Recovery and Investment Act of 2009" provided funding that was used to motivate the installation of wireless smart meters (also called the "Advanced Metering Infrastructure" or "AMI") by offering cost sharing, in the form of grants, to the utilities that would adopt such meters.

https://www.smartgrid.gov/recovery_act/overview/smart_grid_investment_grant_program.html

Many states then extended the impact of the above Act by *mandating* the acceptance of wireless smart meters by the public. These meters contain microwave transmitters/receivers and are placed either on, or inside, every home and many businesses. A California court-ordered document indicates that each smart meter broadcasts bursts of radiation, on average about 10,000 times per day and up to a maximum of about 190,000 times per day. Such bursts flood neighborhoods with radiation, day and night, throughout the year.

http://emfsafetynetwork.org/wp-content/uploads/2011/11/PGERFDataOpt-outalternatives_11-1-11-3pm.pdf

Increasingly, the public is becoming aware of the threat that wireless radiation poses to health. The initial opposition focuses primarily on *mandated* sources of exposure, especially when the individuals exposed include the unborn and young children as they are among the most vulnerable. Thus, the strongest initial opposition is surfacing for cell towers, especially on school grounds; for Wi-Fi in schools and colleges; and for wireless smart meters placed on, or inside, homes and businesses. Most states now have opposition groups, and some states have even 10 or 20 such groups. These groups are pursuing relief through state regulatory bodies, through state legislatures, and through the courts. Below is a sampling of the hundreds of U.S. websites that reflect the nature and scope of the opposition to the unbridled expansion of wireless technology. Such websites seek to educate the public and decision-makers, and thus to promote responsive action, based on the underlying science.

The BabySafe Project
http://www.babysafeproject.org/the-science/

National Association for Children and Safe Technology
http://www.nacst.org/

Stop Smart Meter's listing of groups in the USA and other countries opposed to wireless smart meters
http://stopsmartmeters.org/frequently-asked-questions/contacts-database/

Smart Grid Awareness, a Website by SkyVision Solutions, Consumer Protection Advocate
http://smartgridawareness.org

ANNOTATED LIST OF VIDEOS

There are hundreds of videos on the Internet that address the impact of wireless radiation on health. Here are just a few that provide an especially good introduction to this topic. An Internet search will surface many more.

(1) An introduction to the health risks posed by Wi-Fi in schools

> Wi-Fi in Schools, the Facts (September 9, 2013) (18 minutes)
> Produced by Wi-Fi in Schools Australia.
> https://www.youtube.com/watch?v=QQryZbxlqXI&feature=youtu.be

(2) Wide ranging overview of the impact of electromagnetic radiation on human health, particularly at microwave frequencies, with a special emphasis on children and the school environment

> Electromagnetic Radiation Health for Children 2014 (70 minutes)
> Presented by Dr. Erica Mallery-Blythe, a UK physician.
> https://www.youtube.com/watch?v=sNFdZVeXw7M

(3) Documentary on the wireless industry's efforts to suppress public awareness of the health effects of wireless radiation

> Microwaves, Science & Lies (2014) (90 minutes)
> Produced by Jean Heches and Nancy de Meritens of France.
> https://vimeo.com/ondemand/17755/89417454

(4) Samples of video testimony by individuals harmed by the radiation from wireless devices

> Cell Phones Cause Cancer (October 17, 2012) (9 minutes)
> Presented by Jimmy Gonzalez, Esq.
> https://www.youtube.com/watch?v=DIlOVJd0lA8

> Woman suffers acute radiation exposure from a bank of smart meters (January 21, 2015) (3 minutes).
> Produced by Maryland Smart Meter Awareness.
> https://www.youtube.com/watch?v=F9QZuWPw6Y0&feature=youtu.be

> Man experiences adverse health effects from exposure to a smart meter (March 7, 2013) (3 minutes).
> Presented by Garic Schoen of Gaithersburg, MD.
> Produced by Maryland Smart Meter Awareness.
> http://marylandsmartmeterawareness.org/smart-meter-news/maryland-ms-resident-testimony-to-economic-matters-committee-re-hb1038-on-march-14-2013/

> Individuals with high sensitivity to the radiation from wireless devices search for increasingly rare safe electromagnetic environments.
> Searching for a Golden Cage (May 8, 2014) (13 minutes)
> Produced by Nadav Neuhaus.
> http://time.com/golden-cage/

IDEA

IRISH DOCTORS' ENVIRONMENTAL ASSOCIATION
CUMANN COMHSHAOIL DHOCTÚIRÍ NA HEIREANN

7th January, 2013

Dear Principal,

The Irish Doctors Environmental Association (IDEA) has very serious concerns in relation to the ubiquitous use of Wi-Fi in Irish schools, and alerts you to the warnings of many leading international scientists and medical doctors who believe Wi-Fi is harmful to health, especially children's health.
http://wifiinschools.org.uk/resources/safeschools2012.pdf
Wi-Fi is an unregulated technology and there is absolutely no evidence that it is safe.

Since May 31st, 2011, radiofrequency electromagnetic fields (as in Wi-Fi) have been classified by the World Health Organisation as 'possibly carcinogenic' to humans. The IDEA unequivocally supports the Council of Europe, The European Environmental Agency and The International Commission for Electromagnetic Safety (ICEMS) in urging the adoption of the Precautionary Principle to protect human health.
Warnings by Scientists and Doctors:
http://www.iemfa.org/index.php/appeals

The Precautionary Principal has already been adopted by a number of Governments and agencies internationally.
Governments & organisations banning and warning against Wi-Fi:
http://www.cellphonetaskforce.org/?page_id128

While we fully support the promotion of technology in education we urge you to use wired technologies for your own safety and that of your pupils and staff. The tragedy of avoidable illness is only superseded by the knowledge that it could have been avoided.

Yours sincerely

Elizabeth Cullen

Elizabeth Cullen M.B. B.Ch. B.A.O. M.Sc. Ph. D 045-485215

pp. Philip Michael

Philip Michael M.B. B.Ch. B.A.O. D.C.H. MICGP 023 8844697

Komitéen for Strålebeskyttelse
c/o Advokatfirma Christian Harlang
Nytorv 5, 1.sal
DK-1450 København K
Denmark

CANADIANS FOR SAFE TECHNOLOGY
CANADIENS POUR UNE TECHNOLOGIE SÉCURITAIRE

PO Box 33
Maple Grove Village Postal Outlet
Oakville, ON
Canada
L6J 7P5

April 9, 2014

Via email: rec@harlanglaw.dk

Dear members of The Committee on Radiation Protection/Komitéen for Strålebeskyttelse:

My name is Frank Clegg and I am the CEO of Canadians for Safe Technology, C4ST, a volunteer based, national organization which promotes the safe use of wireless technology.

In my previous role as President of Microsoft Canada, I witnessed the incredible benefits that technology can provide. I also witnessed the potential harmful effects if technology is not implemented safely. Though wireless technologies afford schools various advantages, this solution cannot overshadow the evidence which demonstrates cause for concern. I request that you consider the following important facts.

The Canadian Teachers' Federation (CTF) is a national alliance of provincial and territorial teacher organizations that represent nearly 200,000 elementary and secondary school teachers across Canada. In their submission to the public consultation of the Royal Society of Canada, Oct. 28, 2013, they submitted the following recommendations. (Safety Code 6 is Health Canada's guideline regarding the limits of radiation from wireless devices).
Recommendations...
... That Safety Code 6 include a recommendation for prudent use of Wi-Fi whenever possible including the recommendation to limit consistent exposure in schools by turning off wireless access points when not in use. ...
That Safety Code 6 exposure thresholds be based upon both thermal and biological effects of exposure to Wi-Fi.
... That the Expert Panel recommend an education program regarding the relative safety of Wi-Fi exposure and that appropriate resources be developed to educate the public regarding ways to avoid potential exposure risks of Wi-Fi access points and devices.

As reported by CBC News on Aug. 17, 2013, http://www.cbc.ca/news/canada/toronto/story/2013/08/17/toronto-cell-phone-ban.html "The Elementary Teachers' Federation of Ontario has updated its policy position on the student use of personal electronic devices, preferring for them to be turned off and put away unless a teacher says otherwise. That policy, which was amended at the union's annual general meeting, informs ETFO in its discussions with the government and school boards on related issues. A portion of that policy now states that such devices, which include cellphones, should "be stored and turned off during the instructional day unless their use is directly authorized by staff." In a separate resolution, ETFO voted to study the effects of non-ionizing electromagnetic radiation, the potentially harmful radiation emitted by cellphones. A report is due on the matter in February."

In a letter to the Peel Region, April 22, 2013, The American Academy of Environmental Medicine stated "To install this widespread wireless internet access system in Peel District schools risks a widespread public health hazard that the medical system is not yet prepared to address. Statistics show that you can expect to see an immediate reaction in 3% and delayed effects in 30%, including teachers."

In 2012, the BC Confederation of Parent Advisory Councils passed resolution 18 which states: "BCCPAC call on Boards of Education to cease to install Wi-Fi and other wireless networks in schools where other networking technology is feasible."
http://www.bccpac.bc.ca/resolutions/wi-fi-classrooms-committee-report

In May 2011, the World Health Organization (WHO) announced that the radiation emitted from wireless devices, including Wi-Fi, is a Class 2B carcinogen, which falls into the same category as lead and DDT.

You may already be aware that some schools and libraries in France and Switzerland have already removed Wi-Fi due to the suspected harmful health effects.

The Council of Europe, which includes 47 countries, adopted resolution 1815 which suggests in member countries "give preference to wired Internet connections, and strictly regulate(s) the use of mobile phones by schoolchildren on school premises."

The European Parliament (EU) resolutions 2008/2211(INI) & 2007/2252(INI,) state: "wireless technology (mobile phones, Wi-Fi / WiMAX, Bluetooth, DECT landline telephones) emits EMFs that may have adverse effects on human health... particularly to young people whose brains are still developing... **the limits on exposure to electromagnetic fields which have been set for the general public are obsolete."** (emphasis in original)

Other countries such as Israel, Russia, Switzerland, Frankfurt, Bavaria, and Salzburg have followed suit making the difficult decision to use hard wired connections as well. Recently, France passed a law recommending hard wired technology in schools.

The Austrian Medical Chamber shares that “WiFi may lead to concentration difficulties and memory problems in certain individuals.” The Austrian Medical Association recommends Wi-Fi free school environments.

The International Society of Doctors for the Environment (ISDE) and Irish Doctors Environmental Association (IDEA) advises to “Avoid Wi-Fi in home or work if possible, particularly in schools or hospitals. Use wired technology whenever possible” sharing that: “Because of the potentially increased risks for the fetus, infants and young children due to their thinner more permeable skulls and developing systems, particularly the immune and neurological systems, based on the precautionary principal and on the mounting evidence for harm at the sub-cellular level, we recommend that EMR exposure should be kept to a minimum.”

The American Academy of Pediatrics (AAP) - 60,000 Pediatricians and Pediatric Surgeons calls for caution as well stating that "The differences in bone density and the amount of fluid in a child’s brain compared to an adult’s brain could allow children to absorb greater quantities of RF energy deeper into their brains than adults... the current exposure limits may not reflect the latest research on RF energy" and lends support to removing Wi-Fi from schools as well.

As stewards of the public trust, I urge you to ensure the safest possible learning environment for the students in your care and to set an example for school districts by removing Wi-Fi and adopting “Best Practices” which limit the use of other wireless technologies.

Sincerely,

Frank Clegg
CEO,
Canadians for Safe Technology (C4ST)
frank@c4st.org

cc: Susanne Hansen, sh.klodskov@gmail.com

UNIVERSITY AT ALBANY
State University of New York

Institute for Health and the Environment
and
Department of Environmental Health Sciences
School of Public Health

28 February 2011

Chairman and Trustees
Kawartha Pine Ridge District School Board
Education Centre
1994 Fisher Drive
Peterborough, Ontario K9J7A1

Dear Sirs/Madams:

This is concerning potential adverse health effects associated with exposure to radiofrequency (RF) radiation, specifically that from wireless routers. I am a public health physician who has been involved in issues related to electromagnetic fields (EMFs) for a number of years. I served as the Executive Secretary for the New York Powerline Project in the 1980s, a program of research which showed that children living in homes with elevated magnetic fields coming from powerlines suffered from an elevated risk of developing leukemia. I have edited two books on effects of EMFs, including RF radiation. I served as the co-editor of the Bioinitiative Report (www.bioinitiative.org), a comprehensive review of the literature on this subject. The public health chapter from this report was subsequently published in a peer reviewed journal, and that is attached. Also I testified before the President's Cancer Panel on this subject in 2009, and a publication coming from that testimony is also attached. Thus this is a subject which I know well, and one on which I take a public health approach that has as a fundamental principle the need to protect against risk of disease even when one does not have all the information that would be desirable.

There is clear and strong evidence that intensive use of cell phones increases the risk of brain cancer, tumors of the auditory nerve and cancer of the parotid gland, the salivary gland in the cheek by the ear. The evidence for this conclusion is detailed in the attached publications. WiFi uses similar radiofrequency radiation (1.8 to 5.0 GHz), although the intensity of exposure in the immediate environment is much lower than what one gets from holding a cell phone close to your head. The difference between a cell phone and a WiFi environment, however, is that while the cell phone is used only intermittently a WiFi environment is continuous. In addition WiFi transmitters are indoors, where people (and in this case, children) may be very close to them. There is evidence from Scandinavian studies of cell phone usage that children who use cell phones are about five times more likely to develop brain cancer than if use starts as an adult. Thus it is especially important to protect children.

To my knowledge there has not been any health investigation of individuals living or working in WiFi environments as compared to others who are not. However, because the radiation is the same as those for cell phones, there is every reason to assume that the health effects would be the same, varying only in relation to the total dose of radiation. Wired facilities do not generate any RF radiation. While there is not specific proof that WiFi increases risk of cancer, there is certainly no evidence that it is safe. I urge you to not put WiFi in any school. Children should not be put at increased risk of developing cancer.

Yours sincerely,

David O Carpenter

David O. Carpenter, M.D.
Director, Institute for Health and the Environment
University at Albany

East Campus, 5 University Place, Room A217, Rensselaer, NY 12144-3429
PH: 518-525-2660 FX: 518-525-2665
www.albany.edu/ihe

Dr., CEO Andrew Zuckerman 13th December 2015
Montgomery County Schools
Carver Educational Services Center
850 Hungerford Drive
Rockville, MD 20850
U.S.A

PhD Mikko Ahonen, Tampere, Finland
MD Lena Hedendal, Luleå, Sweden
MSc. Tarmo Koppel, Tallinn, Estonia

1. Regarding: Measurements related problems in the MCPS Wi-Fi Report

We have analysed the measurement report and would like to note the following:

- In the **Comparison-table 2.2.** the MCPS provides only average values, no peak values. In cell phone technologies (like GSM) the difference between average and peak value is 2-fold. **In Wireless local area technologies like Wi-Fi, the difference between average value and peak value is up to 100-fold** (Ferro & Potorti, 2005). Note that in the table 2.2. by the MCPS only average values are presented. Later you provide **in the chapter 7.2.2 Maximum, Instantaneous Power Density**, **which needs attention since these levels occasionally exceeded in your school measurements allowable EMC-levels (EN60601-1 → 3 V/m) for medical instruments** (Robinson *et al*., 2003).

- **Almost all MCPS measurements were done in the near field of the devices under 3 wavelengths.** The wavelength for 2,4 GHz is 12,5 cm and for 5 GHz is 6 cm. That means that the near field will be <37,5 cm for 2,4 GHz and <18 cm for 5 GHz. In order to assess power density exposure in near field one needs to measure both electric and magnetic field components.

- The MCPS has not provided **information about Wi-Fi technology, namely it's beacon signal**. This signal, officially **SSID (Service Set IDentifier), is created by the access point (AP) by sending constantly SSID 10 times in a second , at 10 Hz** (Ferro and Poporti, 2005). **Mobile industry has patented technology to avoid this constant SSID sending for health reasons** (Swisscom, 2004). This SSID sending at 10 Hz is an additional risk-factor and it should be mentioned. Our brain operates in alpha, beta and gamma bands. This Wi-Fi beacon overlaps the alpha band. Low-frequency EMFs (including low-frequency pulses) have an effect on evoked potentials of the brain (Carrubba *et al*., 2008).

- **Because of the risk of this 10 Hz Beacon signal of Wi-Fi, The European Academy for Environmental Medicine has assigned very strict precautionary RF-levels for Wi-Fi** (Belyaev et al., 2015). Please, pay attention to Wi-Fi RF power density peak-levels in the next picture.

RF source Max Peak/Peak Hold	Daytime exposure	Nighttime exposure	Sensitive populations[1)]
Radio broadcast (FM)	10,000 μW/m²	1000 μW/m²	100 μW/m²
TETRA	1000 μW/m²	100 μW/m²	10 μW/m²
DVBT	1000 μW/m²	100 μW/m²	10 μW/m²
GSM (2G) 900/1800 MHz	100 μW/m²	10 μW/m²	1 μW/m²
DECT (cordless phone)	100 μW/m²	10 μW/m²	1 μW/m²
UMTS (3G)	100 μW/m²	10 μW/m²	1 μW/m²
LTE (4G)	100 μW/m²	10 μW/m²	1 μW/m²
GPRS (2.5G) with PTCCH* (8.33 Hz pulsing)	10 μW/m²	1 μW/m²	0.1 μW/m²
DAB+ (10.4 Hz pulsing)	10 μW/m²	1 μW/m²	0.1 μW/m²
Wi-Fi 2.4/5.6 GHz (10 Hz pulsing)	10 μW/m²	1 μW/m²	0.1 μW/m²

Picture. Precautionary levels for RF-radiation. **For Wi-Fi less than 10 μW/m² (peak value), which is 0,001 μW/cm² (peak value).** By the **European Academy for Environmental Medicine** (Belyaev *et al*., 2015, p. 356)

- **We would like to draw attention to** long-term exposure related health risks.

Radiofrequency radiation from Wi-Fi devices causes fertility problems as shown by several in vivo and in vitro studies (see for example Atasoy *et al.,* 2013, Avendaño *et al,.* 2012, Dasdag *et al.,* 2015a, Shokri *et al*., 2015).

Additionally, **RF-radiation from Wi-Fi access points (AP) causes oxidative stress in cells which leads to several disorders** (see for example Nazıroğlu *et al*., 2012, Aynali *et al.,* 2013, Salah *et al.,* 2013). The overall detrimental impact of RF radiation induced oxidative stress is summarised in the review of Yakymenko *et al*. (2015).

2. Regarding: The IARC classification of RF-EMF as Group 2B, i.e., 'possibly' carcinogenic to humans and the MCPS Report's inaccurate interpretation

The classification of radiofrequency electromagnetic fields (RF-EMF) as Group 2B, i.e., 'possibly' carcinogenic to humans,was made by 30 scientists from 14 countries at a meeting 2011 for the International Agency for Research on Cancer (IARC), World Health Organization (IARC 2011, Baan et al. 2012). **The working group mainly based their classification on one cohort study** (Schüz et al., 2006) **and five case-control studies** (Muscat et al., 2000, Inskip et al., 2001, Auvinen et al.,2002, The Interphone study group, 2010, Hardell et al., 2011).

They also reviewed more than 40 studies that assessed the carcinogenicity of RF-EMF in rodents, including seven 2-year cancer bioassays and also many studies with endpoints relevant to mechanisms of carcinogenesis, including genotoxicity, effects on immune function, gene and protein expression, cell signaling, oxidative stress, and apoptosis (Baan et al., 2011).

The referred INTERPHONE study (The Interphone study group, 2010), in the MCPS radiation report, was one of the case-control studies. **The Interphone study was a multicentre study of mobile phone use and brain tumours, including malignant tumours in the brain as glioma and benign tumours as acoustic neuroma and meningioma**. The pooled analysis included 2708 glioma cases and 2972 controls (participation rates 64% and 53%, respectively). In the Interphone study a regular user of mobile phones had an average of at least one call per week for a period of ≥6 months. **This very <u>low</u> user group was compared to several other groups of <u>low</u> users compared to nowadays more extensive use of mobile phones.** The highest group of users, ≥1640 hours was divided in three sub groups depending on how many years they had used a mobile phone. For the shortest time span on 1-4 years only 23 of the glioma cases and 8 of the controls had used their mobile phones for more than 1640 hours. If any of these 23 persons with a brain cancer or any of the 8 controls had used their mobile phones for only one year they would have used it at least in average for four and a half hours a day during a year. If they instead had talked in their mobile phones during four years it would be for an average of a little more than an hour a day.
For the group of users between 5 and 9 years, 84 cases and 73 controls, the use per day would be at least between 54 minutes and 30 minutes. **For the long user group of 10 years or more, 93 cases and 73 controls, they talked in their mobile phones for 27 minutes a day or less for more than 10 years of use.**
For the main part of cases their use of mobile phones had been for a lot less than four hours a day. Today when most people use only their mobile phone and landline phones both at home and at work are becoming scarce, an amount of 4 hours or more wireless telephone use / day for salesman, telephone operators and so on is not uncommon.
In the Interphone study there was an statistical significant increased risk for a malignant brain tumour of 1.4 times (odds ratio, OR, 1.4, 95% CI 1.03-1.89) only for the highest user group of a total on more than 1640 hours.
Hardell et al. (2011) in Sweden found that **cases who had used a mobile phone for more than 1 year had an increased risk for glioma of 1.3** (OR 1.3, 95% Cl 1.1-1.6).

The **risk increased with increasing time since first use and with total call time, reaching 3.2 times** (OR 3,2, Cl 2.0-5.1) **for more than 2000 hours of use**. Use of the mobile phone on the same side of the head as the tumour was associated with higher risk.

Since 2011 several other studies have been published which are strengthening the possible association between RF-EMF and cancer. Using the **Bradford Hill viewpoints for evaluating strengths of evidence of the risk for brain tumours associated with use of mobile and cordless phones the classification <u>should be upgraded to group 1 carcinogen, i.e., "the agent is carcinogenic to humans"</u>** (Hardell & Carlberg, 2013).

New case-control studies have verified Hardell's studies (Coureau et al., 2014) and up to 20 years of mobile phone use have found even higher risk for brain tumours (Hardell & Carlberg, 2015).

A newly published study has found a tumor promotion effect on mice from exposure to radiofrequency electromagnetic fields below exposure limits for humans (Lerchl *et al*., 2015). RF-EMFs do not cause direct DNA damage. On the contrary **numerous studies have shown generation of reactive oxygen species (ROS) that can cause oxidative damage of DNA. This is a well-known mechanism in carcinogenesis for many agents.** The broad biological potential of ROS and other free radicals makes radiofrequency radiation a potentially hazardous factor for human health, not only cancer risk but also other health effects (Yakymenko *et al*., 2015).

The IARC classification of RF-EMF as Group 2B, possibly carcinogenic to humans, doesn't only include exposure from mobile phones near the ear. **The classification includes all sources of RF-EMFs.** The exposure from mobile phone base stations, Wi-Fi access points, smart phones, laptops and tablets can be long term, sometimes around the clock both at home and at school. **This constant exposure to lower levels of exposure may be as deleterious to health as higher exposure during short time** (Fragopoulou et al., 2012, Dasdag et al., 2015b). This **risk may be accentuated for children because their probable longer use of wireless devices** (Morgan et al., 2014). **Children are also growing and have more immature cells which can be more sensible to RF-EMF** (Markova et al., 2010)

In conclusion, long term health effects from RF EMFs are still under investigation and a significant amount of troublesome scientific evidence has surfaced. By using wireless technologies at close range, long term health risks cannot be excluded. Therefore, we recommend schools to use wired technologies.

Respectfully submitted

Sincerely,

Mikko Ahonen

Mr. Mikko Ahonen, PhD
Research manager of Finland, Institute of Environmental Health and Safety, Tallinn, Estonia & Partner, Sustainable Mobile Inc, Tampere, Finland.
Piiskusalmentie 4, 33450 Siivikkala, Finland.
E-mail: mikko.ahonen@tutanota.com.

Lena Hedendahl

Mrs. Lena Hedendahl, MD
General Practitioner
Östra Skolgatan 12, 972 53 Luleå, Sweden
E-mail: lenahedendahl@telia.com

Tarmo Koppel

Mr. Tarmo Koppel, MSc., PhD Candidate
Department of Work Environment and Safety, Tallinn University of Technology,
Ehitajate tee 5, 19086 Tallinn, Estonia,
E-mail: tarmo.koppel@ttu.ee

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24 March 2014

Open letter by British medical doctors: Health and safety of Wi-Fi and mobile phones

We wish to highlight our concern over the safety of exposure to microwave radiation from wireless technology, particularly for vulnerable groups like children, pregnant women, the elderly and those with compromised health.

There is growing concern that chronic (long-term) exposure to radiofrequency/microwave radiation from wireless technologies causes damage, particularly genetic damage, cognitive damage, cancer and decreased fertility. There is now substantial evidence of a link between mobile phone use and brain cancer. This was recognised by the International Agency for Research on Cancer (IARC)'s 30-strong panel of scientists, which in 2011 classed radiofrequency radiation as "possibly carcinogenic".

Additionally, doctors are encountering a significant and growing number of people presenting with **a range of acute (short-term) symptoms from wireless radiation, including headaches, palpitations, rashes, fatigue, sleep disturbance, allergies and memory and concentration problems.**

International medical agencies have recognised the evidence of harm (see appended list) but these rulings may take many years to be reflected in public health policy. This controversy is a common characteristic of scientific understanding when environmental exposures are new.

New technologies and substances often come with scientific conflict, which can continue for several decades before consensus is achieved. Commercial pressures often delay the acceptance of health risks, even when scientific evidence is compelling. In the case of tobacco, asbestos, x-rays and leaded petrol, for example, it took many decades before damage was established and accepted by health agencies and, during those decades, millions of people suffered ill health and death as a result of the delay. Now, despite evidence of harm, wireless technology is being rolled out widely.

We urge health agencies and the public to act immediately to reduce exposure to radiofrequency/ microwave radiation. This is especially important for children, who are physiologically more vulnerable to this exposure, and for whom adults have a safeguarding responsibility. **Children's health should be put ahead of convenience and commercial benefits. Children should not use mobile phones except in an emergency, and WiFi should be replaced with wired alternatives in schools and other settings where children spend considerable time.**

Yours faithfully,

Dr Elizabeth Evans MA (Cantab), MBBS (Lond), DRCOG – Medical Doctor
Dr Andrew Tresidder MRCGP (1989), MBBS (Lond) – Medical Doctor
Dr Erica Mallery Blythe BM - Medical Doctor
Dr Elizabeth Cullen MBBCh BAO MSc PhD – Medical Doctor
Dr Philip Michael MBBCh BAO DCH MICGP – Medical Doctor
Dr Shideh Pouria MBBS, BSc, MRCP – Medical Doctor
Dr Rodney Adeniyi-Jones LRCP&SI, MRCP – Medical Doctor
Dr Jenny Goodman MA, MBChB – Ecological Physician
Dr Damian Downing MBBS, MSB – President BSEM
Dr Elena Toma MD - Psychiatrist
Dr Joan Kinder MA, MBBChir(Cantab), MRCPCH – retired Consultant Paediatrician
Dr Sarah Myhill MBBS – General Practitioner (GP)
Dr Dee Marshall MBBS, MFHom – Medical Doctor
Dr Charles Forsyth MBBS, FFHom – Medical Doctor
Dr Zac Cox BDS - Dentist

BCM SSITA London WC1N 3XX
www.ssita.org.uk

Appendix – International Rulings

1. In 2011 the **World Health Organization's scientific panel, the International Agency for Research on Cancer (IARC),** reviewed all the evidence on carcinogenesis (cancer-causing) and categorised electromagnetic radiation from mobile phones and Wi-Fi as **Possibly Carcinogenic (Class 2B).**

See http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

2. **The Council of Europe has called for member states to take measures to reduce exposure to electromagnetic fields and give preference to wired internet connections for children, particularly in schools and classrooms.**

The Parliamentary Assembly stated that "the Assembly regrets that, despite calls for the respect of the precautionary principle and despite all the recommendations, declarations and a number of statutory and legislative advances, there is still a lack of reaction to known or emerging environmental and health risks and virtually systematic delays in adopting and implementing effective preventive measures. Waiting for high levels of scientific and clinical proof before taking action to prevent well-known risks can lead to very high health and economic costs, as was the case with asbestos, leaded petrol and tobacco."

See http://assembly.coe.int/mainf.asp?link=/documents/adoptedtext/ta11/eres1815.htm

3. **The BioInitiative Report**, updated in 2012 by 29 scientists, states that **biological effects are clearly established and occur at very low levels of exposure to electromagnetic fields and radiofrequency radiation** from just minutes of exposure to mobile phone masts (cell towers), WI-FI, and wireless utility 'smart' meters.

See http://www.bioinitiative.org/conclusions

4. **The American Academy of Environmental Medicine** stated in a 2012 Position Paper that "**Multiple studies correlate RF exposure with diseases such as cancer, neurological disease, reproductive disorders, immune dysfunction, and electromagnetic hypersensitivity."**

See http://aaemonline.org/emf_rf_position.html

6. **International Society of Doctors for the environment (ISDE) and Irish Doctors' Environmental Association (IDEA)** state that "**there is sufficient scientific evidence to warrant more stringent controls** on the level and distribution of electromagnetic radiation [EMR]. The joint statement and recommendations are part of a call by medical and scientific experts for safe technologies in schools."

See http://www.env-health.org/news/members-news/article/isde-idea-statement-on

5. The Safe Schools Report 2012 lists statements by **other doctors and medical associations** raising concerns over children's exposure to electromagnetic fields from Wi-Fi and other wireless technology.

See http://wifiinschools.org.uk/resources/safeschools2012.pdf

Dr. Magda Havas, B.Sc., Ph.D.

Environmental & Resource Studies, Trent University, Peterborough, ON, Canada
phone: (705) 748-1011 x7882 **fax**: (705) 748-1569 **email**: mhavas@trentu.ca

July 10, 2009.

Open Letter to Parents, Teachers, & School Boards Regarding Wi-Fi Networks in Schools and Cell Phone Antennas near School Property

I am a scientist who does research on the health effects of electromagnetic radiation and I am becoming increasingly concerned that a growing number of schools are installing WiFi networks and are making their school grounds available for cell phone antennas.

You will be told by both the federal government (Federal Communication Commission in the US; Health Canada and Industry Canada in Canada) as well as by the Wi-Fi provider that this technology is **safe** provided that exposures to radio frequency radiation remain below federal guidelines.

This information is **outdated** and **incorrect** based on the growing number of scientific publications that are reporting adverse health and biological effects below our "short-term, thermal-based" guidelines (see www.bioiniative.org) and the growing number of scientific and medical organizations that are asking for stricter guidelines to be enforced.

For these reasons it is irresponsible to introduce Wi-Fi microwave radiation into a school environment where young children and school employees spend hours each day.

FACT:

1. **GUIDELINES: Guidelines for microwave radiation (which is what is used in Wi-Fi) range 5 orders of magnitude in countries around the world.** The lowest guidelines are in Salzburg Austria and now in Liechtenstein. The guideline in these countries is 0.1 microW/cm^2. See short video (http://videos.next-up.org/SfTv/Liechtenstein/AdoptsTheStandardOf06VmBioInitiative/09112008.html). In Switzerland the guideline is 1 and in both Canada and the US it is 1000 microW/cm^2!

   Why do Canada and the US have guidelines that are so much higher than other countries? Our guidelines are based on a short-term (6-minute in Canada and 30-minute in US) heating effect. It is assumed that if this radiation does not heat your tissue it is "safe". This is NOT correct. Effects are documented at intensities well below those that are able to heat body tissue. See attached report: *Analysis of Health and Environmental Effects of Proposed San Francisco Earthlink Wi-Fi Network* (2007). These biological effects include increased permeability of the blood brain barrier, increased calcium flux, increase in cancer and DNA breaks, induced stress proteins, and nerve damage. Exposure to this energy is associated with altered white blood cells in school children; childhood leukemia; impaired motor function, reaction time, and memory; headaches, dizziness, fatigue, weakness, and insomnia.

2. **ELECTRO-HYPER-SENSITIVITY:** A growing population is adversely affected by these electromagnetic frequencies. The illness is referred to as "electro-hyper-sensitivity" (EHS) and is recognized as a disability in Sweden. The World Health Organization defines EHS as:

   ". . . a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic, or electromagnetic fields (EMFs). . . EHS is a real and sometimes a debilitating problem for the affected persons, while the level of EMF in their neighborhood is no greater than is encountered in normal living environments. Their exposures are generally several orders of magnitude under the limits in internationally accepted standards. "

   Health Canada acknowledges in their Safety Code 6 guideline that some people are more sensitive to this form of energy but they have yet to address this by revising their guidelines.

Symptoms of EHS include sleep disturbance, fatigue, pain, nausea, skin disorders, problems with eyes and ears (tinnitus), dizziness, etc. It is estimated that 3% of the population are severely affected and another 35% have moderate symptoms. Prolonged exposure may be related to sensitivity and for this reason it is imperative that children's exposure to microwave radiation (Wi-Fi and mobile phones) be minimized as much as possible.

3. **CHILDREN'S SENSITIVITY:** Children are more sensitive to environmental contaminants and that includes microwave radiation. The Stewart Report (2000) recommended that children not use cell phones except for emergencies. The cell phone exposes your head to microwave radiation. A wireless computer (Wi-Fi) exposes your entire upper body and if you have the computer on your lap it exposes your reproductive organs as well. Certainly this is not desirable, especially for younger children and teenagers. For this reason we need to discourage the use of wireless technology by children, especially in elementary schools. That does not mean that students cannot go on the Internet. It simply means that access to the Internet needs to be through wires rather than through the air (wireless, Wi-Fi).

4. **REMOVAL OF WI-FI:** Most people do not want to live near either cell phone antennas or Wi-Fi antennas because of health concerns. Yet when Wi-Fi (wireless routers) are used inside buildings it is similar to the antenna being inside the building rather than outside and is potentially much worse with respect to exposure since you are closer to the source of emission.

   Libraries in France are removing Wi-Fi because of concern from both the scientific community and their employees and patrons.

   The Vancouver School Board (VSB) passed a resolution in January 2005 that prohibits construction of cellular antennas within 1000 feet (305 m) from school property.

   Palm Beach, Florida, Los Angeles, California, and New Zealand have all prohibited cell phone base stations and antennas near schools due to safety concerns. The decision not to place cell antennas near schools is based on the likelihood that children are more susceptible to this form of radiation. **Clearly if we do not want antennas "near" schools", we certainly do not want antennas "inside" schools!** The safest route is to have wired internet access rather than wireless. While this is the more costly alternative in the short-term it is the least costly alternative in the long run if we factor in the cost of ill health of both teachers and students.

5. **ADVISORIES:** Advisories to limit cell phone use have been issued by the various countries and organizations including the UK (2000), Germany (2007), France, Russia, India, Belgium (2008) as well as the Toronto Board of Health and the Pittsburgh Cancer Institute (July 2008). While these advisories relate to cell phone use, they apply to Wi-Fi exposure as well since both use microwave radiation. If anything, Wi-Fi computers expose more of the body to this radiation than do cell phones.

6. **PRECAUTIONARY PRINCIPLE**: Even those who do not "accept" the science showing adverse biological effects of microwave exposure should recognize the need to be careful with the health of children. For this reason we have the Precautionary Principle, which states:

   In order to protect the environment, the precautionary approach shall be widely applied by States according to their capability. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation.

   In this case "States" refers to the School Board and those who make decisions about the health of children.

The two most important environments in a child's life are the home (especially the bedroom) and the school. For this reason it is imperative that these environments remain as safe as possible. **If we are to err, please let us err on the side of caution.**

Respectfully submitted,
Dr. Magda Havas,
Associate Professor
Trent University
July 10, 2009

Shallow Minds:
How the Internet and Wi–Fi in Schools Can Affect Learning

By Cindy Lee Russell, MD
VP-Community Health, Santa Clara County Medical Association

Most of us cannot live without our computers, text messaging, e-mail, and immediate access to the vast cloud of information, especially kids and teenagers who have grown up in the age of the Internet. In fact, more schools are integrating computers at younger ages, even in kindergarten. Forty-nine states are phasing out cursive handwriting altogether. What effects does it have, however, on learning, brain development, cognition, and brain health? Studies have shown some interesting ways that technology is rewiring and shaping our brain, which may not be "all good."

A growing body of scientific evidence suggests that the Internet, with its distractions and interruptions, is turning us into scattered, superficial thinkers. What does that portend for our kids?

Multitasking and Internet Addiction

Nicholas Carr explains, in his book "The Shallows," that we are changing the way we process information. "Dozens of studies by psychologists, neurobiologists, educators, and Web designers point to the same conclusion: When we go online, we enter an environment that promotes cursory reading, hurried and distracted thinking, and superficial learning….The Net delivers precisely the kind of sensory and cognitive stimuli-repetitive, intensive, interactive, addictive, that have been shown to result in strong and rapid alterations in brain circuits and functions."

Researchers from Stanford, in 2009, gave a battery of cognitive tests to a group of heavy and light media Internet multitaskers. They found that the heavy multitaskers were much more easily distracted by "irrelevant environmental stimuli" and had less control over their working memory. In addition, they were much less able to focus on a particular task. Professor Clifford Nass, who led the research, stated intensive multitaskers are "suckers for irrelevancy. Everything distracts them." (5)

"Teaching is a human experience. Technology is a distraction when we need literacy, numeracy, and critical thinking." Paul Thomas, author and associate professor of education at Furman University

Law School Professors Ban Laptops in Classrooms

Several years ago, professors who were irritated with students surfing the Web and hiding behind laptop screens began banning the use of the Internet or laptops in the classroom. Laptops have been banned in classes at Harvard Law School, Yale, George Washington University, University of Virginia, and South Texas College of Law, to mention a few. (4)(15) A 2006 study by Carrie Fried backed up the policies, demonstrating that students who used laptops in class spent considerable time multitasking. They more importantly found that the level of laptop use was negatively related to several measures of student learning. (3)

A 2012 survey by Elon University, the Pew Internet, and American Life Project asked over 1,000 leaders in the U.S. their thoughts about cognition in our millennial generation. They were asked to consider how the Internet and its environment are changing, for better or worse. Overall, the survey found that multitasking is the new norm and that hyper-connectivity may be leading to a lack of patience and concentration. The "always on" ethos may be encouraging a culture of expectation and instant gratification.

Brain Maturation, Learning, Memory, and Intelligence

The maturation of intelligence requires quiet, deep thought, and time. Established research findings in cognitive science leads to the conclusion that laptop use, especially with Wi-Fi access, could interfere with learning.

The hippocampus, which lies under the cortex, is intimately involved in long-term memory storage. Initial experiences are stored and stabilized in the hippocampus and then later transferred to the cortex. Removal of the hippocampus does not affect long-term memories, but prevents new memories from forming.

Learning depends on the ability to transfer information from our working memory to long-term memory and weave this into other acquired knowledge. There is a bottleneck in the passage of working memory to long-term memory. We have a limited ability as humans to capture and process information. The Internet provides too many choices and too much information at once. Excess distracting information creates "overload," preventing long-term memorization and important information is lost. No one disagrees that we need to protect our memories. As author Nicholas Carr highlights, personal memory is not just for the individual to function, but it shapes and sustains our collective cultural memory.

Brain Drain:

Adverse Neurologic and Health Effects of Wireless Microwave Communications

A growing body of peer reviewed research is showing neurologic damage to fetal brain and other systems from Wi-Fi and other microwave wireless sources. In a prior article, "Why-Fi: Is Wireless Communication Hazardous to Your Health?" in the Sept/Oct 2010 SCCMA *Bulletin*, the full range of effects of EMF from our cell phones and wireless devices was discussed. New basic science research in the last three years is confirming these findings. Initially, the Bioinitiative report of 2007 reviewed the biological effects of low level EMF. It found that there was clear evidence of adverse effects to living systems at current environmental exposures and at doses well below the threshold of the International Commission of Non-Ionizing Radiation Protection (ICNIRP) safety guidelines. Current microwave safety limits are based solely on the heating of tissue and do not take into account research showing negative biological effects on DNA, cancer, protein synthesis, skin tissue changes, sperm motility and viability, cognitive functioning, and disruption of the blood brain barrier.

Current Research on Cognition and Wireless Communication

Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice. *Scientific Reports*. March 2012.

Aldad et al noted that neurobehavioral disorders are increasingly prevalent in children with 3%-7% of school-aged children diagnosed with attention deficit hyperactivity disorder (ADHD). The etiology is unclear, however, an association between prenatal cellular telephone use and hyperactivity in children has been postulated by others. To test this, he exposed pregnant mice to cell phone radiation throughout gestation (days 1-17), with a sham cell phone control group. He found that the exposed group had dose responsive impaired neurologic transmission in the prefrontal cortex and that the mice exposed in utero were hyperactive and had impaired memory. He concluded "that these behavioral changes were due to altered neuronal developmental programming."(3)

Microwave Radiation Induced Oxidative Stress, Cognitive Impairment, and Inflammation in Brain of Fischer Rats. Megha. 2012.

Megha evaluated the intensity of oxidative stress, cognitive impairment, and brain inflammation in rats exposed to typical cell phone microwave radiation. They were subjected to 900 and 1,800 MHz EMF for two hours a day, for 30 days. They state, "Significant impairment in cognitive function and induction of oxidative stress in brain tissues of microwave exposed rats were observed, in comparison with sham exposed groups… Results of the present study indicated that increased oxidative stress due to microwave exposure may contribute to cognitive impairment and inflammation in brain."

Effect of Low Level Microwave Radiation Exposure on Cognitive Function and Oxidative Stress in Rats. Deshmukh. 2013.

The author highlights the exponential increase in wireless communication devices we are exposed to. He evaluated the effects of cell phone radiation on oxidation in tissues, in addition to cognition in rats. They subjected rats to 900 MHz EMF for two hours per day, five days a week, for 30 days, with an unexposed control group. "Results showed significant impairment in cognitive function and increase in oxidative stress, as evidenced by the increase in levels of MDA (a marker of lipid peroxidation) and protein carbonyl (a marker of protein oxidation) and unaltered GSH content in blood. Thus, the study demonstrated that low level MW radiation had significant effect on cognitive function and was also capable of leading to oxidative stress."

The Internet Can Damage Teenage Brains

A large radiologic study from China, published July 2011, looked at structural brain changes in Internet-addicted teenagers. It is estimated that 24 million teenagers are addicted to the Internet in China. The researchers found a consistent atrophy of grey matter in parts of the brain and shrinkage of the surface of the brain in those addicted to the Internet. The effects were worse the longer the addiction. In addition, the study revealed changes in white matter of the brain, which function to transmit messages in the brain to the grey matter. They concluded these structural abnormalities were most likely associated with functional impairments in cognitive control.

"It strikes me as a terrible shame that our society requires photos of brains shrinking in order to take seriously the common-sense assumption that long hours in front of screens is not good for our children's health. Dr Aric Sigman, Fellow of the Royal Society of Medicine

WHO Classifies EMF as a Carcinogen

In 2011, The WHO/International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as "possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer1, associated with wireless phone use."

France Bans Wi-Fi in Schools, But Replaces With Ethernet

The French National Assembly, March 2013, passed an amendment to ban Wi-Fi in their schools until it's proven "safe for human consumption." They instead agreed to install far safer, wired Ethernet cable connections.

The Council of Europe has called for a ban on Wi-Fi use in schools and also recommends a wired alternative.

In Austria, the Austrian Medical Society has also issued a policy statement asking for a ban of Wi-Fi in schools.

The U.K. has a useful frequently-updated website on Wi-Fi in schools, which provides much scientific research. http://www.wifiinschools.org.uk/ Still the controversy persists.

The Cost of a Virtual World

There are a host of concerns with classroom technology, and the virtual world it creates, that have not been explored in the rush to "modernize" education and prevent our kids from becoming "computer illiterate," despite the fact that computers are designed for ease of use. These issues range from distraction in the classroom, impairment of cognitive development and long-term memory, deficiency in learning social skills, Internet addiction, cyber bullying, access to inappropriate content, eye fatigue, and security risks to online learning networks. In addition, the sheer cost of computers and continuous upgrades is likely to break many school budgets. We have not mentioned the issue of toxic e-waste, another growing public health problem.

Common Sense

We will not get rid of the Internet or computers. We should not ignore, however, the enlarging body of science that points to real threats to public health and, especially, our children's safety and well-being. The best approach is precautionary. Reduce the risk by reducing the microwave emissions. It is our obligation as physicians and parents to protect our children. They are the future and our legacy.

1. Remove wireless devices (white boards and routers) in schools in favor of wired connections and fiberoptic.
2. If there is Wi-Fi, then give teachers the authority to turn it off when not in use or if they feel it is not necessary.
3. Ban cell towers near or on schools.
4. Limit screen time on computers.
5. Limit or ban cell phone use in the class.
6. Limit or ban cell phone use at home.
7. Do not allow laptops to be placed on laps.
8. Undertake independent scientific studies on Wi-Fi and computer use that look at acute and long-term health effects.
9. Train teachers how to recognize symptoms of EMF reactions.
10. Conduct meetings with parents and teachers to address this issue in each school.

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Minimize health risks from electronic devices

Published in the September 2016 NJEA Review
by Adrienne Markowitz and Eileen Senn

Desktops, laptops, tablets, eBook readers, printers, projectors, smart boards, smart TVs, cellphones, cordless phones and wireless networks (WiFi) have become ubiquitous in schools. At their best, they are powerful tools for education. At their worst, they threaten the physical and mental health of teachers, paraeducators, secretaries, librarians and other school staff members and students who spend numerous hours using the devices.

Physical health risks from electronic devices include pain and tingling from repetitive strain injuries to the hands and wrists; pain in the neck, shoulders and back; dry, burning, itchy eyes, blurred vision and headaches; altered sleep patterns and next-day fatigue from exposure to blue screen light; distracted driving; and various health problems from exposure to radiation.

Mental health risks arise from stress due to raised expectations for multitasking, productivity and proficiency with devices; dealing with malfunctioning devices; student and colleague distraction from and addiction to devices; and intrusion of devices into nonwork time.

WiFi devices emit radiation

Radio frequency (RF) electromagnetic frequency (EMF) radiation is sent and/or received by the antennae of phones, routers and other wireless devices. RF radiation is capable of causing cancer, reproductive, neurological and ocular effects. The amount of radiation exposure received depends on the amount of time exposed and distance from the source. Radiation levels fall off exponentially with distance from antennae. If you double the distance, the radiation is four times less. If you triple the distance, it is nine times less, and so on. Children and developing fetuses are particularly at risk because their bodies are still growing. People with implanted medical devices are at risk for device interference.

Hazards and solutions

The most straightforward ways to minimize health risks are to use electronic devices in moderation and to maximize your distance from them. There are also specific solutions to specific hazards listed below.

Local associations should work with their UniServ field representative to negotiate solutions that are in the control of district administrators such as providing training and ergonomic equipment and hard-wiring devices. Individuals should take steps within their control, such as:

For repetitive strain injuries

- Use voice control/speech recognition.
- Use ergonomic alternatives to traditional mice and keyboards.
- Use as many fingers as possible when typing and both thumbs when texting.

For neck, shoulder and back pain

- Ensure an ergonomic workstation.
- When using a hand-held device, support it and the forearms.
- Avoid bending the head down or jutting it forward.
- Take frequent, short breaks from the device.
- Ensure good posture and change positions frequently.
- Stand and do stretching exercises.

For eye pain, blurred vision and headaches

- Use sufficient, but not excessive, lighting.
- Use assistive technology built into Apple, Android and Windows devices.
- Enlarge and darken the cursor and pointer.
- Enlarge the font; magnify the text.
- Use text-to-speech instead of reading.
- Use special computer glasses.
- Relax the eyes on a minibreak.

For altered sleep patterns and next-day fatigue

- Stop using devices at least one hour before bedtime.

For distracted driving

- Use hands-free devices, preferably speakerphones.
- Pull over and park.
- Let someone else drive.

For radiation exposure

- Keep devices away from the body and bedroom.
- Carry phones in briefcases, etc., not on the body.
- Put devices on desks, not laps.
- Hard wire all devices that connect to the internet.
- Hard wire all fixed devices such as printers, projectors and boards.
- Use hard-wired phones instead of cell or cordless phones.
- Text rather than call.
- Keep conversations short or talk in person.
- Put devices in airplane mode, which suspends EMF transmission by the device, thereby disabling Bluetooth, GPS, phone calls, and WiFi.
- Use speaker phone or ear buds instead of holding the phone next your head.
- Take off Bluetooth devices when not using them.

For stress

- Training in device use, assistive technology.
- Easy access to user manuals.
- Easily available technical support.

Cell phones and cancer

The National Toxicology Program (NTP) is conducting the largest set of laboratory rodent studies to date on cellphone RF radiation. The studies cost $25 million and are designed to mimic human exposure. They are based on the cellphone frequencies and modulations currently in use in the United States. The NTP studies are designed to look at effects in all parts of the body.

On May 27, 2016, NTP released a report with partial results of the studies. They found increased occurrence of rare brain tumors called gliomas and increases in nerve tumors called schwannoma of the heart in male rats. The released results are partial because more rat studies and all of the mouse studies will be forthcoming by 2017. The cells that became cancerous in the rats were the same types of cells as those that have been reported to develop into tumors in human cellphone users.

The EMF produced by cellphones was classified as possibly carcinogenic to humans by the World Health Organization in 2011. They found that long-term use of a cell phone might lead to two different types of tumors, gliomas and acoustic neuroma, a tumor of the auditory nerve.

For more information

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Adrienne Markowitz holds a Master of Science in Industrial Hygiene from Hunter College, City University of New York. Eileen Senn holds a Master of Science in Occupational Health from Temple University in Philadelphia. They are consultants with the New Jersey Work Environment Council, which is a frequent partner with NJEA on school health and safety concerns.

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Resolution 1815 (2011)[1]
Final version

The potential dangers of electromagnetic fields and their effect on the environment

Parliamentary Assembly

1. The Parliamentary Assembly has repeatedly stressed the importance of states' commitment to preserving the environment and environmental health, as set out in many charters, conventions, declarations and protocols since the United Nations Conference on the Human Environment and the Stockholm Declaration (Stockholm, 1972). The Assembly refers to its past work in this field, namely Recommendation 1863 (2009) on environment and health: better prevention of environment-related health hazards, Recommendation 1947 (2010) on noise and light pollution, and more generally, Recommendation 1885 (2009) on drafting an additional protocol to the European Convention on Human Rights concerning the right to a healthy environment and Recommendation 1430 (1999) on access to information, public participation in environmental decision-making and access to justice – implementation of the Ǻrhus Convention.

2. The potential health effects of the very low frequency of electromagnetic fields surrounding power lines and electrical devices are the subject of ongoing research and a significant amount of public debate. According to the World Health Organization, electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which anxiety and speculation are spreading. All populations are now exposed in varying degrees to electromagnetic fields, the levels of which will continue to increase as technology advances.

3. Mobile telephony has become commonplace around the world. This wireless technology relies upon an extensive network of fixed antennae, or base stations, relaying information with radio-frequency signals. Over 1.4 million base stations exist worldwide and the number is increasing significantly with the introduction of third generation technology. Other wireless networks that allow high-speed Internet access and services, such as wireless local area networks, are also increasingly common in homes, offices and many public areas (airports, schools, residential and urban areas). As the number of base stations and local wireless networks increases, so does the radio-frequency exposure of the population.

4. While electrical and electromagnetic fields in certain frequency bands have wholly beneficial effects which are applied in medicine, other non-ionising frequencies, whether from extremely low frequencies, power lines or certain high frequency waves used in the fields of radar, telecommunications and mobile telephony, appear to have more or less potentially harmful, non-thermal, biological effects on plants, insects and animals as well as the human body, even when exposed to levels that are below the official threshold values.

5. As regards standards or threshold values for emissions of electromagnetic fields of all types and frequencies, the Assembly strongly recommends that the ALARA (as low as reasonably achievable) principle is applied, covering both the so-called thermal effects and the athermic or biological effects of electromagnetic emissions or radiation. Moreover, the precautionary principle should be applied when scientific evaluation does not allow the risk to be determined with sufficient certainty. Given the context of growing exposure of the population, in particular that of vulnerable groups such as young people and children, there could be extremely high human and economic costs if early warnings are neglected.

1. Text adopted by the Standing Committee, acting on behalf of the Assembly, on 27 May 2011 (see Doc. 12608, report of the Committee on the Environment, Agriculture and Local and Regional Affairs, rapporteur: Mr Huss).

6. The Assembly regrets that, despite calls for the respect of the precautionary principle and despite all the recommendations, declarations and a number of statutory and legislative advances, there is still a lack of reaction to known or emerging environmental and health risks and virtually systematic delays in adopting and implementing effective preventive measures. Waiting for high levels of scientific and clinical proof before taking action to prevent well-known risks can lead to very high health and economic costs, as was the case with asbestos, leaded petrol and tobacco.

7. Moreover, the Assembly notes that the problem of electromagnetic fields or waves and their potential consequences for the environment and health has clear parallels with other current issues, such as the licensing of medication, chemicals, pesticides, heavy metals or genetically modified organisms. It therefore highlights that the issue of independence and credibility of scientific expertise is crucial to accomplish a transparent and balanced assessment of potential negative impacts on the environment and human health.

8. In light of the above considerations, the Assembly recommends that the member states of the Council of Europe:

8.1. in general terms:

8.1.1. take all reasonable measures to reduce exposure to electromagnetic fields, especially to radio frequencies from mobile phones, and particularly the exposure to children and young people who seem to be most at risk from head tumours;

8.1.2. reconsider the scientific basis for the present standards on exposure to electromagnetic fields set by the International Commission on Non-Ionising Radiation Protection, which have serious limitations, and apply ALARA principles, covering both thermal effects and the athermic or biological effects of electromagnetic emissions or radiation;

8.1.3. put in place information and awareness-raising campaigns on the risks of potentially harmful long-term biological effects on the environment and on human health, especially targeting children, teenagers and young people of reproductive age;

8.1.4. pay particular attention to “electrosensitive” people who suffer from a syndrome of intolerance to electromagnetic fields and introduce special measures to protect them, including the creation of wave-free areas not covered by the wireless network;

8.1.5. in order to reduce costs, save energy, and protect the environment and human health, step up research on new types of antenna, mobile phone and DECT-type device, and encourage research to develop telecommunication based on other technologies which are just as efficient but whose effects are less negative on the environment and health;

8.2. concerning the private use of mobile phones, DECT wireless phones, WiFi, WLAN and WIMAX for computers and other wireless devices such as baby monitors:

8.2.1. set preventive thresholds for levels of long-term exposure to microwaves in all indoor areas, in accordance with the precautionary principle, not exceeding 0.6 volts per metre, and in the medium term to reduce it to 0.2 volts per metre;

8.2.2. undertake appropriate risk-assessment procedures for all new types of device prior to licensing;

8.2.3. introduce clear labelling indicating the presence of microwaves or electromagnetic fields, the transmitting power or the specific absorption rate (SAR) of the device and any health risks connected with its use;

8.2.4. raise awareness on potential health risks of DECT wireless telephones, baby monitors and other domestic appliances which emit continuous pulse waves, if all electrical equipment is left permanently on standby, and recommend the use of wired, fixed telephones at home or, failing that, models which do not permanently emit pulse waves;

8.3. concerning the protection of children:

8.3.1. develop within different ministries (education, environment and health) targeted information campaigns aimed at teachers, parents and children to alert them to the specific risks of early, ill-considered and prolonged use of mobiles and other devices emitting microwaves;

8.3.2. for children in general, and particularly in schools and classrooms, give preference to wired Internet connections, and strictly regulate the use of mobile phones by schoolchildren on school premises;

8.4. concerning the planning of electric power lines and relay antenna base stations:

8.4.1. introduce town planning measures to keep high-voltage power lines and other electric installations at a safe distance from dwellings;

8.4.2. apply strict safety standards for the health impact of electrical systems in new dwellings;

8.4.3. reduce threshold values for relay antennae in accordance with the ALARA principle and install systems for comprehensive and continuous monitoring of all antennae;

8.4.4. determine the sites of any new GSM, UMTS, WiFi or WIMAX antennae not solely according to the operators' interests but in consultation with local and regional government authorities, local residents and associations of concerned citizens;

8.5. concerning risk assessment and precautions:

8.5.1. make risk assessment more prevention oriented;

8.5.2. improve risk-assessment standards and quality by creating a standard risk scale, making the indication of the risk level mandatory, commissioning several risk hypotheses to be studied and considering compatibility with real-life conditions;

8.5.3. pay heed to and protect "early warning" scientists;

8.5.4. formulate a human-rights-oriented definition of the precautionary and ALARA principles;

8.5.5. increase public funding of independent research, in particular through grants from industry and taxation of products that are the subject of public research studies to evaluate health risks;

8.5.6. create independent commissions for the allocation of public funds;

8.5.7. make the transparency of lobby groups mandatory;

8.5.8. promote pluralist and contradictory debates between all stakeholders, including civil society (Århus Convention).

Ronald M. Powell, Ph.D.[1]

The Health Argument against Cell Phones and Cell Towers

The biomedical evidence showing that the radiofrequency radiation emitted by cell phones and cell towers is harmful to health continues to grow. This document summarizes the health argument against cellular technology, whatever the benefits of that technology may be. You may wish to inform yourself about these arguments for any of several reasons:

- You use a cell phone.
- You encourage, or do not discourage, the use of cell phones by family members.
- You live in, or are contemplating moving into, a community close to a cell tower.
- Your school, college, fire station, or police station is considering permitting the installation of a cell tower on its property.
- Your community is considering permitting the installation of cellular repeaters, small-cell towers, or even full cell towers within its jurisdiction.

Below, I introduce myself, provide evidence of the harmfulness of cellular radiation, and show that U.S. Government is not protecting us from harm and is unlikely to do so in the near future. That means that we must protect ourselves and our families at the individual and the community levels while working toward protective action by governments at the local, state, and Federal levels.

Who am I?

I am a retired U.S. Government career scientist (Ph.D., Applied Physics, Harvard University, 1975). During my Government career, I worked for the Executive Office of the President of the United States, the National Science Foundation, and the National Institute of Standards and Technology. For those organizations, respectively, I addressed Federal research and development program evaluation, energy policy research, and measurement development in support of the electronics and electrical-equipment industries and the biomedical research community. I currently interact with other scientists and with physicians around the world on the impact of electromagnetic fields on human health.

Evidence of harm

I present below key evidence, and associated references, that the exposure of humans to radiofrequency radiation, and specifically cellular radiation, is harmful to health.

In 2016, the National Toxicology Program, at the National Institutes of Health, linked cellular radiation to brain and heart tumors.

The National Toxicology Program (NTP), at the National Institutes of Health (NIH), just published the "Partial Findings" of a $25 million multi-year study of the impact of cellular radiation on health. The U.S. Food and Drug Administration "nominated" this NTP study. The NTP indicated that this is the largest and most complex study ever conducted by the NTP.

[1] Ronald M. Powell, Ph.D., USA, email ronpowell@verizon.net, web site https://www.scribd.com/document/291507610/.

The NTP study exposed each of six separate groups of male rats to one of the six possible combinations of three different levels of cellular radiation and two different modulation formats. The modulation format is the method used to impress information on the cellular signal. A separate seventh group of male rats was used as a "control", that is, for comparison, and was protected from exposure to any cellular radiation.

The NTP study found a "likely" causal relationship between exposure to cellular radiation and the occurrence of malignant brain cancer (glioma) and malignant nerve tumors (schwannomas) of the heart in the male rats:

> The rates of occurrence of brain glioma in the male rats ranged from 0 to 3.3 percent for the six groups exposed to radiation. The mean rate of occurrence was 2.0 percent across all six groups.[2]
>
> The rates of occurrence of heart schwannoma in the male rats ranged from 1.1 to 6.6 percent for the six groups exposed to radiation. The mean rate of occurrence was 3.5 percent across all six groups.[3]
>
> The seventh group of male rats, which was used as a control and which was protected from exposure to any cellular radiation, experienced no instances of brain glioma or heart schwannoma.

The NTP considered its findings so important to public health that it issued the "Partial Findings" (May 2016) prior to completing the full study. The NTP then presented those findings at an international conference (BioEM2016, June 2016) attended by 300 scientists from 41 countries. The NTP characterized the motivation for the early release of the "Partial Findings" this way:

> "Given the widespread global usage of mobile communications among users of all ages, even a very small increase in the incidence of disease resulting from exposure to RFR [radiofrequency radiation] could have broad implications for public health. There is a high level of public and media interest regarding the safety of cell phone RFR and the specific results of these NTP studies."

The NTP promised further findings from its study for publication through 2017. Included in those further findings will be test results on mice. You can learn more about this study from the following references:

> **Reference:** NTP's brief description of its study. National Toxicology Program: Cell Phones. (http://ntp.niehs.nih.gov/results/areas/cellphones/index.html)
>
> **Reference:** NTP's published "Partial Findings" of the study. Michael Wyde, Mark Cesta, Chad Blystone, Susan Elmore, Paul Foster, Michelle Hooth, Grace Kissling, David Malarkey, Robert Sills, Matthew Stout, Nigel Walker, Kristine Witt, Mary Wolfe, and John Bucher, Report of Partial Findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats (Whole Body Exposure), posted June 23, 2016. (http://biorxiv.org/content/biorxiv/early/2016/06/23/055699.full.pdf)
>
> **Reference:** Informative discussion of the NTP study. Environmental Health Trust, Frequently Asked Questions about the U.S. National Toxicology Program Radiofrequency Rodent Carcinogenicity Research Study. (http://ehtrust.org/science/facts-national-toxicology-program-cellphone-rat-cancer-study)

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[2] In the "Partial Findings" reference cited above, the mean (average) rate of occurrence for malignant glioma in male rats was determined from Table 1 on page 13 as follows: (3 + 3 + 2 + 0 + 0 + 3)/(90 + 90 + 90 + 90 + 90 + 90) = 2.0 percent.

[3] In the "Partial Findings" reference cited above, the mean (average) rate of occurrence for malignant heart schwannoma in male rats was determined from Table 3 on page 15 as follows: (2 + 1 + 5 + 2 + 3 + 6)/(90 + 90 + 90 + 90 + 90 + 90) = 3.5 percent.

Reference: Announcement of the BioEM2016 presentation. Results of NIEHS' National Toxicology Program GSM/CDMA phone radiation study to be presented at BioEM2016 Meeting in Ghent, 05 June 2016 — 10 June 2016 Ghent University, Belgium. (http://www.alphagalileo.org/ViewItem.aspx?ItemId=164837&CultureCode=en)

Reference: Viewgraphs presented by Michael Wyde, Ph.D., NTP study scientist, at BioEM2016 Meeting, Ghent, Belgium, June 8, 2016. NTP Toxicology and Carcinogenicity Studies of Cell Phone Radiofrequency Radiation. (http://ntp.niehs.nih.gov/ntp/research/areas/cellphone/slides_bioem_wyde.pdf)

The NTP study reinforces the classification of radiofrequency radiation, including cellular radiation, as a possible human carcinogen, made by the International Agency for Research on Cancer of the World Health Organization in 2011.

In its "Partial Findings" the NTP noted that its study reinforces a decision made by the International Agency for Research on Cancer (IARC) of the World Health Organization (WHO) in 2011. That decision classified radiofrequency radiation, including specifically cellular radiation, as a Group 2B carcinogen (possible carcinogen for humans). This classification was based on the increased risk of malignant brain cancer (glioma) and acoustic neuroma (a benign tumor of the auditory nerve), which is a form of schwannoma (vestibular schwannoma).[4]

Reference: Announcement of the IARC classification. International Agency for Research on Cancer**,** IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic To Humans, Press Release No. 208, 31 May 2011. (http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf)

Reference: Full report on the IARC classification. IARC Monographs: Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields, Volume 102, 2013. (http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf)

The findings of the NTP study, in combination with the findings of other studies conducted since 2011, have greatly increased the likelihood that the IARC will raise its classification of radiofrequency radiation to Group 2A (probable carcinogen for humans) or even to Group 1 (known carcinogen for humans) in the near future.

In 2015, hundreds of international scientists appealed to the United Nations and the World Health Organization to warn the public about the health risks caused by electromagnetic fields (EMF), including radiofrequency radiation and, specifically, cellular radiation.

As of January 29, 2017, 224 scientists from 41 nations have signed an international appeal first submitted to the United Nations and to the World Health Organization in May 2015. These scientists seek improved protection of the public from harm caused by the radiation produced by many wireless sources, including "cellular and cordless phones and their base stations, Wi-Fi, broadcast antennas, smart meters, and baby monitors" among others. Together, these scientists "have published more than 2000 research papers and studies on EMF." They state the following:

[4] The Mayo Clinic describes acoustic neuroma here: http://www.mayoclinic.org/diseases-conditions/acoustic-neuroma/basics/definition/CON-20023851.

"Numerous recent scientific publications have shown that EMF affects living organisms at levels well below most international and national guidelines. Effects include increased cancer risk, cellular stress, increase in harmful free radicals, genetic damages, structural and functional changes of the reproductive system, learning and memory deficits, neurological disorders, and negative impacts on general well-being in humans. Damage goes well beyond the human race, as there is growing evidence of harmful effects to both plant and animal life."

Reference: Welcome to EMFscientist.org.
(https://www.emfscientist.org)

Reference: International EMF Scientist Appeal: Scientists call for Protection from Non-ionizing Electromagnetic Field Exposure, May 15, 2015 (updated October 10, 2016).
(https://www.emfscientist.org/index.php/emf-scientist-appeal)

Reference: International Scientists Petition U.N. to Protect Humans and Wildlife from Electromagnetic Fields and Wireless Technology.
(https://www.emfscientist.org/images/docs/International_EMF_Scientist_Appeal_Description.pdf)

In 2012, the BioInitiative Working Group published the most comprehensive of the recent analyses of the international biomedical research, showing a multitude of biological effects from exposure to radiofrequency radiation, including cellular radiation, at levels below the current exposure guidelines set by the Federal Communications Commission (FCC).

The health risks posed by the expanding use of radiofrequency radiation in wireless devices are not limited to cancer, as devastating as that consequence is. The broad range of health effects was extensively reviewed in the BioInitiative Report 2012. This 1479-page review considered about 1800 peer-reviewed biomedical research publications, most issued in the previous five years. The BioInitiative Report 2012 was prepared by an international body of 29 experts, heavy in Ph.D.s and M.D.s, from 10 countries, including the USA which contributed the greatest number of experts (10). The report concluded the following:

"The continued rollout of wireless technologies and devices puts global public health at risk from unrestricted wireless commerce unless new, and far lower exposure limits and strong precautionary warnings for their use are implemented."

Reference: BioInitiative Working Group, Cindy Sage, M.A. and David O. Carpenter, M.D., Editors, BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation, December 31, 2012.
(http://www.bioinitiative.org)

The BioInitiative Report 2012 documented, in its "RF Color Charts", examples of eight categories of biological effects that occurred at levels below the current exposure guidelines set by the FCC:

- stress proteins, heat shock proteins, and disrupted immune function
- reproduction and fertility effects
- oxidative damage, reactive ion species (ROS), DNA damage, and DNA repair failure
- disrupted calcium metabolism
- brain tumors and blood-brain barrier
- cancer (other than brain) and cell proliferation

- sleep, neuron firing rate, electroencephalogram (EEG), memory, learning, and behavior
- cardiac, heart muscle, blood-pressure, and vascular effects.

These biological effects were attributed to "Radiofrequency Radiation at Low Intensity Exposure" from "cell towers, Wi-Fi, wireless laptops, and smart meters".

> **Reference:** See the "RF Color Charts", accessed from the left column of the web page below. (http://www.bioinitiative.org)

The U.S. Government is not protecting us.

The radiation exposure guidelines of the FCC do not protect us because they are outdated and based on a false assumption.

The current radiation exposure guidelines of the FCC were adopted in 1996, 20 years ago. Those guidelines are based primarily on an analysis by the National Council on Radiation Protection and Measurements (NCRP) which was published in 1986, 30 years ago. That was many years before the emergence of nearly all of the digital wireless devices in use today.

> "The FCC-adopted limits for Maximum Permissible Exposure (MPE) are generally based on recommended exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP) in 'Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields,' NCRP Report No. 86, Sections 17.4.1, 17.4.1.1, 17.4.2 and 17.4.3. Copyright NCRP, 1986, Bethesda, Maryland 20814...."
>
> **Reference:** Federal Communications Commission, Office of Engineering & Technology, Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, OET Bulletin 65, Edition 97-01 (August 1997). See the last paragraph on page 64. (http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf)

Those exposure guidelines have not been substantially changed since that analysis in 1986. They are based on the *thermal assumption* that the only harm that radiofrequency radiation can cause is due to tissue heating. This thermal assumption has been thoroughly disproved since, as biological effects have been found to occur at levels of radiation below, and even far below, those that cause significant tissue heating. Such lower levels are commonly referred to as *nonthermal* levels. The result is that many authorities now consider the FCC's current exposure guidelines as entirely outdated and much too high (that is, much too permissive) to protect the public.

The evidence disproving the thermal assumption is based on the broadened understanding of the biological effects of radiofrequency radiation made possible by thousands of peer-reviewed papers published by international biomedical scientists since 1986. The BioInitiative Report 2012 is the most recent comprehensive review of that research and provides many examples of bioeffects occurring at nonthermal radiation levels, as described above. Further, the new study by the National Toxicology Program, also described above, added to the evidence disproving the thermal assumption. That study exposed rats to levels of radiation below those that cause significant heating, and both above and below the FCC's current exposure guidelines as well. Yet, even below the FCC's current exposure guidelines, the male rats still developed malignant brain cancer (glioma) and malignant tumors (schwannomas) of the nerves of the heart.

The shortcomings of the FCC's exposure guidelines are described in detail in the following reference:

> **Reference:** Outdated FCC "Safety" Standards: The Five Fallacies of the Electromagnetic Radiation Exposure Limits.
> (http://ehtrust.org/policy/fcc-safety-standards/)

The FCC is not a credible source for exposure guidelines because it lacks health expertise and because it is too heavily influenced by the wireless industries that it is supposed to regulate.

The FCC lacks the health expertise required for developing health-related radiation exposure guidelines. Further, the FCC seems more interested in assuring compatibility among electronic systems than in assuring the compatibility of electronic systems with human, animal, and plant life. Since the exposure guidelines relate to health, it would make more sense for them to be developed by an agency with health expertise, such as the Environmental Protection Agency (EPA).

In addition, the FCC lacks the impartiality required to be a source of credible guidelines. The FCC is too heavily influenced by the wireless industries that the FCC is supposed to regulate. The FCC has acted in partnership with the wireless industries by permitting wireless radiation levels far higher than the biomedical research literature indicates are necessary to protect human health. The success of the wireless industries in capturing the FCC, the committees in the U.S. Congress that oversee the FCC, and the Executive Branch is detailed in a recent monograph from the Center for Ethics at Harvard University.

> **Reference:** Norm Alster, Captured Agency: How the Federal Communications Commission is Dominated by the Industries It Presumably Regulates (2015).
> http://ethics.harvard.edu/news/new-e-books-edmond-j-safra-research-lab

As an example of that capture, President Obama, in 2013, appointed Thomas Wheeler, as the Chairman of the FCC. At that time, Mr. Wheeler was the head of the CTIA – The Wireless Association, which is the major lobbying organization for the wireless industries. This is the infamous "revolving door".

The FCC's decision to fast-track Fifth Generation (5G) cellular technology without prior study of its health impact demonstrates the FCC's disinterest in the public health.

On July 14, 2016, the FCC adopted new rules that would promote fast-tracking the expansion of cellular service to new and higher frequencies as part of the Fifth Generation (5G) of cellular technology. This decision will open selected frequency bands above 24 gigahertz (GHz) and up to 71 GHz. At the same time, the FCC has requested comment on opening even higher frequencies, possibly above 95 GHz.

> **Reference:** FCC Takes Steps to Facilitate Mobile Broadband and Next Generation Wireless Technologies in Spectrum above 24 GHz: New rules will enable rapid development and deployment of next generation 5G technologies and services.
> (http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0714/DOC-340301A1.pdf)

> **Reference:** Fact Sheet: Spectrum Frontiers Rules Identify, Open Up Vast Amounts of New High-Band Spectrum for Next Generation (5G) Wireless Broadband.
> (http://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0714/DOC-340310A1.pdf)

All five commissioners of the FCC, including Chairman Thomas Wheeler, approved this expedited move to 5G. No commissioner called for evaluating the health impact before proceeding with 5G, despite the recent findings of the National Toxicology Program at NIH that cellular radiation likely causes tumors. Nor did even one commissioner express any interest in, or concern about, the impact of this new technology on public health. Rather, the FCC's emphasis was on the billions of dollars to be made by proceeding to implement 5G as rapidly as possible, with a minimum of regulatory interference, to assure an international competitive position.

In contrast to the FCC's disinterest in the impact of 5G on the public health, extensive written comments from individual members of the public and from many interested organizations raised a host of health concerns that were totally ignored in the FCC's presentations.

> **Reference:** July 2016 Open Commission Meeting addressing "Spectrum Frontiers" and "Advancing Technology Transitions".
> (https://www.fcc.gov/news-events/events/2016/07/july-2016-open-commission-meeting)

> **Reference:** The FCC Approves 5G Millimeter Wave Spectrum Frontiers. Includes excerpts from selected comments provided to the FCC by individuals and organizations that expressed concern about the health impact of the FCC's plan for 5G.
> (http://ehtrust.org/policy/fcc-approves-5g-millimeter-wave-spectrum-frontiers/)

> **Reference:** Comments on FCC Docket 14-177, Spectrum Bands above 24 GHz. All of the comments submitted to the FCC about the key docket leading to the implementation of 5G.
> (https://www.fcc.gov/ecfs/search/filings?proceedings_name=14-177&sort=date_disseminated,DESC)

U.S. Government agencies, and U.S. medical organizations, have disputed the validity of the FCC's exposure guidelines.

U.S. Government agencies, as well as U.S. medical organizations, have disputed the validity of the FCC's thermal exposure guidelines, maintaining that they are outdated and need to be updated to provide adequate protection of human beings, including children and seniors as well as other vulnerable groups.

U.S. Environmental Protection Agency

The Environmental Protection Agency (EPA) would be a better agency than the FCC to entrust with setting radiofrequency radiation exposure guidelines because the EPA has both health expertise and environmental responsibilities. The EPA is often cited by the FCC, and by the wireless industries, as one of the agencies that the FCC has *consulted* about the FCC's exposure guidelines, as if to increase the credibility of those guidelines. However, the fact that the EPA has *explicitly disputed* the validity of those guidelines is consistently omitted from those FCC citations.

Specifically, in 2002, the EPA addressed the limitations of the thermal exposure guidelines of the FCC, and the similar guidelines of private organizations, including the Institute of Electrical and Electronics Engineers and the International Commission on Non-Ionizing Radiation Protection:

> "The FCC's current exposure guidelines, as well as those of the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-ionizing Radiation Protection, are thermally based, and do not apply to chronic, nonthermal exposure situations…. The FCC's exposure guideline is

considered protective of effects arising from a thermal mechanism but not from all possible mechanisms. Therefore, the generalization by many that the guidelines protect human beings from harm by any or all mechanisms is not justified."

"Federal health and safety agencies have not yet developed policies concerning possible risk from long-term, nonthermal exposures. When developing exposure standards for other physical agents such as toxic substances, health risk uncertainties, with emphasis given to sensitive populations, are often considered. Incorporating information on exposure scenarios involving repeated short duration/nonthermal exposures that may continue over very long periods of time (years), with an exposed population that includes children, the elderly, and people with various debilitating physical and medical conditions, could be beneficial in delineating appropriate protective exposure guidelines."

Reference: Letters from Frank Marcinowski, Director, Radiation Protection Division, EPA, and Norbert Hankin, Center for Science and Risk Assessment, Radiation Protection Division, EPA, to Janet Newton, President, the EMR Network, with copies to the FCC and the IEEE, dated July 16, 2002. (http://www.emrpolicy.org/litigation/case_law/docs/noi_epa_response.pdf)

In summary, the EPA makes the following points: (1) the FCC 's thermal exposure guidelines do *not* protect against all harm, only the harm caused by too much heating; (2) the FCC's thermal exposure guidelines do *not* apply to "chronic, nonthermal exposure", which is the type of exposure generated by cell towers and many other wireless devices; and (3) when new FCC guidelines are developed for chronic nonthermal exposures, they must accommodate "children, the elderly, and people with various debilitating physical and medical conditions" because those groups are not accommodated now.

U.S. Food and Drug Administration

The Food and Drug Administration (FDA) is also often cited by the FCC, and by the wireless industries, as one of the agencies that the FCC has consulted about exposure guidelines. But the FDA is the agency that "nominated" the NTP study of the possible health effects of cellular radiation, in part because of the FDA's uncertainty about the validity of the FCC's exposure guidelines:

"Currently cellular phones and other wireless communication devices are required to meet the radio frequency radiation (RFR) exposure guidelines of the Federal Communications Commission (FCC), which were most recently revised in August 1996. The existing exposure guidelines are based on protection from acute injury from thermal effects of RFR exposure, and may not be protective against any non-thermal effects of chronic exposures."

Reference: Nominations from FDA's Center from [for] Device[s] and Radiological Health, Radio Frequency Radiation Emissions of Wireless Communication Devices (CDRH), Executive Summary, as attached to transmittal letter from William T. Allaben, Ph.D., FDA Liaison, to Dr. Errol Zeiger, Coordinator, Chemical Nomination and Selection, National Toxicology Program, May 19, 1999,[5] (http://ntp.niehs.nih.gov/ntp/htdocs/chem_background/exsumpdf/wireless051999_508.pdf)

The FDA's wisdom in nominating the NTP study was well justified by the NTP's publication of the "Partial Findings" described above. Those findings demonstrated both that the FCC's exposure guidelines are not protective and that the thermal assumption on which those guidelines are based is invalid.

[5] This date and the referenced URL were changed when this superior reference was posted, at my request, by the NTP/NIEHS/NIH.

U.S. Department of the Interior

In 2014 the Department of the Interior (Fish and Wildlife Service) also addressed the limitations of the FCC's thermal exposure guidelines. The Department of the Interior was motivated by the multiple adverse effects of electromagnetic radiation on the health, and the life, of birds, particularly in connection with cell towers. The Department of the Interior stated the following:

> "However, the electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today."
>
> **Reference:** Letter from Willie R. Taylor, Director, Office of Environmental Policy and Compliance, Office of the Secretary, United States Department of the Interior, to Mr. Eli Veenendaal, National Telecommunications and Information Administration, U.S. Department of Commerce, dated February 7, 2014.
> (https://www.ntia.doc.gov/files/ntia/us_doi_comments.pdf)

American Academy of Environmental Medicine

The American Academy of Environmental Medicine (AAEM), which trains physicians in preparation for Board Certification in Environmental Medicine, states the following:

> "The AAEM strongly supports the use of wired Internet connections, and encourages avoidance of radiofrequency such as from WiFi, cellular and mobile phones and towers, and 'smart meters'."
>
> "The peer reviewed, scientific literature demonstrates the correlation between RF [radiofrequency] exposure and neurological, cardiac, and pulmonary disease as well as reproductive and developmental disorders, immune dysfunction, cancer and other health conditions. The evidence is irrefutable."
>
> "To install WiFi in schools plus public spaces risks a widespread public health hazard that the medical system is not yet prepared to address."
>
> **Reference:** American Academy of Environmental Medicine, Wireless Radiofrequency Radiation in Schools, November 14, 2013.
> (http://www.aaemonline.org/pdf/WiredSchools.pdf)

American Academy of Pediatrics

The American Academy of Pediatrics (AAP), whose 60,000 doctors care for our children, supports the development of more restrictive standards for radiofrequency radiation exposure in order to better protect the public, particularly the children. In a letter to the Federal Communications Commission (FCC) and the Food and Drug Administration (FDA), dated August 29, 2013, the AAP states the following:

> "Children are not little adults and are disproportionately impacted by all environmental exposures, including cell phone radiation. Current FCC standards do not account for the unique vulnerability and use patterns specific to pregnant women and children. It is essential that any new standard for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded throughout their lifetimes."

Reference: American Academy of Pediatrics, letter dated August 29, 2013 addressed to The Honorable Mignon L. Clyburn, Acting Commissioner, Federal Communications Commission, and The Honorable Dr. Margaret A. Hamburg, Commissioner, U.S. Food and Drug Administration. (http://apps.fcc.gov/ecfs/document/view?id=7520941318)

After reviewing the "Partial Findings" from the new study by the National Toxicology Program at the National Institutes of Health, described above, the American Academy of Pediatrics cautioned parents about the use of cell phones by their children:

"In light of the findings, the Academy continues to reinforce its recommendation that parents should limit use of cell phones by children and teens."

Reference: American Academy of Pediatrics, AAP responds to study showing link between cell phone radiation, tumors in rats, May 27, 2016. (http://www.aappublications.org/news/2016/05/27/Cancer052716)

The Telecommunications Act of 1996, in combination with the FCC's exposure guidelines, empowers the wireless industries to mandate the exposure of the public to levels of radiofrequency radiation already found harmful to health.

The Telecommunications Act of 1996 bars state and local governments from objecting to the placement of cell towers on environmental/health grounds unless the FCC's exposure guidelines would be exceeded. Specifically, the Act states the following:

"No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's [FCC's] regulations concerning such emissions."

Reference: Telecommunications Act of 1996, Section 704 Facilities Siting; Radio Frequency Emission Standards, page 117. (http://transition.fcc.gov/Reports/tcom1996.pdf)

This Act, in combination with the FCC's permissive exposure guidelines, strips state and local governments of the right to protect their own residents from levels of radiofrequency radiation already shown to be harmful to health. In effect, this Act transfers to the wireless industries the right to ***mandate*** the exposure of the public, including those most vulnerable to harm, to radiofrequency radiation without the need for further governmental action. State and local governments can still resist, but to do so they must confront this Act which is designed to frustrate their success. Even so, some governments do heroically resist and some do succeed.

Protecting ourselves and our families

We can act on our own to protect ourselves and our families, but only partially.

Instead of increasing our exposure to cellular radiation, and to the radiation from other digital wireless devices, we can decrease our exposure and improve our chances for good health. Desirable steps in this direction include the following:

- Reduce or stop the use of cell phones. Reserve them for emergencies or other essential uses.
- Replace cordless telephones with corded telephones.
- Establish wired (Ethernet) interconnections between routers and the wireless devices that the routers support. Then turn off the wireless capabilities, such as Wi-Fi and Bluetooth, of them all.
- “Opt out” of the wireless smart meter on your residence, if your state or local electric power company permits. Many states, but not all, have an opt-out provision.
- Alert family members about the health risks posed by wireless devices, particularly for vulnerable groups such as pregnant mothers, unborn children, young and teenage children, adult males of reproductive age, seniors, the disabled, and anyone with a chronic health condition. Everyone is vulnerable, but these groups are more so.

  Reference: For more information on reducing radiation at home, please see Ronald M. Powell, Ph.D., How to Reduce the Electromagnetic Radiation in Your Home, which is document (10) on the following list.
  (https://www.scribd.com/document/291507610/)

We can obtain better protection if we work together.

We can contribute our efforts to the hundreds of new organizations that are emerging nationwide to raise awareness about the health risks posed by the radiation exposure from wireless devices in homes, in the workplace, in schools, and in public places, especially where children are present. Through the Internet, look for organizations that address the intersection of health with cell phones, cordless phones, Wi-Fi, smart meters, and wireless desktop computers, laptops, and tablets. These wireless devices are the principal sources of radiofrequency radiation in the home.

Take care for our children. Today's adults grew up in an environment with much less radiofrequency radiation than exists today. Today’s children are not so lucky. To have the same chance at a healthy life, they need a lot of help. Unfortunately, the levels of radiofrequency radiation in our environment are rising exponentially as governments and wireless industries continue to promote, and even mandate, the exposure of the public to ever higher levels of radiofrequency radiation, with no limit in sight. That means that many of our children will become chronically ill, and many will die, while still young adults. This is a tragedy in the making. To stop it will require greatly increased awareness of the problem and serious political action at multiple levels of government. That is no small task, but we all can help. We can join with others to become a part of the solution for ourselves and our families, but especially for our children and our grandchildren.

Gandhi, G., Kaur, G., & Nisar, U. (2015). A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station. *Electromagnetic Biology and Medicine*, *34*(4), 344–354. https://doi.org/10.3109/15368378.2014.933349

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Santini, R., Santini, P., Le Ruz, P., Danze, J. M., & Seigne, M. (2003). Survey Study of People Living in the Vicinity of Cellular Phone Base Stations. *Electromagnetic Biology and Medicine*, *22*(1), 41–49. https://doi.org/10.1081/JBC-120020353

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Shahbazi-Gahrouei, D., Karbalae, M., Moradi, H. A., & Baradaran-Ghahfarokhi, M. (2014). Health effects of living near mobile phone base transceiver station (BTS) antennae: A report from Isfahan, Iran. *Electromagnetic Biology and Medicine*, *33*(3), 206–210. https://doi.org/10.3109/15368378.2013.801352

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Risks to Health and Well-Being From Radio-Frequency Radiation Emitted by Cell Phones and Other Wireless Devices

Anthony B. Miller[1]*, Margaret E. Sears[2], L. Lloyd Morgan[3], Devra L. Davis[3], Lennart Hardell[4], Mark Oremus[5] and Colin L. Soskolne[6,7]

[1] Dalla Lana School of Public Health, University of Toronto, Toronto, ON, Canada, [2] Ottawa Hospital Research Institute, Prevent Cancer Now, Ottawa, ON, Canada, [3] Environmental Health Trust, Teton Village, WY, United States, [4] The Environment and Cancer Research Foundation, Örebro, Sweden, [5] School of Public Health and Health Systems, University of Waterloo, Waterloo, ON, Canada, [6] School of Public Health, University of Alberta, Edmonton, AB, Canada, [7] Health Research Institute, University of Canberra, Canberra, ACT, Australia

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***Correspondence:**
Anthony B. Miller
ab.miller@utoronto.ca

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Radiation exposure has long been a concern for the public, policy makers, and health researchers. Beginning with radar during World War II, human exposure to radio-frequency radiation[1] (RFR) technologies has grown substantially over time. In 2011, the *International Agency for Research on Cancer* (IARC) reviewed the published literature and categorized RFR as a "possible" (Group 2B) human carcinogen. A broad range of adverse human health effects associated with RFR have been reported since the IARC review. In addition, three large-scale carcinogenicity studies in rodents exposed to levels of RFR that mimic lifetime human exposures have shown significantly increased rates of Schwannomas and malignant gliomas, as well as chromosomal DNA damage. Of particular concern are the effects of RFR exposure on the developing brain in children. Compared with an adult male, a cell phone held against the head of a child exposes deeper brain structures to greater radiation doses per unit volume, and the young, thin skull's bone marrow absorbs a roughly 10-fold higher local dose. Experimental and observational studies also suggest that men who keep cell phones in their trouser pockets have significantly lower sperm counts and significantly impaired sperm motility and morphology, including mitochondrial DNA damage. Based on the accumulated evidence, we recommend that IARC re-evaluate its 2011 classification of the human carcinogenicity of RFR, and that WHO complete a systematic review of multiple other health effects such as sperm damage. In the interim, current knowledge provides justification for governments, public health authorities, and physicians/allied health professionals to warn the population that having a cell phone next to the body is harmful, and to support measures to reduce all exposures to RFR.

Keywords: brain cancer, electromagnetic hypersensitivity, glioma, non-cancer outcomes, policy recommendations, radiofrequency fields, child development, acoustic neuroma

[1] Per IEEE C95.1-1991, the radio-frequency radiation frequency range is from 3 kHz to 300 GHz and is non-ionizing.

INTRODUCTION

We live in a generation that relies heavily on technology. Whether for personal use or work, wireless devices, such as cell phones, are commonly used around the world, and exposure to radiofrequency radiation (RFR) is widespread, including in public spaces (1, 2).

In this review, we address the current scientific evidence on health risks from exposure to RFR, which is in the non-ionizing frequency range. We focus here on human health effects, but also note evidence that RFR can cause physiological and/or morphological effects on bees, plants and trees (3–5).

We recognize a diversity of opinions on the potential adverse effects of RFR exposure from cell or mobile phones and other wireless transmitting devices (WTDs) including cordless phones and Wi-Fi. The paradigmatic approach in cancer epidemiology, which considers the body of epidemiological, toxicological, and mechanistic/cellular evidence when assessing causality, is applied.

CARCINOGENICITY

Since 1998, the *International Commission on Non-Ionizing Radiation Protection* (ICNIRP) has maintained that no evidence of adverse biological effects of RFR exist, other than tissue heating at exposures above prescribed thresholds (6).

In contrast, in 2011, an expert working group of the *International Agency for Research on Cancer* (IARC) categorized RFR emitted by cell phones and other WTDs as a Group 2B ("possible") human carcinogen (7).

Since the IARC categorization, analyses of the large international Interphone study, a series of studies by the Hardell group in Sweden, and the French CERENAT case-control studies, signal increased risks of brain tumors, particularly with ipsilateral use (8). The largest case-control studies on cell phone exposure and glioma and acoustic neuroma demonstrated significantly elevated risks that tended to increase with increasing latency, increasing cumulative duration of use, ipsilateral phone use, and earlier age at first exposure (8).

Pooled analyses by the Hardell group that examined risk of glioma and acoustic neuroma stratified by age at first exposure to cell phones found the highest odds ratios among those first exposed before age 20 years (9–11). For glioma, first use of cell phones before age 20 years resulted in an odds ratio (OR) of 1.8 (95% confidence interval [CI] 1.2–2.8). For ipsilateral use, the OR was 2.3 (CI 1.3-4.2); contralateral use was 1.9 (CI 0.9-3.7). Use of cordless phone before age 20 yielded OR 2.3 (CI 1.4–3.9), ipsilateral OR 3.1 (CI 1.6–6.3) and contralateral use OR 1.5 (CI 0.6–3.8) (9).

Although Karipidis et al. (12) and Nilsson et al. (13) found no evidence of an increased incidence of gliomas in recent years in Australia and Sweden, respectively, Karipidis et al. (12) only reported on brain tumor data for ages 20–59 and Nilsson et al. (13) failed to include data for high grade glioma. In contrast, others have reported evidence that increases in specific types of brain tumors seen in laboratory studies are occurring in Britain and the US:

- The incidence of neuro-epithelial brain cancers has significantly increased in all children, adolescent, and young adult age groupings from birth to 24 years in the United States (14, 15).
- A sustained and statistically significant rise in glioblastoma multiforme across all ages has been described in the UK (16).

The incidence of several brain tumors are increasing at statistically significant rates, according to the 2010–2017 *Central Brain Tumor Registry of the U.S.* (CBTRUS) dataset (17).

- There was a significant increase in incidence of radiographically diagnosed tumors of the pituitary from 2006 to 2012 (APC = 7.3% [95% CI: 4.1%, 10.5%]), with no significant change in incidence from 2012 to 2015 (18).
- Meningioma rates have increased in all age groups from 15 through 85+ years.
- Nerve sheath tumor (Schwannoma) rates have increased in all age groups from age 20 through 84 years.
- Vestibular Schwannoma rates, as a percentage of nerve sheath tumors, have also increased from 58% in 2004 to 95% in 2010-2014.

Epidemiological evidence was subsequently reviewed and incorporated in a meta-analysis by Röösli et al. (19). They concluded that overall, epidemiological evidence does not suggest increased brain or salivary gland tumor risk with mobile phone (MP) use, although the authors admitted that some uncertainty remains regarding long latency periods (>15 years), rare brain tumor subtypes, and MP usage during childhood. Of concern is that these analyses included cohort studies with poor exposure classification (20).

In epidemiological studies, recall bias can play a substantial role in the attenuation of odds ratios toward the null hypothesis. An analysis of data from one large multicenter case-control study of RFR exposure, did not find that recall bias was an issue (21). In another multi-country study it was found that young people can recall phone use moderately well, with recall depending on the amount of phone use and participants' characteristics (22). With less rigorous querying of exposure, prospective cohort studies are unfortunately vulnerable to exposure misclassification and imprecision in identifying risk from rare events, to the point that negative results from such studies are misleading (8, 23).

Another example of disparate results from studies of different design focuses on prognosis for patients with gliomas, depending upon cell phone use. A Swedish study on glioma found lower survival in patients with glioblastoma associated with long term use of wireless phones (24). Ollson et al. (25), however, reported no indication of reduced survival among glioblastoma patients in Denmark, Finland and Sweden with a history of mobile phone use (ever regular use, time since start of regular use, cumulative call time overall or in the last 12 months) relative to no or non-regular use. Notably, Olsson et al. (25) differed from Carlberg and Hardell (24) in that the study did not include use of cordless phones, used shorter latency time and excluded patients older than 69 years. Furthermore, a major shortcoming was that patients with the worst prognosis were excluded, as in Finland inoperable cases were excluded, all of which would bias the risk estimate toward unity.

In the interim, three large-scale toxicological (animal carcinogenicity) studies support the human evidence, as do modeling, cellular and DNA studies identifying vulnerable subgroups of the population.

The *U.S. National Toxicology Program* (NTP) (National Toxicology Program (26, 27) has reported significantly increased incidence of glioma and malignant Schwannoma (mostly on the nerves on the heart, but also additional organs) in large animal carcinogenicity studies with exposure to levels of RFR that did not significantly heat tissue. Multiple organs (e.g., brain, heart) also had evidence of DNA damage. Although these findings have been dismissed by the ICNIRP (28), one of the key originators of the NTP study has refuted the criticisms (29).

A study by Italy's Ramazzini Institute has evaluated lifespan environmental exposure of rodents to RFR, as generated by 1.8 GHz GSM antennae of cell phone radio base stations. Although the exposures were 60 to 6,000 times lower than those in the NTP study, statistically significant increases in Schwannomas of the heart in male rodents exposed to the highest dose, and Schwann-cell hyperplasia in the heart in male and female rodents were observed (30). A non-statistically significant increase in malignant glial tumors in female rodents also was detected. These findings with far field exposure to RFR are consistent with and reinforce the results of the NTP study on near field exposure. Both reported an increase in the incidence of tumors of the brain and heart in RFR-exposed Sprague-Dawley rats, which are tumors of the same histological type as those observed in some epidemiological studies on cell phone users.

Further, in a 2015 animal carcinogenicity study, tumor promotion by exposure of mice to RFR at levels below exposure limits for humans was demonstrated (31). Co-carcinogenicity of RFR was also demonstrated by Soffritti and Giuliani (32) who examined both power-line frequency magnetic fields as well as 1.8 GHz modulated RFR. They found that exposure to Sinusoidal-50 Hz Magnetic Field (S-50 Hz MF) combined with acute exposure to gamma radiation or to chronic administration of formaldehyde in drinking water induced a significantly increased incidence of malignant tumors in male and female Sprague Dawley rats. In the same report, preliminary results indicate higher incidence of malignant Schwannoma of the heart after exposure to RFR in male rats. Given the ubiquity of many of these co-carcinogens, this provides further evidence to support the recommendation to reduce the public's exposure to RFR to as low as is reasonably achievable.

Finally, a case series highlights potential cancer risk from cell phones carried close to the body. West et al. (33) reported four "extraordinary" multifocal breast cancers that arose directly under the antennae of the cell phones habitually carried within the bra, on the sternal side of the breast (the opposite of the norm). We note that case reports can point to major unrecognized hazards and avenues for further investigation, although they do not usually provide direct causal evidence.

In a study of four groups of men, of which one group did not use mobile phones, it was found that DNA damage indicators in hair follicle cells in the ear canal were higher in the RFR exposure groups than in the control subjects. In addition, DNA damage increased with the daily duration of exposure (34).

Many profess that RFR cannot be carcinogenic as it has insufficient energy to cause direct DNA damage. In a review, Vijayalaxmi and Prihoda (35) found some studies suggested significantly increased damage in cells exposed to RF energy compared to unexposed and/or sham-exposed control cells, others did not. Unfortunately, however, in grading the evidence, these authors failed to consider baseline DNA status or the fact that genotoxicity has been poorly predicted using tissue culture studies (36). As well funding, a strong source of bias in this field of enquiry, was not considered (37).

CHILDREN AND REPRODUCTION

As a result of rapid growth rates and the greater vulnerability of developing nervous systems, the long-term risks to children from RFR exposure from cell phones and other WTDs are expected to be greater than those to adults (38). By analogy with other carcinogens, longer opportunities for exposure due to earlier use of cell phones and other WTDs could be associated with greater cancer risks in later life.

Modeling of energy absorption can be an indicator of potential exposure to RFR. A study modeling the exposure of children 3–14 years of age to RFR has indicated that a cell phone held against the head of a child exposes deeper brain structures to roughly double the radiation doses (including fluctuating electrical and magnetic fields) per unit volume than in adults, and also that the marrow in the young, thin skull absorbs a roughly 10-fold higher local dose than in the skull of an adult male (39). Thus, pediatric populations are among the most vulnerable to RFR exposure.

The increasing use of cell phones in children, which can be regarded as a form of addictive behavior (40), has been shown to be associated with emotional and behavioral disorders. Divan et al. (41) studied 13,000 mothers and children and found that prenatal exposure to cell phones was associated with behavioral problems and hyperactivity in children. A subsequent Danish study of 24,499 children found a 23% increased odds of emotional and behavioral difficulties at age 11 years among children whose mothers reported any cell phone use at age 7 years, compared to children whose mothers reported no use at age 7 years (42). A cross-sectional study of 4,524 US children aged 8–11 years from 20 study sites indicated that shorter screen time and longer sleep periods independently improved child cognition, with maximum benefits achieved with low screen time and age-appropriate sleep times (43). Similarly, a cohort study of Swiss adolescents suggested a potential adverse effect of RFR on cognitive functions that involve brain regions mostly exposed during mobile phone use (44). Sage and Burgio et al. (45) posit that epigenetic drivers and DNA damage underlie adverse effects of wireless devices on childhood development.

RFR exposure occurs in the context of other exposures, both beneficial (e.g., nutrition) and adverse (e.g., toxicants or stress). Two studies identified that RFR potentiated adverse effects of lead on neurodevelopment, with higher maternal use of mobile phones during pregnancy [1,198 mother-child pairs, (46)] and

Attention Deficit Hyper-activity Disorder (ADHD) with higher cell phone use and higher blood lead levels, in 2,422 elementary school children (47).

A study of Mobile Phone Base Station Tower settings adjacent to school buildings has found that high exposure of male students to RFR from these towers was associated with delayed fine and gross motor skills, spatial working memory, and attention in adolescent students, compared with students who were exposed to low RFR (48). A recent prospective cohort study showed a potential adverse effect of RFR brain dose on adolescents' cognitive functions including spatial memory that involve brain regions exposed during cell phone use (44).

In a review, Pall (49) concluded that various non-thermal microwave EMF exposures produce diverse neuropsychiatric effects. Both animal research (50–52) and human studies of brain imaging research (53–56) indicate potential roles of RFR in these outcomes.

Male fertility has been addressed in cross-sectional studies in men. Associations between keeping cell phones in trouser pockets and lower sperm quantity and quality have been reported (57). Both *in vivo* and *in vitro* studies with human sperm confirm adverse effects of RFR on the testicular proteome and other indicators of male reproductive health (57, 58), including infertility (59). Rago et al. (60) found significantly altered sperm DNA fragmentation in subjects who use mobile phones for more than 4 h/day and in particular those who place the device in the trousers pocket. In a cohort study, Zhang et al. (61) found that cell phone use may negatively affect sperm quality in men by decreasing the semen volume, sperm concentration, or sperm count, thus impairing male fertility. Gautam et al. (62) studied the effect of 3G (1.8–2.5 GHz) mobile phone radiation on the reproductive system of male Wistar rats. They found that exposure to mobile phone radiation induces oxidative stress in the rats which may lead to alteration in sperm parameters affecting their fertility.

RELATED OBSERVATIONS, IMPLICATIONS AND STRENGTHS OF CURRENT EVIDENCE

An extensive review of numerous published studies confirms non-thermally induced biological effects or damage (e.g., oxidative stress, damaged DNA, gene and protein expression, breakdown of the blood-brain barrier) from exposure to RFR (63), as well as adverse (chronic) health effects from long-term exposure (64). Biological effects of typical population exposures to RFR are largely attributed to fluctuating electrical and magnetic fields (65–67).

Indeed, an increasing number of people have developed constellations of symptoms attributed to exposure to RFR (e.g., headaches, fatigue, appetite loss, insomnia), a syndrome termed *Microwave Sickness* or *Electro-Hyper-Sensitivity* (EHS) (68–70).

Causal inference is supported by consistency between epidemiological studies of the effects of RFR on induction of human cancer, especially glioma and vestibular Schwannomas, and evidence from animal studies (8). The combined weight of the evidence linking RFR to public health risks includes a broad array of findings: experimental biological evidence of non-thermal effects of RFR; concordance of evidence regarding carcinogenicity of RFR; human evidence of male reproductive damage; human and animal evidence of developmental harms; and limited human and animal evidence of potentiation of effects from chemical toxicants. Thus, diverse, independent evidence of a potentially troubling and escalating problem warrants policy intervention.

CHALLENGES TO RESEARCH, FROM RAPID TECHNOLOGICAL ADVANCES

Advances in RFR-related technologies have been and continue to be rapid. Changes in carrier frequencies and the growing complexity of modulation technologies can quickly render "yesterdays" technologies obsolete. This rapid obsolescence restricts the amount of data on human RFR exposure to particular frequencies, modulations and related health outcomes that can be collected during the lifespan of the technology in question.

Epidemiological studies with adequate statistical power must be based upon large numbers of participants with sufficient latency and intensity of exposure to specific technologies. Therefore, a lack of epidemiological evidence does not necessarily indicate an absence of effect, but rather an inability to study an exposure for the length of time necessary, with an adequate sample size and unexposed comparators, to draw clear conclusions. For example, no case-control study has been published on fourth generation (4G; 2–8 GHz) Long-term Evolution (LTE) modulation, even though the modulation was introduced in 2010 and achieved a 39% market share worldwide by 2018 (71).

With this absence of human evidence, governments must require large-scale animal studies (or other appropriate studies of indicators of carcinogenicity and other adverse health effects) to determine whether the newest modulation technologies incur risks, prior to release into the marketplace. Governments should also investigate short-term impacts such as insomnia, memory, reaction time, hearing and vision, especially those that can occur in children and adolescents, whose use of wireless devices has grown exponentially within the past few years.

The Telecom industry's fifth generation (5G) wireless service will require the placement of many times more small antennae/cell towers close to all recipients of the service, because solid structures, rain and foliage block the associated millimeter wave RFR (72). Frequency bands for 5G are separated into two different frequency ranges. Frequency Range 1 (FR1) includes sub-6 GHz frequency bands, some of which are bands traditionally used by previous standards, but has been extended to cover potential new spectrum offerings from 410 to 7,125 MHz. Frequency Range 2 (FR2) includes higher frequency bands from 24.25 to 52.6 GHz. Bands in FR2 are largely of millimeter wave length, these have a shorter range but a higher available bandwidth than bands in the FR1. 5G technology is being developed as it is also being deployed, with large arrays of directional, steerable, beam-forming antennae, operating at higher power than previous technologies. 5G is not stand-alone—it will operate and interface with other (including 3G and 4G) frequencies and modulations to enable diverse devices under continual development for the "internet of things," driverless vehicles and more (72).

Novel 5G technology is being rolled out in several densely populated cities, although potential chronic health or environmental impacts have not been evaluated and are not being followed. Higher frequency (shorter wavelength) radiation associated with 5G does not penetrate the body as deeply as frequencies from older technologies although its effects may be systemic (73, 74). The range and magnitude of potential impacts of 5G technologies are under-researched, although important biological outcomes have been reported with millimeter wavelength exposure. These include oxidative stress and altered gene expression, effects on skin and systemic effects such as on immune function (74). *In vivo* studies reporting resonance with human sweat ducts (73), acceleration of bacterial and viral replication, and other endpoints indicate the potential for novel as well as more commonly recognized biological impacts from this range of frequencies, and highlight the need for research before population-wide continuous exposures.

GAPS IN APPLYING CURRENT EVIDENCE

Current exposure limits are based on an assumption that the only adverse health effect from RFR is heating from short-term (acute), time-averaged exposures (75). Unfortunately, in some countries, notably the US, scientific evidence of the potential hazards of RFR has been largely dismissed (76). Findings of carcinogenicity, infertility and cell damage occurring at daily exposure levels—within current limits—indicate that existing exposure standards are not sufficiently protective of public health. Evidence of carcinogenicity alone, such as that from the NTP study, should be sufficient to recognize that current exposure limits are inadequate.

Public health authorities in many jurisdictions have not yet incorporated the latest science from the U.S. NTP or other groups. Many cite 28-year old guidelines by the *Institute of Electrical and Electronic Engineers* which claimed that "Research on the effects of chronic exposure and speculations on the biological significance of non-thermal interactions have not yet resulted in any meaningful basis for alteration of the standard" (77)[2].

Conversely, some authorities have taken specific actions to reduce exposure to their citizens (78), including testing and recalling phones that exceed current exposure limits.

While we do not know how risks to individuals from using cell phones may be offset by the benefits to public health of being able to summon timely health, fire and police emergency services, the findings reported above underscore the importance of evaluating potential adverse health effects from RFR exposure, and taking pragmatic, practical actions to minimize exposure.

We propose the following considerations to address gaps in the current body of evidence:

- As many claim that we should by now be seeing an increase in the incidence of brain tumors if RFR causes them, ignoring the increases in brain tumors summarized above, a detailed evaluation of age-specific, location-specific trends in the incidence of gliomas in many countries is warranted.
- Studies should be designed to yield the strongest evidence, most efficiently:
  - ➢ Population-based case-control designs can be more statistically powerful to determine relationships with rare outcomes such as glioma, than cohort studies. Such studies should explore the relationship between energy absorption (SAR[3]), duration of exposure, and adverse outcomes, especially brain cancer, cardiomyopathies and abnormal cardiac rythms, hematologic malignancies, thyroid cancer.
  - ➢ Cohort studies are inefficient in the study of rare outcomes with long latencies, such as glioma, because of cost-considerations relating to the follow-up required of very large cohorts needed for the study of rare outcomes. In addition, without continual resource-consuming follow-up at frequent intervals, it is not possible to ascertain ongoing information about changing technologies, uses (e.g., phoning vs. texting or accessing the Internet) and/or exposures.
  - ➢ Cross-sectional studies comparing high-, medium-, and low-exposure persons may yield hypothesis-generating information about a range of outcomes relating to memory, vision, hearing, reaction-time, pain, fertility, and sleep patterns.
- Exposure assessment is poor in this field, with very little fine-grained detail as to frequencies and modulations, doses and dose rates, and peak exposures, particularly over the long-term. Solutions such as wearable meters and phone apps have not yet been incorporated in large-scale research.
- Systematic reviews on the topic could use existing databases of research reports, such as the one created by *Oceania Radiofrequency Science Advisory Association* (79) or EMF Portal (80), to facilitate literature searches.
- Studies should be conducted to determine appropriate locations for installation of antennae and other broadcasting systems; these studies should include examination of biomarkers of inflammation, genotoxicity, and other health indicators in persons who live at different radiuses around these installations. This is difficult to study in the general population because many people's greatest exposure arises from their personal devices.
- Further work should be undertaken to determine the distance that wireless technology antennae should be kept away from humans to ensure acceptable levels of safety, distinguishing among a broad range of sources (e.g., from commercial transmitters to Bluetooth devices), recognizing that exposures fall with the inverse of the square of the distance

[2]The FCC adopted the IEEE C95.1 1991 standard in 1996.

[3]When necessary, SAR values should be adjusted for age of child in W/kg.

(The inverse-square law specifies that intensity is inversely proportional to the square of the distance from the source of radiation). The effective radiated power from cell towers needs to be regularly measured and monitored.

POLICY RECOMMENDATIONS BASED ON THE EVIDENCE TO DATE

At the time of writing, a total of 32 countries or governmental bodies within these countries[4] have issued policies and health recommendations concerning exposure to RFR (78). Three U.S. states have issued advisories to limit exposure to RFR (81–83) and the *Worcester Massachusetts Public Schools* (84) voted to post precautionary guidelines on Wi-Fi radiation on its website. In France, Wi-Fi has been removed from pre-schools and ordered to be shut off in elementary schools when not in use, and children aged 16 years or under are banned from bringing cell phones to school (85). Because the national test agency found 9 out of 10 phones exceeded permissible radiation limits, France is also recalling several million phones.

We therefore recommend the following:

1. Governmental and institutional support of data collection and analysis to monitor potential links between RFR associated with wireless technology and cancers, sperm, the heart, the nervous system, sleep, vision and hearing, and effects on children.
2. Further dissemination of information regarding potential health risk information that is in wireless devices and manuals is necessary to respect users' *Right To Know*. Cautionary statements and protective measures should be posted on packaging and at points of sale. Governments should follow the practice of France, Israel and Belgium and mandate labeling, as for tobacco and alcohol.
3. Regulations should require that any WTD that could be used or carried directly against the skin (e.g., a cell phone) or in close proximity (e.g., a device being used on the lap of a small child) be tested appropriately as used, and that this information be prominently displayed at point of sale, on packaging, and both on the exterior and within the device.
4. IARC should convene a new working group to update the categorization of RFR, including current scientific findings that highlight, in particular, risks to youngsters of subsequent cancers. We note that an IARC Advisory Group has recently recommended that RFR should be re-evaluated by the IARC Monographs program with high priority.
5. The World Health Organization (WHO) should complete its long-standing RFR systematic review project, using strong modern scientific methods. National and regional public health authorities similarly need to update their understanding and to provide adequate precautionary guidance for the public to minimize potential health risks.
6. Emerging human evidence is confirming animal evidence of developmental problems with RFR exposure during pregnancy. RFR sources should be avoided and distanced from expectant mothers, as recommended by physicians and scientists (babysafeproject.org).
7. Other countries should follow France, limiting RFR exposure in children under 16 years of age.
8. Cell towers should be distanced from homes, daycare centers, schools, and places frequented by pregnant women, men who wish to father healthy children, and the young.

Specific examples of how the health policy recommendations above, invoking the Precautionary Principle, might be practically applied to protect public health, are provided in the **Annex**.

[4] Argentina, Australia, Austria, Belgium, Canada, Chile, Cyprus, Denmark, European Environmental Agency, European Parliament, Finland, France, French Polynesia, Germany, Greece, Italy, India, Ireland, Israel, Namibia, New Zealand, Poland, Romania, Russia, Singapore, Spain, Switzerland, Taiwan, Tanzania, Turkey, United Kingdom, United States.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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ANNEX: EXAMPLES OF ACTIONS FOR REDUCING RFR EXPOSURE

1. Focus actions for reducing exposure to RFR on pregnant women, infants, children and adolescents, as well as males who might wish to become fathers.
2. Reduce, as much as possible, the extent to which infants and young children are exposed to RFR from Wi-Fi-enabled devices such as baby monitors, wearable devices, cell phones, tablets, etc.
3. Avoid placing cell towers and small cell antennae close to schools and homes pending further research and revision of the existing exposure limits. In schools, homes and the workplace, cable or optical fiber connections to the Internet are preferred. Wi-Fi routers in schools and daycares/kindergartens should be strongly discouraged and programs instituted to provide Internet access via cable or fiber.
4. Ensure that WTDs minimize radiation by transmitting only when necessary, and as infrequently as is feasible. Examples include transmitting only in response to a signal (e.g., accessing a router or querying a device, a cordless phone handset being turned on, or voice or motion activation). Prominent, visible power switches are needed to ensure that WTDs can be easily turned on only when needed, and off when not required (e.g., Wi-Fi when sleeping).
5. Lower permitted power densities in close proximity to fixed-site antennae, from "occupational" limits to exposure limits for the general public.
6. Update current exposure limits to be protective against the non-thermal effects of RFR. Such action should be taken by all heath ministries and public health agencies, as well as industry regulatory bodies. Exposure limits should be based on measurements of RFR levels related to biological effects (2).
7. Ensure that advisories relating to cell phone use are placed in such a way that purchasers can find them easily, similar to the Berkeley Cell Phone "Right to Know" Ordinance (86).
8. Advise the public that texting and speaker mode are preferable to holding cell phones to the ear. Alternatively, use hands-free accessories for cell phones, including air tube headsets that interrupt the transmission of RFR.
9. When possible, keep cell phones away from the body (e.g., on a nearby desk, in a purse or bag, or on a mounted hands-free accessory in motor vehicles).
10. Delay the widespread implementation of 5G (and any other new technology) until studies can be conducted to assess safety. This includes a wide range of household and community-wide infrastructure WTDs and self-driving vehicles, as well as the building of 5G minicells.
11. Fiber-optic connections for the Internet should be made available to every home, office, school, warehouse and factory, when and where possible.

GLOSSARY

ALARA	As Low a level As Reasonably Achievable
CBTRUS	Central Brain Tumor Registry of the United States
CI	Confidence Interval
EMR	Electro Magnetic Radiation
IARC	International Agency for Research on Cancer
ICNIRP	International Commission on Non-Ionizing Radiation Protection
INEP	International Network for Epidemiology in Policy
LTE	Long-Term Evolution modulation
NTP	U.S. National Toxicology Program
OR	Odds Ratio
RFR	Radio-Frequency Radiation
SAR	Specific Absorption Rate
WTD	Wireless Transmitting Device

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Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective☆

Dominique Belpomme [a, b, 1], Lennart Hardell [a, c, 1, 2], Igor Belyaev [a, d, e, 1], Ernesto Burgio [a, f], David O. Carpenter [a, g, h, *, 1]

[a] European Cancer Environment Research Institute, Brussels, Belgium
[b] Paris V University Hospital, Paris, France
[c] Department of Oncology, Orebro University Hospital, Faculty of Medicine, Orebro, Sweden
[d] Department of Radiobiology, Cancer Research Institute, Biomedical Research Center, Slovak Academy of Science, Bratislava, Slovak Republic
[e] Laboratory of Radiobiology, Institute of General Physics, Russian Academy of Science, Moscow, Russian Federation
[f] Instituto Scientifico Biomedico Euro Mediterraneo, Mesagne, Italy
[g] Institute for Health and the Environment, University at Albany, Albany, NY, USA
[h] Child Health Research Centre, The University of Queensland, Faculty of Medicine, Brisbane, Australia

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A B S T R A C T

Exposure to low frequency and radiofrequency electromagnetic fields at low intensities poses a significant health hazard that has not been adequately addressed by national and international organizations such as the World Health Organization. There is strong evidence that excessive exposure to mobile phone-frequencies over long periods of time increases the risk of brain cancer both in humans and animals. The mechanism(s) responsible include induction of reactive oxygen species, gene expression alteration and DNA damage through both epigenetic and genetic processes. *In vivo* and *in vitro* studies demonstrate adverse effects on male and female reproduction, almost certainly due to generation of reactive oxygen species. There is increasing evidence the exposures can result in neurobehavioral decrements and that some individuals develop a syndrome of "electro-hypersensitivity" or "microwave illness", which is one of several syndromes commonly categorized as "idiopathic environmental intolerance". While the symptoms are non-specific, new biochemical indicators and imaging techniques allow diagnosis that excludes the symptoms as being only psychosomatic. Unfortunately standards set by most national and international bodies are not protective of human health. This is a particular concern in children, given the rapid expansion of use of wireless technologies, the greater susceptibility of the developing nervous system, the hyperconductivity of their brain tissue, the greater penetration of radiofrequency radiation relative to head size and their potential for a longer lifetime exposure.

1. Introduction

Electromagnetic fields (EMFs) are packets of energy that have no mass. They vary in frequency and wavelength. At the high end of the electromagnetic spectrum there are cosmic and X-rays that have enough energy to cause ionization, and therefore are known as ionizing EMFs. Below in frequency and energy are ultraviolet, visible light and infrared EMFs. Excessive exposure to ultraviolet EMFs poses clear danger to human health, but life on earth would not be possible without visible light and infrared EMFs. Below these forms of EMF are those used for communications (radiofrequency or RF-EMFs, 30 kHz-300 GHz) and those generated by electricity (extremely low-frequency or ELF-EMFs, 3 Hz-3 kHz). These EMFs do not have sufficient energy to directly cause ionization, and are therefore known as non-ionizing radiation. RF-EMFs at sufficient intensity cause tissue heating, which is the basis of operation of the microwave oven. However the question to be addressed here is human health effects secondary to exposures to non-ionizing EMFs at low intensities that do not cause measureable heating.

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* Corresponding author. Institute for Health and the Environment, University at Albany, Renneselaer, NY 12144, USA.
E-mail address: dcarpenter@albany.edu (D.O. Carpenter).
[1] These authors contributed equally to this work.
[2] Current address: The Environment and Cancer Research Foundation, Örebro, Sweden.

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In spite of a large body of evidence for human health hazards from non-ionizing EMFs at intensities that do not cause measureable tissue heating, summarized in an encyclopedic fashion in the Bioinitiative Report (www.bioinitiative.org), the World Health Organization (WHO) and governmental agencies in many countries have not taken steps to warn of the health hazards resulting from exposures to EMFs at low, non-thermal intensities, nor have they set exposure standards that are adequately health protective. In 2001 the International Agency for Research on Cancer (IARC, 2002), part of the WHO, declared ELF-EMFs to be "possibly carcinogenic to humans", and in 2011 they made a similar declaration for RF-EMFs (Baan et al., 2011; IARC, 2013). The classification of RF-EMFs as a "possible" human carcinogen was based primarily on evidence that long-term users of mobile phones held to the head resulted in an elevated risk of developing brain cancer. One major reason that the rating was not at "probable" or "known" was the lack of clear evidence from animal studies for exposure leading to cancer. The US National Toxicology Program has released preliminary results of a study of long term exposure of rats to cell phone radiation which resulted in a statistically significant increase in brain gliomas, the same cancer found in people after long-term cell phone use, and schwannomas, a tumor similar to the acoustic neuroma also seen after intensive mobile phone use (Wyde et al., 2016). Similar results in rats have been reported in an independent study at the Ramazzini Institute with exposures similar to those from a mobile phone base station (Falcioni et al., 2018). This evidence, in conjunction with the human studies, demonstrates conclusively that excessive exposure to RF-EMF results in an increased risk of cancer. In light of this new evidence for cancer in rodents in response to prolonged exposure to mobile phone frequencies, the IARC rating should be raised at least to "probable" (Group 2A) if not "known" (Group 1).

Unfortunately the International EMF Project of the WHO, which is part of the Department of Public Health, Environment and Social Determinants of Health in Geneva, has consistently minimized health concerns from non-ionizing EMFs at intensities that do not cause tissue heating (WHO, 2014). In this regard WHO has failed to provide an accurate and human health-protective analysis of the dangers posed to health, especially to the health of children, resulting from exposure to non-thermal levels of electromagnetic fields. The Department of Public Health, Environment and Social Determinates of Disease takes its advice on the issues related to human health effects of non-ionizing EMFs from the International Commission on Non-ionizing Radiation Protection (ICNIRP). Almost all members of the core group preparing the new Environmental Health Criteria (EHC) document for the WHO are members of ICNIRP (Starkey, 2016; Hardell, 2017), a non-goverment organization (NGO) whose members are appointed by other members. In spite of recent efforts to control for conflicts of interest, ICNIRP has a long record of close associations with industry (Maisch, 2006). When queried as to why the WHO would take recommendations from such a group, WHO staff replied that ICNIRP is an official NGO which works closely with the WHO. Why this should exclude other scientific research groups and public health professionals is unclear, particularly since most members of ICNIRP are not active researchers in this field. We are particularly concerned that a new WHO EHC document on RF-EMFs is scheduled to be released soon, and that the members of the EHC Core Group and the individuals whose assistance has been acknowledged are known to be in denial of serious non-thermal effects of RF-EMFs in spite of overwhelming scientific evidence to the contrary (Starkey, 2016; Hardell, 2017).

Others have dismissed the strong evidence for harm from ELF- and RF-EMFs by arguing that we do not know the mechanism whereby such low energetic EMFs might cause cancer and other diseases. We have definitive evidence that use of a mobile phone results in changes in brain metabolism (Volkow et al., 2011). We know that low-intensity ELF- and RF-EMFs generate reactive oxygen species (ROS), alter calcium metabolism and change gene expression through epigenetic mechanims, any of which may result in development of cancer and/or other diseases or physiological changes (see www.bioinitiative.org for many references). We do not know the mechanisms behind many known human carcinogens, dioxins and arsenic being two examples. Given the strength of the evidence for harm to humans it is imperative to reduce human exposure to EMFs. This is the essence of the "precautionary principle".

There are a number of reasons for our concern. In the past the major exposure of the general population to RF-EMFs came from radio and television signals. Now there are almost as many mobile phones as there are people in the world, all of them being exposed to RF-EMFs. There are mobile phone towers everywhere, and in many developing countries there are no land-lines that allow communication without exposure to RF-EMFs. There is rapid movement in many developed countries to place small cell transmitting devices (5G) operating at higher frequencies (24–70 GHz) every approximately 300 m along sidewalks in residential neighborhoods. There are other significant sources of exposure, coming from WiFi, smart meters and soon from automobiles operating without a human driver. Therefore human exposure has increased dramatically in recent years, and continues to increase rapidly. While we already are seeing harm from these exposures, the degree of harm will only increase with time because of the latency that is known to occur between exposure and development of diseases such as cancer.

Standards for protection of human health from EMFs vary greatly around the world. Many countries set standards based on the false assumption that there are no adverse health effects of RF-EMFs other than those that are caused by tissue heating. This is the case in North America, Australia and some European countries. Many countries from the former Soviet Union have much more restrictive standards. However information from cellular and human studies show biological effects that constitute hazards to human health at exposure levels that are often exceeded during daily life.

This report follows a recent non-official meeting in Geneva with WHO representives, where the authors urged WHO to acknowlege low intensity effects of ELF-EMFs and non-thermal health effects of RF-EMFs. This report does not attempt to present a complete overview of the subject [see the Bioinitiative Report (www.bioinitiative.org) for that] but rather to provide a holistic picture of the processes explaining most or all of the adverse effects of EMF exposures. It summarizes the evidence for cancer resulting from exposure to EMFs, and identifies other diseases or pathological conditions such as Alzheimer's disease and hypofertility that have been shown to be associated with excesive exposure to low-intensity EMFs. We also focus on electrohypersensitivity (EHS) in both children and adults and cognitive and behavioural problems in children resulting from the increasing exposure. Finally we discuss what is known about the mechanisms whereby non-thermal EMF radiation can cause disease with special reference to EMF-related free radical production and epigenetic and genetic mechanisms.

2. Mobile phone use and the risk for glioma, meningioma and acoustic neuroma

The brain is the main target for exposure to RF-EMF radiation during use of handheld wireless phones, both mobile and cordless phones (Cardis et al., 2008; Gandhi et al., 2012). An increased risk for brain tumors has been of concern for a long time. The results of the Swedish National Inpatient Register have documented an increasing incidence of brain tumors in recent years (Carlberg and Hardell, 2017). In May 2011 RF radiation in the frequency range 30 kHz–300 GHz was evaluated to be a Group 2B, i.e. a “possible” human carcinogen, by IARC (Baan et al., 2011; IARC, 2013). This was based on an increased risk for glioma and acoustic neuroma in human epidemiological studies. In the following an updated summary is given of case-control studies on brain and head tumors; glioma, meningioma and acoustic neuroma. The Danish cohort study on ‘mobile phone users’ (Johansen et al., 2001; Schüz et al., 2006) is not included due to serious methodological shortcomings in the study design, including misclassification of exposure (see Söderqvist et al., 2012a).

2.1. Glioma

Glioma is the most common malignant brain tumor and represents about 60% of all central nervous system (CNS) tumors. Most of these are astrocytic tumors that can be divided into low-grade (WHO grades I-II) and high-grade (WHO grades III-IV). The most common glioma type is glioblastoma multiforme (WHO grade IV) with peak incidence in the age group 45–75 years and median survival less than one year (Ohgaki and Kleihues, 2005). Three research groups have provided results in case-control studies on glioma (Interphone, 2010; Coureau et al., 2014; Hardell and Carlberg, 2015). Hardell and colleagues have published results from case-control studies on use of wireless phones and brain tumor risk since the end of the 1990s (Hardell et al., 1990; for more discussion see Carlberg and Hardell, 2017).

A random effects model was used for meta-analyses of published studies, based on test for heterogeneity in the overall group (“all mobile”). Note that only the Hardell group also assessed use of cordless phones. Thus their reference category included cases and controls with no use of wireless phones in contrast to the other studies investigating only mobile phone use. In Table 1 results for highest cumulative use in hours of mobile phones is given. All studies reported statistically significant increased risk for glioma and the meta-analysis yielded an odds ratio (OR) = 1.90 [95% confidence interval (CI) = 1.31–2.76]. For ipsilateral mobile phone use the risk increased further to OR = 2.54 (95% CI = 1.83–3.52) in the meta-analysis based on 247 exposed cases and 202 controls.

Carlberg and Hardell (2014) found shorter survival in patients with glioblastoma multiforme associated with use of wireless phones compared with patients with no use. Interestingly mutation of the p53 gene involved in disease progression has been reported in glioblastoma multiforme in patients with mobile phone use ≥3 h per day. The mutation was statistically significantly correlated with shorter overall survival time (Akhavan-Sigari et al., 2014). Further support for the increased risk of glioma associated with mobile phone use has been obtained in additional analyses of parts of the Interphone study (Cardis et al., 2011; Grell et al., 2016; Momoli et al., 2017).

2.2. Meningioma

Meningioma is an encapsulated, well-demarked and rarely malignant tumor. It is the most common benign tumor and accounts for about 30% of intracranial neoplasms. It develops from the pia and arachnoid membranes that cover the CNS. It is slowly growing and gives neurological symptoms by compression of adjacent structures. The most common symptoms are headaches and seizures. The incidence is about two times higher in women than in men. Meningioma develops mostly among middle aged and older persons (Cea-Soriano et al., 2012). Carlberg and Hardell (2015) included meningioma in their case-control studies. The results of the meta-analysis for cumulative exposure in the highest category are given in Table 2. In total there was an increased (but not statistically significant) risk for cumulative exposure but the increased risk was statistically significant for ipsilateral use of mobile phones (OR = 1.49, 95% CI = 1.08–2.06).

2.3. Acoustic neuroma

Acoustic neuroma, also called vestibular schwannoma, is a benign tumor located on the eighth cranial nerve from the inner ear to the brain. It is usually encapsulated and grows in relation to the auditory and vestibular portions of the nerve. It grows slowly and due to the narrow anatomical space may give compression of vital brain stem structures. First symptoms of acoustic neuroma are usually tinnitus and hearing problems. Results for use of mobile phones in Interphone (2011) and Hardell et al. (2013) are given in Table 3. Statistically significant increased risk was found for cumulative ipsilateral use ≥1640 h yielding OR = 2.71 (95% CI = 1.72–4.28).

The study by Moon et al. (2014) was not included in the meta-analysis because data on cumulative mobile phone use with numbers of cases and controls were not given. Support of an increased risk was seen in the case-case part of the study (Moon et al., 2014) and also in the report by Sato et al. (2011). Pettersson et al. (2014) made a case-control study on acoustic neuroma in Sweden not overlapping the Hardell et al. (2013) study. An increased risk for the highest category of cumulative use of both mobile phone (≥680 h OR = 1.46, 95% CI = 0.98–2.17) and cordless phone (≥900 h OR = 1.67, 95% CI = 1.13–2.49) was found.Pettersson et al. (2014) was not included in the meta-analysis due to the many scientific shortcomings in the study, e.g. laterality analysis was not made for cordless phone, the numbers in the laterality analysis for mobile phone are not consistent in text and tables and the ‘unexposed’ reference category included subjects using either mobile and cordless phone, which is clearly not correct (Hardell and Carlberg, 2014).

Table 1
Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95% confidence interval (CI) for glioma in case-control studies in the highest category of cumulative hours of mobile phone use.

	All			Ipsilateral		
	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Interphone 2010						
Cumulative use ≥1640 h	210/154	1.40	1.03–1.89	100/62	1.96	1.22–3.16
Coureau et al., 2014						
Cumulative use ≥896 h	24/22	2.89	1.41–5.93	9/7	2.11	0.73–6.08
Carlberg and Hardell, 2015						
Cumulative use ≥1640 h	211/301	2.13	1.61–2.82	138/133	3.11	2.18–4.44
Meta-analysis						
Longest cumulative use	445/477	1.90	1.31–2.76	247/202	2.54	1.83–3.52

Table 2
Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95% confidence interval (CI) for meningioma in case-control studies in the highest category of cumulative hours of mobile phone use.

	All			Ipsilateral		
	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Interphone 2010						
Cumulative use ≥1640 h	130/107	1.15	0.81–1.62	46/35	1.45	0.80–2.61
Coureau et al., 2014						
Cumulative use ≥896 h	13/9	2.57	1.02–6.44	6/4	2.29	0.58–8.97
Carlberg and Hardell 2015						
Cumulative use ≥1640 h	141/301	1.24	0.93–1.66	67/133	1.46	0.98–2.17
Meta-analysis						
Longest cumulative use	284/417	1.27	0.98–1.66	119/172	1.49	1.08–2.06

Table 3
Numbers of exposed cases (Ca) and controls (Co) and odds ratio (OR) with 95% confidence interval (CI) for acoustic neuroma in case-control studies in the highest category of cumulative hours of mobile phone use.

	All			Ipsilateral		
	Ca/Co	OR	95% CI	Ca/Co	OR	95% CI
Interphone 2011						
Cumulative use ≥1640 h	77/107	1.32	0.88–1.97	47/46	2.33	1.23–4.40
Hardell et al., 2013						
Cumulative use ≥1640 h	27/301	2.40	1.39–4.16	19/133	3.18	1.65–6.12
Meta-analysis						
Cumulative use ≥1640 h	104/408	1.73	0.96–3.09	66/179	2.71	1.72–4.28

2.4. *In summary*

Based on case-control studies there was a consistent finding of increased risk for glioma and acoustic neuroma associated with use of mobile phones. Similar results were found for cordless phones in the Hardell group studies, although such use was not reported by the other study groups. The findings are less consistent for meningioma although somewhat increased risk was seen in the meta-analysis of ipsilateral mobile phone use. A longer follow-up time is necessary for this type of slow growing tumor.

The results on glioma and acoustic neuroma are supported by results from animal studies showing co-carcinogenic and tumor promoting effects from RF-EMF (Tillmann et al., 2010; Lerchl et al., 2015). Recent results from the National Toxicology Program (NTP) study showed genotoxicity of RF radiation in rats and mice exposed to RF-EMF (Smith-Roe et al., 2017). That result supports previous findings of DNA strand breaks in rat brain cells exposed to RF-EMF (Lai and Singh, 1997).

Of importance also is that the results in the NTP and Ramazzini studies both demonstrated an increased incidence of tumors of the same type, glioma and malignant schwannoma, as has been seen in humans with mobile phone use (Wyde et al., 2016; Falcioni et al., 2018). Acoustic neuroma (vestibular schwannoma) is a similar type of tumor as malignant schwannoma, although benign. In fact, rates of brain tumors are increasing in Sweden and use of wireless phones has been suggested to be the cause (Hardell and Carlberg. 2017).

3. Other diseases and pathological conditions attributed to exposure to low-intensity EMFs

The evidence for harm from RF-EMF is strongest for cancer as a consequence of intensive mobile phone use, especially gliomas, glioblastomas and acoustic neuromas. But there is other evidence for elevation in risk of leukemia among children living near to very high intensity radio transmission towers (Michelozzi et al., 2002; Ha et al., 2007). This is particularly interesting because leukemia is the cancer most associated with elevated exposure to ELF-EMFs arising from power lines (Ahlbom et al., 2000; Greenland et al., 2000). There is some evidence for elevations in breast cancer risk among women who wear their mobile phones in their bra (West et al., 2013). Heavy use of a mobile phone was associated with significantly elevated rates of ipsilateral parotid tumors in studies from both Israel (Sadetzki et al., 2007) and China (Duan et al., 2011). No increased risk was found in a Swedish study, but the results were limited by low number of participants and lack of data on heavy and long-term use of wireless phones (Söderqvist et al., 2012b).

There are other significant human health hazards of concern. There is strong animal and human evidence that exposure to RF-EMFs as well as ELF-EMFs reduces fertility in both males (reviewed by McGill and Agarwal, 2014) and females (Roshangar et al., 2014). An association between spontaneous abortion and non-thermal EMF exposure including ELF-EMFs was reported in several case-control studies (Dodge, 1970; Juutilainen et al., 1993; Li et al., 2017). The increased use of mobile phones and increased exposure coming from WiFi, smart meters and other wireless devices has been paralled in time with male hypofertility and sperm abnormalities in semen (Rolland et al., 2013). These effects may be related to holding an active wireless laptop in a man's lap or having an active mobile phone on their belt, but more study is needed. There is evidence that isolated human sperm exposed to RF-EMFs are damaged by generation of reactive oxygen species (Agarwal et al., 2009).

There are other diseases or physiologic alterations which have been reported to be associated with exposure to non-thermal EMFs in humans and in animals (Belyaev et al., 2016). Alzheimer disease has been shown to be significantly associated with chronic ELF-EMF occupational exposure in prospective epidemiological studies (García et al., 2008; Davanipour and Sobel, 2009). Exposure to RF-EMFs has been reported to increase neuropsychiatric and behavioural disorders (Johansson et al., 2010; Divan et al., 2012), trigger cardiac rhythm alteration and peripheral arterial pressure instability (Havas, 2013; Saili et al., 2015), induce changes in immune system function (Lyle et al., 1983; Grigoriev et al., 2010; Sannino et al., 2011, 2014) and alter salivary (Augner et al., 2010) and thyroid (Koyu et al., 2005; Mortavazi et al., 2009; Pawlak et al., 2014) function. There is an urgent need for more study of these diseases or biological alterations in relation to exposure to both ELF- and RF-EMFs.

4. An emerging concern: cognitive and neurobehavioral problems in children

Children, and especially fetuses, are more vulnerable than adults for most environmental exposures (Sly and Carpenter, 2012). This is because their cells are rapidly dividing and their organ systems are not mature. As a result, events that perturb cellular function early in life can result is abnormalities that last. There is a building body of evidence indicating that exposure to RF-EMFs has adverse effects on cognition and neurobehavior, especially in children and adolescents. Concern about the particular sensitivity of children to RF-EMFs emitted from mobile phone was first raised in 2000 by a British independent expert group (IEG, 2000) that noted that the increased sensitivity to EMFs of children could be due not only to the natural vulnerability of the developing nervous system, but also to the smaller head size and thickness of the skull. These factors, plus the higher conductivity of the young nervous system, result in greater penetration of RF-EMFs into the brain (Gandhi et al., 1996). Of concern is the fact that any adverse effects during development may have life-long consequences and that young people, because they will have a longer life span, will receive a greater cumulative exposure than adults (Kheifets et al., 2005; Hansson Mild et al., 2006).

There are several reasons to be concerned. Animal studies have shown that *in utero* RF-EMF exposure from mobile phones affects fetal programming and leads to alteration in neurodevelopment and behavior of offsprings (Aldad et al., 2012; Zhang et al., 2015). Exposure of young rats to non-thermal intensities impairs learning and spatial memory secondary to a deleterious impact of EMFs on hippocampal, pyramidal or cortical neurons. Similar detrimental cognitive and behavioural defects were also observed in adult animals exposed to low-intensity.

EMFs (Bas et al., 2009; Deshmukh et al., 2015; Kumari et al., 2017; Shahin et al., 2017). The exposure induces markers of oxidative stress and inflammation in the brain (Dasdag et al., 2012; Megha et al., 2015).

There are human data consistent with these animal studies. Divan et al. (2008) reported that prenatal and to a lesser degree postnatal exposure to cell phones is associated with emotional and hyperactivity problems in 7-year old children. This finding was confirmed in a second replicative study involving different participants (Divan et al., 2012). Birks et al. (2017) used data from studies in five cohorts from five different countries (83,884 children) and concluded that maternal mobile phone use during pregnancy increased the risk that the child will show hyperactivity and inattention problems. A meta-analysis involving 125,198 children (mean age 14.5 years) reported statistically significant associations between access to and use of portable screen-based media devices (e.g. mobile phones and tablets) and inadequate sleep quality and quantity and excessive daytime sleepiness (Carter et al., 2016). Early life exposure to lead has long been known to cause a reduction in cognitive function and shortened attention span (Needleman et al., 1979). Two studies have shown that prenatal (Choi et al., 2017) or postnatal (Byun et al., 2017) mobile phone exposure results in greater neurobehavioral effects in children with elevated lead levels than those seen with elevated lead alone. These results raise concern that EMFs may have synergistic actions with other environmental contaminants known to cause a reduction in intelligence quotient (IQ) and attention, such as polychlorinated biphenyls, methyl mercury, environmental tobacco smoke and probably others (Carpenter, 2006).

Finally the problem should be considered at the societal, worldwide level. Many adolescents (Lenhart, 2015) and even very young children and infants (Kabali et al., 2015) use cordless devices immoderately, to such a point that the common intensive use of devices in children and adolescents has been ascribed as an addiction (Paz de la Puente and Balmori, 2007; Roberts et al., 2014).

The specific absorption rate (SAR)-based ICNIRP safety limits were established on the basis of simulation of EMF energy absorption using standardized adult male phantoms, and designed to protect people only from the thermal effects of EMFs. These assumptions are not valid for two reasons. Not only do they fail to consider the specific morphological and bioclinical vulnerabilities of children, but also they ignore the effects known to occur at non-thermal intensities. The same criticisms apply to other so called "independent" advisory groups or agencies, such as the Advisory Group of Non-Ionizing Radiation in the UK (AGNIR, 2012), the French Agency for Food, Environmental and Occupational Health & Safety in France (ANSES, 2013), and the Scientific Committee on Emerging Newly Identified Health Risk (SCENIHR, 2009), all of whom deny the detrimental health effects of low intensity, non thermal EMF exposure and make recommendations based only on thermal SAR considerations.

Although several scientific authorities, such as the US American Academy of Pediatrics (AAP, 2013), and the Russian National Committee on Non-Ionizing Radiation Protection (RNCNIRP, 2011) have made specific recommendations to not allow the use of mobile phones by children and to limit their use by adolescents, unfortunately these age categories remain a target for marketing of mobile phone devices [http://www.who.int/peh-emf/project/mapnatreps/RUSSIA%20report%202008.pdf]. The RNCNIRP has warned that if no rational, health-based safety limits are adopted for children and adolescents and no measures are taken to limit the use of cordless devices, we can expect disruption of memory, decreases in learning and cognitive capabilities, increases in irritability, sleep disturbance, and loss of stress adaptation in this population. There will also be long-term effects, including an increase in brain cancer, infertility, EHS, Alzheimer disease and other neurodegenerative diseases (RNCNIRP, 2011; Markov and Grigoriev, 2015). National and international bodies, particularly the WHO, will bear major responsiblity for failing to provide specific science-based guidance and recommendations so as to avoid such global health threats.

5. Electrohypersensitivity, microwave illness or idiopathic environmental intolerance attributed to electromagnetic fields

There is a segment of the human population that is unusually intolerant to EMFs. The term "electromagnetic hypersensitivity" or "electrohypersensitivity (EHS)" to describe the clinical conditions in these patients was first used in a report prepared by a European group of experts for the European Commission (Bergqvist et al., 1997). Santini et al. (2001, 2003) reported similar symptoms occurring in users of digital cellular phones and among people living near mobile phone base stations.

In 2004, because of the seemingly increasing worldwide prevalence, WHO organized an international scientific workshop in Prague in order to define and characterize EHS. Although not acknowledging EHS as being caused by EMF exposure, the Prague working group report clearly defined EHS as "a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic or electromagnetic fields" (www.who.int/pehemf/EHS_Proceedings_June2006.pdf). Following this meeting, WHO acknowledged EHS as an adverse health condition (WHO, 2005).

According to the Prague Workshop recommendations, it was proposed to use the term “idiopathic environmental intolerance (IEI) attributed to electromagnetic fields” (IEI-EMF) because of the lack of a proven causal link with EMF exposure (Hansson Mild et al., 2006). This pathological disorder is identical to what has been previously described under the term “microwave illness” (Carpenter, 2015).

This syndrome is characterized by fatigue, chronic pain and impaired cognitive function (see the Paris appeal, http://appel-de-paris.com/?lang=en). The precise mechanism(s) whereby environmental exposure to either ELF- or RF-EMFs can cause the development of this syndrome are still uncertain. However several lines of experimental and clinical data are sufficiently strong so as to indicate that ELF-EMFs and RF-EMFs exposure is associated with adverse biological and clinical health effects in humans as well as animals (Rea et al., 1991; McCarty et al., 2011; Belpomme et al., 2015; Hedendahl et al., 2015; Irigaray et al., 2018a). The prevalence of EHS has been estimated to range 1–10% in developed countries (Hallberg and Oberfeld, 2006) but appears today to be around 3% (Huang et al., 2018).

Since WHO official reports on mobile phone exposure and public health (WHO, 2014) and more particularly on EHS (WHO, 2005), much clinical and biological progress has been made to identify and objectively characterize EHS, as was summarized during the international scientific consensus meeting of the 5th Paris Appeal Congress that took place in May 2015 in Brussels at the Royal Belgium Academy of Medicine (ISD, 2015). EHS has many characteristics in common with other IEI pathological disorders, including chronic fatigue syndrome, fibromyalgia, Gulf War Illness and especially the syndrome of multiple chemical senssitvity (MCS), which Belpomme et al. (2015) have shown to be associated with EHS in many patients who report being electrohypersensitive.

5.1. Bioclinical identification and characterisation of electrohypersensitivity

In a prospective study involving systematic face-to-face questionnaire-based interviews and clinical physical examinations of nearly two thousand patients who self-reported having EHS or EHS and MCS, Belpomme and colleagues reported that EHS is a well-defined clinico-biological entity, characterized by the progressive occurrence of neurologic symptoms, including headache, tinnitus, hyperacusis, superficial and/or deep sensibility abnormalities, fibromyalgia, vegetative nerve dysfunction and reduced cognitive capability. These symptoms are repeatedly reported by the patients to occur each time they are exposed to EMFs, even of weak intensity. They result in chronic insomnia, fatigue, emotional lability and depressive tendency (Belpomme et al., 2015; Irigaray et al., 2018b).

Table 4 presents the detailed symptomatic picture which was obtained during face-to-face interviews with subjects with EHS in comparison to those with both EHS and MCS and to a series of apparently healthy control subjects that showed no evidence of EHS and/or MCS. As shown in the Table, the symptoms reported are consistent with those in other published questionnaire-based studies of EHS patients (Dodge, 1970; Johansson et al., 2010; Nordin et al., 2014; Medeiros and Sanchez, 2016; Röösli, 2008). The clinical symptoms observed in EHS or EHS/MCS patients are statistically significantly much more frequent that those in apparently normal controls. Although many of these symptoms are non-specific, the general clinical picture resulting from their association and frequency strongly suggests that EHS can be recognized and identified as a specific neurological disorder.

Because of the multiple and relatively common symptoms and the lack of recognized objective diagnosis criteria, studies on EHS were left with only the patient's self-reported interpretation for many years. As a result, EHS has unfortunately been considered to be a psychiatric disease of unknown origin. This helps explain why most mainstream public health and societal bodies claim there is not sufficient data proving that the clinical symptoms experienced and reported by EHS patients are caused by EMF exposure. Therefore they refuse to acknowledge EHS as a true neuropathological disorder. This negative point of view was supported by some blind or double blind studies showing that most individuals who report they suffer from EHS were not able to identify when they were exposed to either EMFs or sham controls (Rubin et al., 2011; Eltiti et al., 2015). However other studies have found that EHS subjects can identify EMF exposure in a statistically significant manner when they are blinded to whether or not the exposure was on (Rea et al., 1991; McCarty et al., 2011).

To account for these seemingly negative results a nocebo effect was suggested (ANSES, 2017). However there is presently no consensus on a biological mechanism through which a nocebo effect could occur (Medeiros and Sanchez, 2016; Chrousos and Gold, 1992; Jakovljevic, 2014). Moreover, results obtained in a carefully designed psycho-clinical study in self-reporting EHS patients are not consistent with an initial nocebo response to perceived EMF exposure, even though it is plausible that after the onset of the disease such phenomena may intervene secondarily through an acquired learning and conditioning process (Dieudonné, 2016). In addition, a meta-analysis of cross sectional studies has documented a 38% greater risk of development of headaches among mobile phone users than non-users, and an increasing risk of headache with longer daily call duration (Wang et al., 2017).

Belpomme, Irigaray and colleagues recently identified several biomarkers in EHS and/or MCS patients which allow physicians to identify and objectively characterize EHS as a true somatic pathological disorder, discounting the hypothesis of a causal psychosomatic or nocebo-related process. These came in part from a prospective clinical and biological analysis of a series of several hundred consecutive cases of individuals who self-reported that they suffered from EHS or both EHS and MCS (Belpomme et al., 2015) and more recently from the prospective anlaysis of an additional series of EHS patients (Irigaray et al., 2018a). Table 5 summarizes the different biomarkers that have been measured in the peripheral blood of these patients and the results which have been obtained based on the EHS and EHS/MCS patient groups. Note that among the different markers, the 6-hydroxymelatonin sulfate/creatinine ratio in urine appears to be the best marker to be used in medical practice since it has been found to be decreased in all cases evaluated to date (Belpomme et al., 2015).

By measuring different major oxidative stress-related biomarkers, such as thiobarbituric acid reactive substances (TBARS), oxided glutathione (GSSG) and nitrotyrosine (NTT) in EHS patients, Irigaray et al. (2018b) have recently shown that near 80% of the EHS patients present with detectable oxidative stress biomarkers (Fig. 1). More than 40% of EHS patients present with at least one positive biomarker, 20% with two and 15% will all three of the biomarkers investigated. This indicates that in addition to the inflammation-related biomarkers previously associated with EHS, EHS patients are also characterized by exhibiting biomarkers of oxidative stress (Belpomme et al., 2015; Irigaray et al., 2018a,b).

The significance of the different biomarkers measured in the peripheral blood of EHS and EHS/MCS patients is that these results imply that these patients present with some degree of oxidative/nitrosative stress, inflammation and autoimmune response. Increased levels of several of these markers (notably protein S100B and NTT) may reflect hypoxia-associated oxidative stress-induced blood brain barrier (BBB) opening. It has been previously hypothesized that opening of the BBB can be caused by environmental

Table 4
Clinical symptom occurrence in EHS and EHS/MCS patients in comparaison with normal controls[a].

	EHS	EHS/MCS	p[b]	Normal controls	p[c]	p[d]
Headache	88%	96%	0.065	0%	<0.0001	<0.0001
Dysesthesia	82%	96%	0.002	0%	<0.0001	<0.0001
Myalgia	48%	76%	<0.0001	6%	<0.0001	<0.0001
Arthralgia	30%	56%	<0.001	18%	0.067	<0.0001
Ear heat/otalgia	70%	90%	<0.001	0%	<0.0001	<0.0001
Tinnitus	60%	88%	<0.0001	6%	<0.0001	<0.0001
Hyperacousis	40%	52%	0.118	6%	<0.0001	<0.0001
Dizziness	70%	68%	0.878	0%	<0.0001	<0.0001
Balance disorder	42%	52%	0.202	0%	<0.0001	<0.0001
Concentration/Attention deficiency	76%	88%	0.041	0%	<0.0001	<0.0001
Loss of immediate memory	70%	84%	0.028	6%	<0.0001	<0.0001
Confusion	8%	20%	0.023	0%	0.007	<0.0001
Fatigue	88%	94%	0.216	12%	<0.0001	<0.0001
Insomnia	74%	92%	0.001	6%	<0.0001	<0.0001
Depression tendency	60%	76%	0.022	0%	<0.0001	<0.0001
Suicidal ideation	20%	40%	0.003	0%	<0.0001	<0.0001
Transitory cardiovascular abnormalities	50%	56%	0.479	0%	<0.0001	<0.0001
Occular deficiency	48%	56%	0.322	0%	<0.0001	<0.0001
Anxiety/Panic	38%	28%	0.176	0%	<0.0001	<0.0001
Emotivity	20%	20%	1	12%	0.176	0.176
Irritability	24%	24%	1	6%	<0.001	<0.001
Skin lesions	16%	45%	<0.0001	0%	<0.0001	<0.0001
Global body dysthermia	14%	8%	0.258	0%	<0.0001	<0.007

[a] This data results from the clinical analysis of the 100 first clinically evaluated cases issued from the already published series of EHS and/or MCS patients who have been investigated for biological markers [Belpomme et al., 2015]. It has been compared symptomatically with data obtained from a series of 50 apparently normal subjects matched for age and sex, used as controls.
[b] Significance levels (p values) obtained for compararison between the EHS and EHS/MCS groups.
[c] Significance levels (p values) obtained for compararison between the EHS and normal control groups.
[d] Significance levels (p values) obtained for compararison between the EHS/MCS and normal control groups.

Table 5
Patient mean values and standard deviations of biomarker levels in comparison with normal reference values as well as the percentage of patients with abnormal values in the peripheral blood in subjects with EHS or both EHS and MCS (Belpomme et al., 2015).

Biomarker and Normal reference values	Patients groups			
	EHS Mean ± SD	% Above normal	EHS/MCS Mean ± SD	% Above Normal[a]
hs-CRP < 3 mg/l	10.3 ± 1.9	15%	6.9 +/1.7	14.3%
Vitamine D > 30 ng/ml	20.6 ± 0.5	69.3%	14.5 ± 1.3	70.1%
Histamine< 10 nmol/l	13.6 ± 0.2	37%	13.6 ± 0.4	41.5%
IgE< 100 UI/ml	329.5 ± 43.9	22%	385 ± 70	24.7%
S100B < 0.105 μg/l	0.20 ± 0.03	14.7%	0.17 ± 0.03	19.7%
Hsp 70 < 5 ng/ml	8.2 ± 0.2	18.7%	8 ± 0.3	25.4%
Hsp 27< 5 ng/ml	7.3 ± 0.2	25.8%	7.2 ± 0.3	31.8%
Anti-O-myelin auto-antibodies[b]	Positive	22.9%	Positive	23.6%
24-h urine 6-OHMS/creatinine ratio >0.8[c]	0.042 ± 0.003	100%	0.048 ± 0.006	100%

hs-CRP, high-sensitivity C-reactive protein; IgE, Immunoglobulin E; S100B, S 100 calcium binding protein B; Hsp 27, heat shock protein 27; Hsp 70, heat shock protein 70; anti-O-myelin auto-antibodies, auto-antibodies against O-myelin; 6-OHMS, 6-hydroxymelatonin sulfate.
[a] There is no statistically significant difference between the two groups of patients for the different biomarkers analyzed, suggesting that EHS and MCS share a common pathological mechanism for genesis.
[b] Qualitative test.
[c] Data restricted to those not on neuroleptic medication as the simultaneous use of several psychotherapeutic drugs may also be associated with a decrease of this 24-h urine ratio by modifying melatonine metabolism.

stressors, be they chemicals or EMFs. This may have occurred in these patients, as has been shown to occur in several (but not all) animal experiments involving EMF exposure (Oscar and Hawkins, 1977; Persson et al., 1997; Eberhardt et al., 2008; Sirav and Seyhan, 2009). Comparable data using metabolic and genetic biomarkers were also obtained in another large series of EHS patients (De Luca et al., 2014). Overall these data indicate that the clinical use of biomarkers allows the objective characterisation and identification of EHS and MCS as two etiopathologic facets of a unique pathological disorder, and also allows insight into the genesis of these two diseases.

The development of new imaging techniques has also greatly increased our ability to objectively characterize EHS and MCS. Using ultrasonic cerebral tomosphygmography (UCTS) (Parini et al., 1984), EHS- and EHS/MCS-patients were found to have a statistically significant decrease in mean pulsometric index in several middle cerebral artery-dependant portions of the temporal lobes, especially in the capsulo-thalamic area, which is part of the limbic

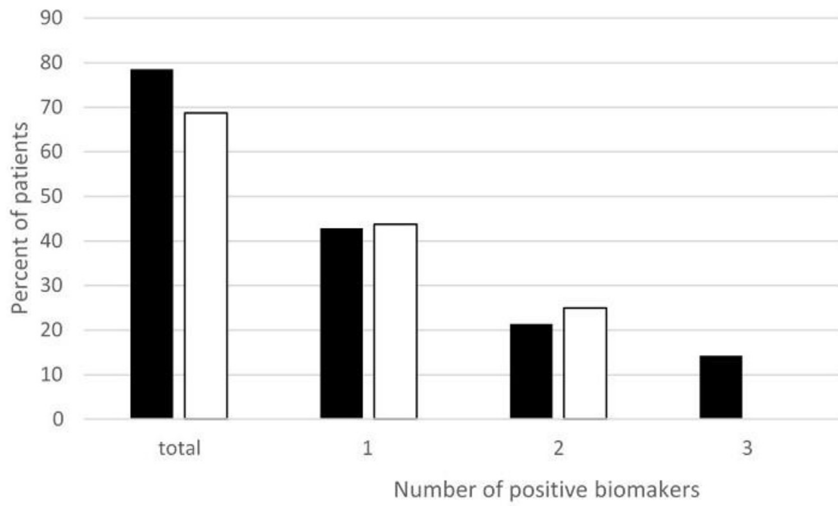

Fig. 1. Percentage of EHS self-reporting patients having positive TBARs, GSSG and/or NTT oxidative stress biomarkers measured in the peripheral blood. "Positive" biomarkers correspond to marker levels above the upper normal limit; "total" corresponds to the patients with one or more positive biomarker levels. Black bars show the percentage of patients with one, two or all three of the biomarkers for TBARS, GSSG and NTT. The white bars show the percentage of patients with either TBARs or GSSG or both oxidative stress markers.

system and the thalamus. This suggests that EHS and EHS/MCS may be associated with a brain blood flow (BBF) deficiency and/or neuronal dysfunction in these brain structures (Belpomme et al., 2015; Irigaray et al., 2018a,b). Irigaray et al. (2018c) have recently confirmed that UCTS is the best imaging technique to diagnose EHS and to follow patients treated for EHS and/or MCS.

In addition, using positron emission tomography (PET) it has been shown that short term exposure to pulse-modulated RF-EMF causally affects regional BBF in normal subjects using a mobile phone (Aalto et al., 2006; Huber et al., 2005), a finding that may account for the modifications observed in the sleep and waking EEG (Huber et al., 2002). By use of functional MRI (fMRI) in EHS patients exposed chronically to ELF-EMFs, regional BBF changes have been reported in the frontal lobes, such as abnormal default mode network and more particularly a decrease in BBF and cerebral metabolism. These observations indicate that fMRI may also be a tool for diagnosis of EHS and clinical follow up of patients (Heuser and Heuser, 2017). A decreased BBF-associated pulsometric index decrease in both hemispheres was also recently observed by the Belpomme group by using transcranial Doppler ultrasound (TDU) (Purlauastja and Sorond, 2012) applied to the middle cerebral artery in a study involving 120 EHS and/or MCS patients. This study revealed a decrease in pulsatility index and an increase in diastolic flow velocity in 70% of the 120 cases investigated to date.

In summary it is the strong opinion of the authors that there is presently sufficient clinical, biological and radiological data emanating from different independent international scientific research groups for EHS, whatever its causal origin, to be acknowledged as a well-defined, objectively characterized pathological disorder. As a result, patients who self-report that they suffer from EHS should be diagnosed and treated utilizing presently available objective biological tests, among which are the concentration of peripheral blood biomarkers and the use of imaging techniques such as PET, fMRI and TDU and, when available, UCTS. Whatever its etiological origin and mechanism of action, EHS should be acknowledge by the WHO as a real and distinct neurological and pathological disorder (McCarty et al., 2011; Hedendahl et al., 2015) and thus be included in the International Classification of Diseases.

5.2. *Possible etiopathogenic processes involved in genesis of electro-hypersensitivity*

EMFs, both RF-EMFs at non-thermal intensities and ELF-EMFs, have been found to cause persistent adverse biological effects in microorganisms (Fojt et al., 2004), plants (Roux et al., 2008; Maffei, 2014), birds (Balmori, 2005; Balmori and Hallberg, 2007; Frey, 1993), and mammals. Therefore the effects observed in humans cannot be due to only a nocebo or psychosomatic effect. These biological effects may be due both to the pulsed and polarised characteristics of man-made EMFs emitted by electric or wireless technologies as opposed to the terrestrial non-polarised and continuously emitted natural EMFs (Blackman, 2009; Belyaev, 2015; Panagopoulos et al., 2015).

The inflammatory and oxidative/nitrosative states that have been documented in EHS patients are remarkable since they confirm the data obtained experimentally in animals exposed to non-thermal EMFs (Esmekaya et al., 2011; Burlaka et al., 2013), and especially in the brain (Megha et al., 2015; Kesari et al., 2011). The limbic system—associated capsulo-thalamic abnormalities that the Belpomme group has observed by using UCTS in EHS and/or MCS patients (Belpomme et al., 2015; Irigaray et al., 2018a,c) may likely correspond to the hippocampal neuronal alterations caused by EMF exposure in the rats (Bas et al., 2009; Furtado-Filho et al., 2015; Deshmukh et al., 2013). Fig. 2 summarizes our hypothesis regarding the inflammation and oxidative stress-related mechanisms which may account for EMF- and/or chemically-related health effects in the brain and consequently for EHS genesis.

6. Mechanisms whereby low intensity electromagnetic fields cause biological effects and harm

Arguments used in the past to attempt to discount the evidence showing deleterious health effects of ELF-EMFs and RF-EMF exposure at non-thermal SAR levels were based on the difficulties encountered in understanding the underlying biological effects and the lack of recognized basic molecular mechanisms accounting for these effects. This is no longer the case. There are a number of well-documented effects of low intensity EMFs that are the mechanistic basis behind the biological effects documented above (www.

bioinitiative.org). These include induction of oxidative stress, DNA damage, epigenetic changes, altered gene expression and induction including inhibition of DNA repair and changes in intracelluar calcium metabolism. Both low-intensity ELF-EMF and non-thermal RF-EMF effects depend on a number of physical parameters and biological variables and physical parameters, which account for the variation in health outcomes (Belyaev, 2015; Belyaev et al., 1999). Importantly, the most severe health effects are observed with prolonged chronic exposures even when intensities are very low (Belyaev, 2017). The physics of non-equilibrium and non-linear systems and quantum mechanics are at least in part the basis of the physical mechanisms responsible for the non-thermal molecular and biological effects of non-thermal EMF radiation (Belyaev, 2015), although a detailed report on these actions is beyond the scope of this review.

Lower RF-EMF intensity is not necessarily less bioactive or less harmful. Non-thermal EMF effects can be observed at intensities which are very close to ordinary background levels and quite similar to intensities emitted by mobile phone base stations. There are time windows for observation of non-thermal EMF effects which may be dependent upon the endpoint measured, the cell type and the duration and power density of exposure. Non-thermal RF-EMF effects are affected by static magnetic fields and electromagnetic stray fields, which result in the variation of non-thermal EMF effects from mobile phones because of adjacent electrical appliances, power lines and other sources of ELF and static magnetic fields, including changes in the geomagnetic field (Gapeev et al., 1999a and b).

Cell-to-cell interactions potentiate the response to non-thermal EMFs (Belyaev et al., 1996). Biological responses to EMFs have been shown to be influenced by sex and age (Zhang et al., 2015; Sirav and Seyhan, 2016). Physiological parameters such as the stage of cell growth, oxygen, divalent ions and temperature are important

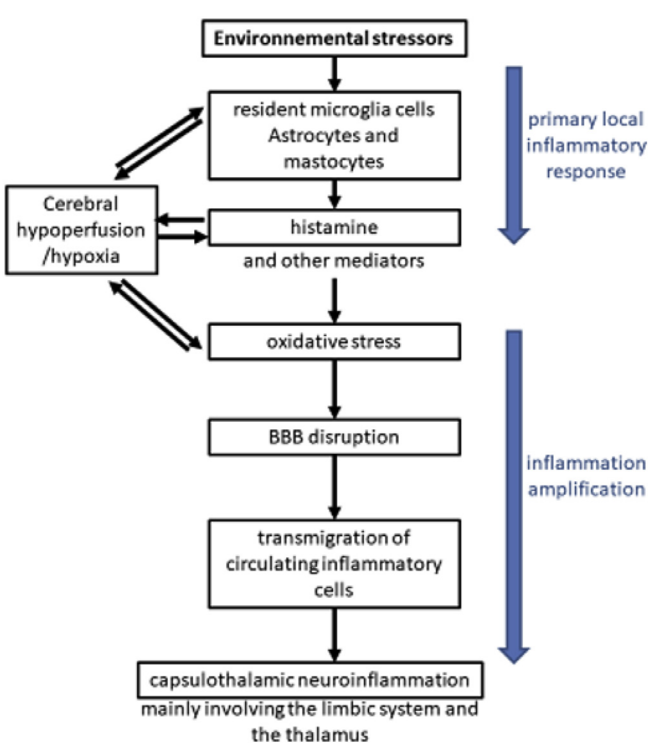

Fig. 2. Hypothetical EHS/MCS common etiopathogenic model based on neuroinflammation and oxidative/nitrosative stress-induced blood brain barrier disruption (Belpomme et al., 2015).

variables affecting cellular responses to EMFs (Liburdy and Vanek, 1987; Sannino et al., 2011).

6.1. Combined exposures

EMFs at non-thermal intensities may interfere with other environmental stressors, showing an interplay of molecular pathways and resulting in either beneficial or detrimental health effects, depending on the nature and conditions of co-exposures (Novoselova et al., 2017; Ji et al., 2016). One example is the demonstration that RF-EMF exposure modulates the DNA damage and repair induced by ionizing radiation (Belyaev et al., 1993). Another example is the synergistic of exposure to lead and EMFs on cognitive function in children described above (Choi et al., 2017; Byun et al., 2017). These co-exposure factors should be considered when assessment of detrimental effects, including carcinogenicity, is performed.

Not all of the effects of EMFs on the nervous system and other organs are necessarily harmful. The best example of a positive effect is the well-documented and clinically useful benefit of applied magnetic fields to promote bone healing (Bassett, 1994). Both ELF-EMF (Zhang et al., 2015) and RF-EMF (Arendash et al., 2010) have been reported to slow cognitive decline in rodent models of Alzheimer's disease. Some human studies report a facilitating effects of cognitive performance (Lee et al., 2001) while Koivisto et al. (2000) reported an increase in response time and vigilance tasks but a decrease in mental arithmetric tasks. These studies clearly show that EMFs have biological effects at non-thermal intensities, but suggest that not all biological effects are necessarily harmful.

6.2. Duration of exposure and dose intensity

Such parameters as power density, dose, and duration of exposure have been analyzed for development of reliable safety standards, which would protect against the detrimental health effects of chronic exposure to RF-EMFs at non-thermal intensities. Some studies show no effect under fixed short-term exposures, but this does not imply that there are no effects from longer-term exposures (Choi et al., 2014). Exposure in studies showing RF-EMF effects was on average twice the duration as those with no significant effects (Cucurachi et al., 2013). The response to non-thermal EMFs depends on both power density and duration of exposure. Importantly, the same response is observed with lower power density but prolonged exposure as at higher power density and shorter exposure (Nordenson et al., 1994). While SAR is a good surrogate for thermal RF effects from acute exposures, many studies have shown that SAR should be either replaced by “dose-specific absorption” or power density complimented by duration of exposure for description of non-thermal RF effects (Belyaev, 2015). Recent studies have provided more evidence for the greater importance of dose and duration of exposure than SAR alone for biological and health effects from long-term exposures to non-thermal RF-EMFs (Furtado-Filho et al., 2015).

6.3. Oxidative stress

Non-ionizing radiation does not have sufficient energy to directly break chemical bonds, and therefore the DNA damage that occurs with non-ionizing EMF exposures is primarily a consequence of generation of reactive oxygen species (ROS), resulting in oxidative stress. There are numerous animal experiments which clearly demonstrate that non thermal EMFs can cause oxidative stress (Esmekaya et al., 2011; Burlaka et al., 2013), particularly in the brain (Shahin et al., 2017; Dasdag et al., 2012; Megha et al., 2015; Furtado-Filho et al., 2015). Oxidative stress is known to play a central role in development of cancer and aging and serves as a signaling agent in the inflammatory response (Holmstrom and Finkel, 2014).

The brain is a particularly important organ for sensitivity to EMFs. Brain cancer resulting from EMF exposures is a serious concern, and EHS is a disease of the central nervous system. Several mechanisms at the cellular and molecular levels have been reported that may be the basis of these non-thermal RF-EMF effects on brain function. ELF- and/or RF-EMF exposure at embryonic or early postnatal stages can alter *in vivo* synaptic efficacy and plasticity of neurons (Balassa et al., 2014), a finding which was further supported by *in vitro* studies showing a significant decrease in the differentiation of neural stem cells into neurons (Eghlidospour et al., 2017), the alteration of transcript levels of neuronal differentiation-related genes and impairment of neurite outgrowth of embryonic neural stem cells exposed to ELF- or RF-EMFs (Ma et al., 2014). These observations support the conclusion that low-intensity but prolonged exposure to non-thermal EMFs may have adverse effects on neurogenesis during development and indicate how important it is to protect the fetus and young child from excessive exposure to all mobile devices.

Animal studies have documented that 900 MHz or 2.45 GHz non thermal RF-EMF exposure in rats, either short term or chronic, can trigger neuronal dysfunction and even apoptosis of hippocampal pyramidal cells (Bas et al., 2009; Shahin et al., 2017) and cerebellum Purkinje cells (Sonmez et al., 2010) through induction of oxidative stress. Exposure of pregnant dams elicited EMF oxidative stress-induced neuronal pathologic changes in offspring (Odaci et al., 2016). Such pathological changes could be due to ROS-induced opening of the BBB (Nordal and Wong, 2005) and/or to ROS-associated brain hypoxia caused by a decrease in EMF-induced BBF and/or EMF-induced hemoglobin deoxygenation (Mousavy et al., 2009; Muehsam et al., 2013). The resulting hypoxia may induce metabolic neuronal dysfunction as in the case of EHS patients (Belpomme et al., 2015) but also neuronal cell death by either apoptosis or necrosis as in the case of Alzheimer's disease and other forms of dementia (Bell and Zlokovic, 2009).

While some consider the laboratory data on EMFs as being inconsistent, showing either detrimental or no effects and on occasion even beneficial effects, the vast majority still show detrimental effects. For example Henry Lai in the Bioinitiative Report Research Summaries Update of November 2017, Chapter 6 on Genotoxic Effects, reported that i) of 46 studies on ELF genotoxicity with the comet assay as the end point, 34 studies (74%) showed detrimental effects, ii). Of 189 total studies on ELF and oxidative stress, 162 (87%) showed a positive correlation, and iii) of 200 studies on RF and free radicals, 180 (90%) showed detrimental effects. One reason for variability between laboratory studies is the strong dependence on low-threshold EMF effects on a number of physical and biological variables (Belyaev, 2010).

6.4. Genetic and epigenetic mechanisms

Genetic effects are the most direct cause for carcinogenicity. This is true both for genotoxic changes caused by exposure to EMFs and existing polymorphic genetic differences within a population that increase susceptibility to cancer. DNA can no longer be considered to be unaffected by environmental EMF levels, as many studies have shown that DNA can be activated and damaged by EMFs at levels that have been considered to be safe (Blank and Goodman, 1999).

The primary mechanism through which low-intensity EMFs can alter DNA is through ROS production. Lai and Singh (2004) first reported that a 2 h exposure of rats to 60 Hz EMFs at 0.1–0.5 mT resulted in DNA strand breaks in neurons, and provided evidence that this effect was mediated by free radical formation and blocked by free radical scavengers. Vijayalaxmi and Prihoda (2009) in a meta-analysis of 87 publications found a biologically small but statistically significant difference between DNA damage in ELF-EMF-exposed somatic cells as compared to controls, and reported evidence for epigenetic changes for some outcomes. For ELF-EMFs this breakage effect was stronger when exposure was intermittent rather than continuous (Nordenson et al., 1994).

Yang et al. (2008) have reported an $OR = 4.31$ (95% $CI = 1.54–12.08$) for leukemia in children living within 100 m of a high voltage powerline if they had a certain polymorphism of a DNA repair gene.

Exposure to RF-EMFs can also induce DNA damage under specific conditions (Markova et al., 2005). Tice et al. (2002) and Vijayalaxmi et al. (2013) reported DNA damage and micronuclei formation in cultured human leukocytes and lymphocytes upon exposure to RF-EMF signals of at least 5 W/kg. Not all cell types showed similar responses. Schwartz et al. (2008) reported micronucleus changes in fibroblasts but not lymphocytes exposed to 1950 MHz EMFs. Kesari et al. (2014) also demonstrated DNA strand breaks in the brains of rats exposed for 2 h per day for 60 days to a 3G mobile phone. Changes in DNA secondary structure (Semin, 1995; Diem et al., 2005) and chromosome instability (Mashevich, 2003) have been observed upon exposure to RF-EMFs emitted by mobile phones.

Epigenetic changes, rather than genetic changes in DNA, may underlie many or even most of the biological effects of non-thermal EMFs (Sage and Burgio, 2017). Non-thermal EMFs are epigenetic stressors which can alter gene expression by acting through physical or biochemical processes and be reflected as chromatin remodeling (Belyaev et al., 1997), histone modification (Wei et al., 1990) or altered microRNA (Dasdag et al., 2015) at intensities far below those that cause measureable tissue heating.

Chromatin plays a key regulatory role in controlling gene expression and, more particularly, the access of transcription factors to DNA. It has been shown that extremely low intensity RF-EMF exposure, i.e. at intensities comparable to that of mobile phone and towers, results in changes in chromatin conformation and gene expression (Belyaev et al., 1997; Belyaev and Kravchenko, 1994; Belyaev et al., 2006; Belyaev et al., 2009). In a large number of cells and tissues, compaction of chromatin in specific loci may lead to gene silencing, loss of histone regulatory effects and DNA repair capacity (Wei et al., 1990). Belyaev and collaborators (Markova et al., 2005; Belyaev et al., 2009) have shown that exposure to RF-EMFs emitted by GSM mobile phone alters chromatin conformation in human lymphocytes and inhibits formation of p53-binding protein 1 (53BP1) and phosphorylated histone H2AX (γ-H2AX) DNA repair foci.

EMFs in both the ELF and RF ranges may epigenetically affect DNA by inducing the expression of stress response genes and consequently the synthesis of chaperone stress proteins (Blank and Goodman, 2011a and b). A specific gene sequence has been identified that acts as a sort of antenna, specifically sensitive and responsive to EMFs (Blank and Goodman, 2011b). This is a gene sequence coding for HSP70, a protein belonging to a family of conserved, ubiquitously expressed "heat shock proteins" that sense danger signals and protect cells from the most disparate stress conditions. This is an unambiguous demonstration that EMF exposure even at non-tissue heating intensities has the potential to be harmful to cells and organisms. The HSP70 promotor contains different DNA regions that are specifically sensitive to diverse stressors, thermal and non-thermal. The EMFs are specifically perceived by the sequences sensitive to non-thermal stimuli. During the process of HSP70-response induction, EMFs can activate directly the HSP70 gene promoter (Rodrequez-De la Fuente et al.,

2010) which contains a magnetic field-responsive domain (Lin et al., 1999, 2001).

EMF-related HSP70 and HSP27 stress responses have been detected in the hippocampus of rats exposed to non-thermal EMFs (Yang et al., 2012). Shahin et al. (2017) reported that mice exposed to 2G mobile phones continuously for four months showed elevated ROS, lipid peroxidation, total nitrate and nitrite concentrations and malondialdehyde levels in homogenates of different tissues, and decreased levels of several antioxidant enzymes. These observations justify the use of these markers to characterize EHS in patients who report that they are sensitive to EMFs.

The EMF effects have been suggested to be mediated by the mitogen-activated protein kinase (MAPk) cascades, which is a central signaling transduction pathway which governs all stress-related cellular processes occurring in response to extracellular stimuli (Friedman et al., 2007). It has been shown that long term exposure of cells to mobile phone frequencies or to ELF-EMFs (Goodman et al., 2009) activates the extracellular-signal regulated kinase (ERK), which is one of the four MAPk cascades so far identified.

Non-thermal RF-EMFs may also alter expression of other genes. As long ago as Byus et al., 1988 showed that 450 MHz RF increased ornithine decarboxylase activity in hepatoma cells. Markova et al. (2005) exposed human fibroblasts and mesenchymal stem cells to mobile phone RF-EMFs with analysis of tumor suppressor p53 binding protein 1. Formation of 53BP1 foci was inhibited in both cells types, but the stem cells always showed a greater response. Fragopoulou et al. (2011) exposed mice to either a typical mobile phone or a wireless DECT base station and analyzed the brain proteome. They found significant alteration in 143 specific proteins (ranging from a 0.003 fold downregulation to up to a 114-fold overexpression.) Luo et al. (2013) exposed pregnant women undergoing a first trimester abortion to a mobile phone applied to the abdomen and performed a proteomic analysist of placental villous tissue. They report 15 proteins which were significantly altered by at least 2- to 2.5-fold in exposed women as compared to control women. Twelve of these proteins were identified. Yan et al. (2008) exposed rats to mobile phones 6 h per day for 126 days, and found upregulation of specific mRNAs that regulated several proteins, including calcium ATPase, neural cell adhesion molecule, neural growth factor and vascular endothelial growth factor. EMFs at non thermal levels may not only alter the expression of many proteins but also may directly affect protein conformation (Fragopoulou et al., 2011; Bohr and Bohr, 2013; Beyer et al., 2013) and modify enzyme activity (Vojisavljevic et al., 2010), so altering the regulating capacity of the epigenome. These are epigenetic, not genetic, effects (Sage and Burgio, 2017).

Non-thermal EMF exposure can epigenetically interfere with the differentiation and proliferation programs of stem cells in fetal and adult tissues through ROS production (Wolf et al., 2007; Falone et al., 2007; Ayşe et al., 2010; Park et al., 2014). Stem cells are the most sensitive cells to EMF exposure (Eghlidospour et al., 2017; Markova et al., 2010) and this is particularly the case for neural stem cells of the hippocampus (Leone et al., 2014).

The endogenous natural ionic currents and electrical fields in the human body (Jaffe and Nuccitelli, 1977) are vulnerable to the oscillary properties of non-thermal EMFs. These consequently may cause detrimental effect on cell differentiation and proliferation in adult tissues (Levin, 2003) in addition to the effects on cell differentiation, proliferation and migration in the fetus (Wolf et al., 2007; Ayşe et al., 2010; Leone et al., 2014). Fetal programming cannot be reduced to only genetic programs. Developmental processes are essentially epigenetic (Leone et al., 2014), and exposure to epigenetic stressors such as non-thermal EMFs are much more dangerous for the fetus than for the adults.

6.5. Calcium regulation

There has long been evidence that EMFs alter several aspects of calcium function. This is important because calcium regulates many different aspects of cell function. Bawin and Adey (1976) reported that very weak ELF-EMFs trigger efflux of calcium from isolated chick brain, although the implications of this observation were not clear. Later they reported a similar action of RF-EMFs (Adey et al., 1982). Pulsed low-frequency EMFs promote bone healing and promote calcium uptake into bone (Spadaro and Bergstrom, 2002) and osteoblasts (Zhang et al., 2010). 50 Hz EMFs increase the number of voltage-gated calcium channels in neuroendocrine cells (Grasso et al., 2004) and presynaptic nerve cell terminals (Sun et al., 2016). Wei et al. (2015) found that ELF-EMFs also altered the frequency of calcium transients in cardiomyocytes and decreased calcium concentrations in sarcoplasmic reticulum. These changes in calcium in heart muscle may be the basis for the cardiovascular effects reported in humans on exposure to EMFs (Havas, 2013). In spite of numerous studies reporting altered calcium metabolism upon exposure to both ELF- and RF-EMFs, the overall implications of these effects are still not clear. However, some have suggested (Ledoigt and Belpomme, 2013) that calcium activation of proteins could be the initial event that results in altered protein configuration, leading to generation of ROS and ultimately activating the molecular pathways to cancer.

7. Public Health Implications of Human Exposure to EMFs

The incidence of brain cancer in children and adolescents has increased between 2000 and 2010 (Ostrom et al., 2015). Gliomas are increasing in the Netherlands (Ho et al., 2014), glioblastomas are increasing in Australia (Dobes et al., 2011) and England (Philips et al., 2018) and all brain cancers are increasing in Spain (Etxeberrua et al., 2015) and Sweden (Hardell and Carlberg, 2017). The latency period between initial exposure and clinical occurrence of brain cancer is not known but is estimated to be long. While not all reports of brain cancer rates show an increase, some do. The continually increasing exposure to EMFs from all sources may contribute to these increases. The prevalence of EHS is unknown, but various reports suggest that it is between 1 and 10% of the population (Hallberg and Oberfeld, 2006; Huang et al., 2018). Male fertility has been declining (Geoffroy-Siraudin et al., 2012; Levine et al., 2017). EMFs increase the risk of each of these diseases and others. Alzheimer's disease is increasing in many countries worldwide and its association with ELF-EMF occupational exposure has been clearly demonstrated through several independent epidemiological studies (Davanipour and Sobel, 2009; Sobel et al., 1996; Qiu et al., 2004) and a meta-analysis of these studies (García et al., 2008). A recent meta-analysis (Huss et al., 2018) has reported an increased risk of amyotrophic lateral sclerosis in workers occupationally exposure to ELF-EMFs.

Safety limits for RF exposure have been based (until today) on the thermal effects of EMFs. But these standards do not protect people, particularly children, from the deleterious health effects of non-thermal EMFs (Nazıroğlu et al., 2013; Mahmoudabadi et al., 2015). Each of these diseases is associated with decrements in health and quality of life. Brain cancer patients often die is spite of some improvement in treatment, while EHS patients present with increased levels of distress, inability to work, and progressive social withdrawal. The ability for humans to reproduce is fundamental for the maintenance of our species.

The scientific evidence for harm from EMFs is increasingly strong. We do not advocate going back to the age before electricity or wireless communication, but we deplore the present failure of public health international bodies to recognize the scientific data showing the adverse effects of EMFs on human health. It is encouraging that some governments are taking action. France has removed WiFi from pre-schools and ordered Wi-Fi to be shut off in elementary schools when not in use (http://www.telegraph.co.uk.news/2017/12/11/france-ipose-total-ban-mobile-phones-schools/). The State of California Department of Public Health has issued a warning on use of mobile phones and offered advice on how to reduce exposure (State of California, 2017). There are many steps that are neither difficult nor expensive that can be taken to use modern technology but in a manner that significally reduces threats to human health.

It is urgent that national and international bodies, particularly the WHO, take this significant public health hazard seriously and make appropriate recommendations for protective measures to reduce exposures. This is especially urgently needed for children and adolescents. It is also important that all parts of society, especially the medical community, educators, and the general public, become informed about the hazards associated with exposure to EMFs and of the steps that can be easily taken to reduce exposure and risk of associated disease.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.envpol.2018.07.019.

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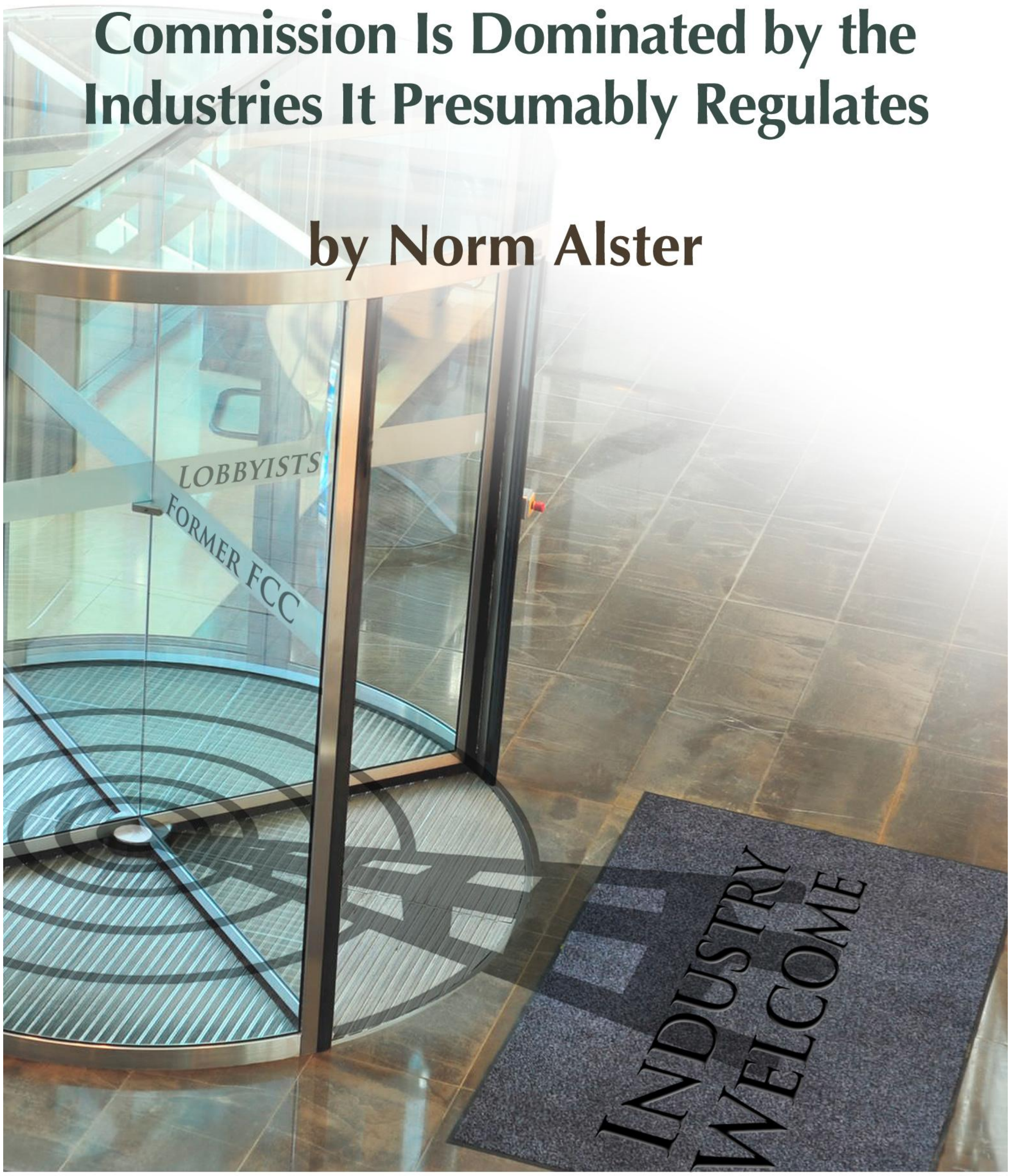
Captured Agency:

How the Federal Communications Commission Is Dominated by the Industries It Presumably Regulates

by Norm Alster



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How the Federal Communications Commission Is Dominated by the Industries It Presumably Regulates

By Norm Alster

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Chapter One: The Corrupted Network

Renee Sharp seemed proud to discuss her spring 2014 meeting with the Federal Communications Commission.

As research director for the non-profit Environmental Working Group, Sharp doesn't get many chances to visit with the FCC. But on this occasion she was able to express her concerns that lax FCC standards on radiation from wireless technologies were especially hazardous for children.

The FCC, however, should have little trouble dismissing those concerns.

Arguing that current standards are more than sufficient and that children are at no elevated risk from microwave radiation, wireless industry lobbyists don't generally have to set up appointments months in advance. They are at the FCC's door night and day.

Indeed, a former executive with the Cellular Telecommunications Industry Association (CTIA), the industry's main lobbying group, has boasted that the CTIA meets with FCC officials "500 times a year."[1]

Sharp does not seem surprised. "There's no question that the government has been under the influence of industry. The FCC is a captured agency," she said.[2]

Captured agency.

That's a term that comes up time and time again with the FCC. Captured agencies are essentially controlled by the industries they are supposed to regulate. A detailed look at FCC actions—and non-actions—shows that over the years the FCC has granted the wireless industry pretty much what it has wanted. Until very recently it has also granted cable what it wants. More broadly, the FCC has again and again echoed the lobbying points of major technology interests.

Money—and lots of it—has played a part. The National Cable and Telecommunications Association (NCTA) and CTIA have annually been among Washington's top lobbying spenders. CTIA alone lobbied on at least 35 different Congressional bills through the first half of 2014. Wireless market leaders AT&T and Verizon work through CTIA. But they also do their own lobbying, spending nearly $15 million through June of 2014, according to data from the Center for Responsive Politics (CRP). In all, CTIA, Verizon, AT&T, T-Mobile USA, and Sprint spent roughly $45 million lobbying in 2013. Overall, the Communications/Electronics sector is one of Washington's super heavyweight lobbyists, spending nearly $800 million in 2013-2014, according to CRP data.

But direct lobbying by industry is just one of many worms in a rotting apple. The FCC sits at the core of a network that has allowed powerful moneyed interests with limitless access a variety of ways to shape its policies, often at the expense of fundamental public interests.

As a result, consumer safety, health, and privacy, along with consumer wallets, have all been overlooked, sacrificed, or raided due to unchecked industry influence. The cable industry has consolidated into giant local monopolies that control pricing while leaving consumers little choice over content selection. Though the FCC has only partial responsibility, federal regulators have allowed the Internet to grow into a vast hunting grounds for criminals and commercial interests: the go-to destination for the surrender of personal information, privacy and identity. Most insidious of all, the wireless industry has been allowed to grow unchecked and virtually unregulated, with fundamental questions on public health impact routinely ignored.

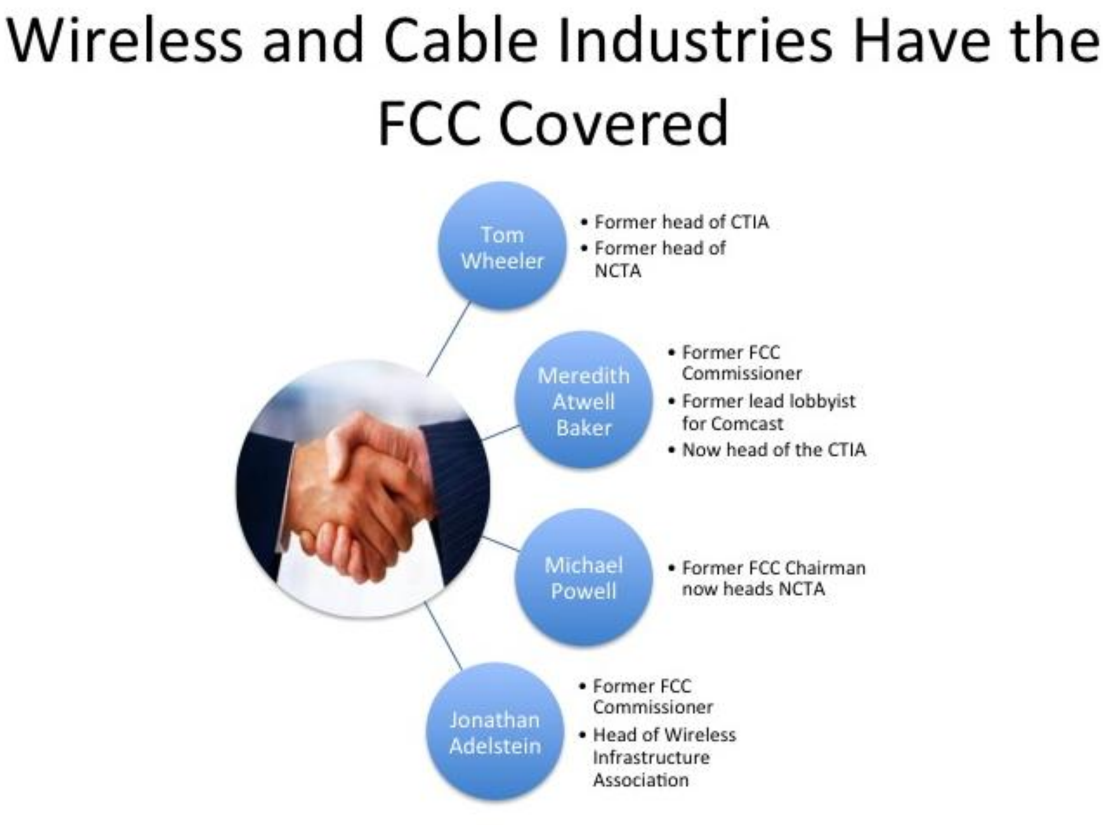
Industry controls the FCC through a soup-to-nuts stranglehold that extends from its well-placed campaign spending in Congress through its control of the FCC's Congressional oversight committees to its persistent agency lobbying. "If you're on a committee that regulates industry you'll be a major target for industry," said Twaun Samuel, chief of staff for Congresswoman Maxine Waters.[3] Samuel several years ago helped write a bill aimed at slowing the revolving door. But with Congress getting its marching orders from industry, the bill never gained any traction.

Industry control, in the case of wireless health issues, extends beyond Congress and regulators to basic scientific research. And in an obvious echo of the hardball tactics of the tobacco industry, the wireless industry has backed up its economic and political power by stonewalling on public relations and bullying potential threats into submission with its huge standing army of lawyers. In this way, a coddled wireless industry intimidated and silenced the City of San Francisco, while running roughshod over local opponents of its expansionary infrastructure.

On a personal level, the entire system is greased by the free flow of executive leadership between the FCC and the industries it presumably oversees. Currently presiding over the FCC is Tom Wheeler, a man who has led the two most powerful industry lobbying groups: CTIA and NCTA. It is Wheeler who once supervised a $25 million industry-funded research effort on wireless health effects. But when handpicked research leader George Carlo concluded that wireless radiation did raise the risk of brain tumors, Wheeler's CTIA allegedly rushed to muffle the message. "You do the science. I'll take care of the politics," Carlo recalls Wheeler saying.[4]

Wheeler over time has proved a masterful politician. President Obama overlooked Wheeler's lobbyist past to nominate him as FCC chairman in 2013. He had, after all, raised more than $700,000 for Obama's presidential campaigns. Wheeler had little trouble earning confirmation from a Senate whose Democrats toed the Presidential line and whose Republicans understood Wheeler was as industry-friendly a nominee as they could get. And while Wheeler, at the behest of his Presidential sponsor, has taken on cable giants with his plans for net neutrality and shown some openness on other issues, he has dug in his heels on wireless.

Newly ensconced as chairman of the agency he once blitzed with partisan pitches, Wheeler sees familiar faces heading the industry lobbying groups that ceaselessly petition the FCC. At CTIA, which now calls itself CTIA - The Wireless Association, former FCC commissioner Meredith Atwell Baker is in charge.



And while cell phone manufacturers like Apple and Samsung, along with wireless service behemoths like Verizon and AT&T, are prominent CTIA members, the infrastructure of 300,000 or more cellular base stations and antenna sites has its own lobbying group: PCIA, the Wireless Infrastructure Association. The President and CEO of PCIA is Jonathan Adelstein, another former FCC commissioner. Meanwhile, the cable industry's NCTA employs former FCC chairman Michael Powell as its president and CEO. Cozy, isn't it?

FCC commissioners in 2014 received invitations to the Wireless Foundation's May 19th Achievement Awards Dinner. Sounds harmless, but for the fact that the chief honoree at the dinner was none other than former wireless lobbyist but current FCC Chairman Tom Wheeler. Is this the man who will act to look impartially at the growing body of evidence pointing to health and safety issues?

The revolving door also reinforces the clout at another node on the industry-controlled influence network. Members of congressional oversight committees are prime targets of industry. The cable industry, for example, knows that key legislation must move through the Communications and Technology Subcommittee of the House Energy and Commerce Committee. Little wonder then that subcommittee chairman Greg Walden was the second leading recipient (after Speaker John Boehner) of cable industry contributions in the last six years (through June 30, 2014). In all, Walden, an Oregon Republican, has taken over $108,000 from cable and satellite production and distribution companies.[5] But he is not alone. Six of the top ten recipients of cable and satellite contributions sit on the industry's House oversight committee. The same is true of senators on the cable oversight committee. Committee members were six of the ten top recipients of campaign cash from the industry.[6]

Cable & Satellite Campaign Contributions

Top House Recipients Funded

Recipient	Amount
John A. Boehner	$135,425
Greg Walden	$108,750
Bob Goodlatte	$93,200
John Conyers Jr.	$84,000
Mike Coffman	$82,137
Fred Upton	**$73,500**
Lee Terry	**$65,916**
Henry A. Waxman	**$65,000**
Cory Gardner	**$64,500**
Anna G. Eshoo	**$60,500**

Cellular Industry Campaign Contributions

Top House Recipients Funded

Recipient	Amount
Henry A. Waxman	**$41,500**
Scott H. Peters	$40,300
Greg Walden	**$35,750**
Fred Upton	**$32,250**
Bob Goodlatte	$31,250
Lee Terry	**$29,600**
Anna G. Eshoo	**$27,000**
Doris O. Matsui	**$25,500**
John Shimkus	**$24,000**
Peter J. Roskam	$21,100

Cable & Satellite Campaign Contributions

Top Senate Recipients Funded

Recipient	Amount
Edward J. Markey	**$320,500**
Kirsten E. Gillibrand	$194,125
Mitch McConnell	$177,125
Harry Reid	$175,600
Charles E. Schumer	$175,450
Mark L. Pryor	**$172,950**
Michael F. Bennet	$159,000
Richard Blumenthal	**$148,800**
Claire McCaskill	**$138,185**
Mark Udall	$136,625

Cellular Industry Campaign Contributions

Top Senate Recipients Funded

Recipient	Amount
Edward J. Markey	**$155,150**
Mark R. Warner	$74,800
Harry Reid	$73,600
Mark L. Pryor	**$71,900**
Roy Blunt	**$57,400**
John McCain	$56,261
Charles E. Schumer	$53,300
Roger F. Wicker	$51,300
Barbara Boxer	$49,578
Kelly Ayotte	$43,333

The compromised FCC network goes well beyond the revolving door and congressional oversight committees. The Washington social scene is one where money sets the tone and throws the parties. A look at the recent calendar of one current FCC commissioner shows it would take very disciplined and almost saintly behavior on the part of government officials to resist the lure of lavishly catered dinners and cocktail events. To paraphrase iconic investigative journalist I.F. Stone, if you're going to work in Washington, bring your chastity belt.

All that free liquor, food and conviviality translates into the lobbyist's ultimate goal: access. "They have disproportionate access," notes former FCC commissioner Michael Copps. "When you are in a town where most people you see socially are in industry, you don't have to ascribe malevolent behavior to it," he added.[7]

Not malevolent in motive. But the results can be toxic. And blame does not lie solely at the feet of current commissioners. The FCC's problems predate Tom Wheeler and go back a long way.

Indeed, former Chairman Newton Minow, enduringly famous for his 1961 description of television as a "vast wasteland," recalls that industry manipulation of regulators was an issue even back then. "When I arrived, the FCC and the communications industry were both regarded as cesspools. Part of my job was to try to clean it up."[8]

More than 50 years later, the mess continues to pile up.

Chapter Two: Just Don't Bring Up Health

Perhaps the best example of how the FCC is tangled in a chain of corruption is the cell tower and antenna infrastructure that lies at the heart of the phenomenally successful wireless industry.

It all begins with passage of the Telecommunications Act of 1996, legislation once described by South Dakota Republican senator Larry Pressler as "the most lobbied bill in history." Late lobbying won the wireless industry enormous concessions from lawmakers, many of them major recipients of industry hard and soft dollar contributions. Congressional staffers who helped lobbyists write the new law did not go unrewarded. Thirteen of fifteen staffers later became lobbyists themselves.[9]

Section 332(c)(7)(B)(iv) of the Act remarkably—and that adverb seems inescapably best here—wrests zoning authority from local governments. Specifically, they cannot cite health concerns about the effects of tower radiation to deny tower licenses so long as the towers comply with FCC regulations.

Congress Silences Public

Section 332(c)(7)(B)(iv) of the Communications Act provides:

> No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions.

In preempting local zoning authority—along with the public's right to guard its own safety and health— Congress unleashed an orgy of infrastructure build-out. Emboldened by the government green light and the vast consumer appetite for wireless technology, industry has had a free hand in installing more than 300,000 sites. Church steeples, schoolyards, school rooftops, even trees can house these facilities.

Is there any reason to believe that the relatively low level radiofrequency emissions of these facilities constitute a public health threat? Certainly, cell phones themselves, held close to the head, have been the focus of most concern on RF emissions. Since the impact of RF diminishes with distance, industry advocates and many scientists dismiss the possibility that such structures pose health risks.

But it's not really that simple. A troubling body of evidence suggests exposure to even low emission levels at typical cellular frequencies between 300 MHz and 3 GHz can have a wide range of negative effects.

In a 2010 review of research on the biological effects of exposure to radiation from cell tower base stations, B. Blake Levitt and Henry Lai found that "some research does exist to warrant caution in infrastructure siting."[10] They summarized the results on one 2002 study that compared the health of 530 people living at various distances within 300 meters of cell towers with a control group living more than 300 meters away. "Results indicated increased symptoms and complaints the closer a person lived to a tower. At <10 m, symptoms included nausea, loss of appetite, visual disruptions, and difficulties in moving. Significant differences were observed up through 100 m for irritability, depressive tendencies, concentration difficulties, memory loss, dizziness, and lower libido."[11]

A 2007 study conducted in Egypt found similar results. Levitt and Lai report, "Headaches, memory changes, dizziness, tremors, depressive symptoms, and sleep disturbance were significantly higher among exposed inhabitants than controls."[12]

Beyond epidemiological studies, research on a wide range of living things raises further red flags. A 2013 study by the Indian scientists S. Sivani and D. Sudarsanam reports: "Based on current available literature, it is justified to conclude that RF-EMF [electro magnetic fields] radiation exposure can change neurotransmitter functions, blood-brain barrier, morphology, electrophysiology, cellular metabolism, calcium efflux, and gene and protein expression in certain types of cells even at lower intensities."[13]

The article goes on to detail the effects of mobile tower emissions on a wide range of living organisms: "Tops of trees tend to dry up when they directly face the cell tower antennas. . . . A study by the Centre for Environment and Vocational Studies of Punjab University noted that embryos of 50 eggs of house sparrows were damaged after being exposed to mobile tower radiation for 5-30 minutes. . . . In a study on cows and calves on the effects of exposure from mobile phone base stations, it was noted that 32% of calves developed nuclear cataracts, 3.6% severely."[14]

Does any of this constitute the conclusive evidence that would mandate much tighter control of the wireless infrastructure? Not in the estimation of industry and its captured agency. Citing other studies—often industry-funded—that fail to establish health effects, the wireless industry has dismissed such concerns. The FCC has typically echoed that position.

Keep in mind that light regulation has been one factor in the extraordinary growth of wireless—CTIA says exactly that in a Web post that credits the Clinton Administrations light regulatory touch.

July 25, 2013

CTIA The Wireless Association® BLOG CTIA is an international nonprofit trade association that has represented the wireless communications industry since 1984.

> But our position as the world's leader was no accident. It started with the Clinton Administration that had the foresight to place a "light regulatory touch" on the wireless industry, which was in its infancy at the time. That light touch has continued through multiple Administrations.

Obviously, cellular technology is wildly popular because it offers many benefits to consumers. But even allowing for that popularity and for the incomplete state of science, don't some of these findings raise enough concern to warrant some backtracking on the ham-fisted federal preemption of local zoning rights?

In reality, since the passage of the 1996 law, the very opposite has occurred. Again and again both Congress and the FCC have opted to stiffen—rather than loosen—federal preemption over local zoning authority. In 2009, for example, the wireless industry convinced the FCC to impose a "shot clock" that requires action within 90 days on many zoning applications. "My sense is that it was an industry request," said Robert Weller, who headed up the FCC's Office of Engineering and Technology when the shot clock was considered and imposed.[15]

And just last November, the FCC voted to further curb the rights of local zoning officials to control the expansion of antenna sites Again and again, Congress and the FCC have extended the wireless industry carte blanche to build out infrastructure no matter the consequences to local communities.

The question that hangs over all this: would consumers' embrace of cell phones and Wi-Fi be quite so ardent if the wireless industry, enabled by its Washington errand boys, hadn't so consistently stonewalled on evidence and substituted legal intimidation for honest inquiry? (See Appendix for online study of consumer attitudes on wireless health and safety.)

Document searches under the Freedom of Information Act reveal the central role of Tom Wheeler and the FCC in the tower siting issue. As both lobbyist and FCC chairman, Wheeler has proved himself a good friend of the wireless industry.

In January of 1997, CTIA chieftain Wheeler wrote FCC Wireless Telecommunications Bureau Chief Michele C. Farquhar citing several municipal efforts to assert control over siting. Wheeler, for example, asserted that one New England state had enacted a law requiring its Public Service Commissioner to issue a report on health risks posed by wireless facilities.[16] He questions whether such a study—and regulations based on its results—would infringe on FCC preemption authority.

FCC bureau chief Farquhar hastily reassured Wheeler that no such study could be consulted in zoning decisions. "Therefore, based on the facts as you have presented them, that portion of the statute that directs the State Commissioner to recommend regulations based upon the study's findings would appear to be preempted,"[17] the FCC official wrote to Wheeler. She emphasized that the state had the right to do the study. It just couldn't deny a siting application based on anything it might learn.

The FCC in 1997 sent the message it has implicitly endorsed and conveyed ever since: study health effects all you want. It doesn't matter what you find. The build-out of wireless cannot be blocked or slowed by health issues.

Now let's fast forward to see Wheeler on the other side of the revolving door, interacting as FCC chairman with a former FCC commissioner who is now an industry lobbyist.

A March 14, 2014 letter[18] reveals the chummy relationship between Wheeler and former commissioner Jonathan Adelstein, now head of PCIA, the cellular infrastructure lobbying group. It also references FCC Chairman Wheeler seeking policy counsel from lobbyist Adelstein:

Wheeler Still Willing to Help

From: Jonathan Adelstein [mailto:adelstein@pcia.com]
Sent: Friday, March 14, 2014 12:24 PM
To: [redacted]
Cc: Renee Gregory; Jonathan Campbell
Subject: How to Spur Wireless Broadband Deployment

Tom – It was great to see you the other night at the FCBA event, and wonderful to see how much fun you're having (if that's the right word). I know I enjoyed my time there (thanks to your help with Daschle in getting me that role in the first place!).

Thanks for asking how we think the FCC can help spur wireless broadband deployment. The infrastructure proceeding perfectly tees up many of the top issues the FCC needs to address. As you requested, I've summarized briefly in the attached letter some of the key steps you can take now.

"Tom – It was great to see you the other night at the FCBA event, and wonderful to see how much fun you're having (if that's the right word). I know I enjoyed my time there (thanks to your help with Daschle in getting me that role in the first place!)."

"Thanks for asking how we think the FCC can help spur wireless broadband deployment," the wireless lobbyist writes to the ex-wireless lobbyist, now running the FCC.

Adelstein's first recommendation for FCC action: *"Amend its rules to categorically exclude DAS and small deployments* [Ed. note: these are compact tower add-ons currently being widely deployed] *from environmental and historic review."* Adelstein outlined other suggestions for further limiting local antenna zoning authority and the FCC soon did its part. Late last year, the agency proposed new rules that largely (though not entirely) complied with the antenna industry's wish list.

James R. Hobson is an attorney who has represented municipalities in zoning issues involving the FCC. He is also a former FCC official, who is now of counsel at Best, Best and Krieger, a Washington-based municipal law practice. "The FCC has been the ally of industry," says Hobson. Lobbyist pressure at the FCC was intense even back in the 70s, when he was a bureau chief there. "When I was at the FCC, a lot of my day was taken up with appointments with industry lobbyists." He says of the CTIA that Wheeler once headed: "Their reason for being is promoting the wireless industry. And they've been successful at it."[19]

The FCC's deferential compliance has allowed industry to regularly bypass and if necessary steamroll local authorities. Violation of the FCC-imposed "shot clock," for example, allows the wireless license applicant to sue.

The FCC's service to the industry it is supposed to regulate is evidently appreciated. The CTIA web site, typically overflowing with self-congratulation, spreads the praise around in acknowledging the enabling contributions of a cooperative FCC. In one brief summation of its own glorious accomplishments, CTIA twice uses the word "thankfully" in describing favorable FCC actions.

In advancing the industry agenda, the FCC can claim that it is merely reflecting the will of Congress. But the agency may not be doing even that.

Remember the key clause in the 96 Telecom Act that disallowed denial of zoning permits based on health concerns? Well, federal preemption is granted to pretty much any wireless outfit on just one simple condition: its installations must comply with FCC radiation emission standards. In view of this generous carte blanche to move radiation equipment into neighborhoods, schoolyards and home rooftops, one would think the FCC would at the very least diligently enforce its own emission standards. But that does not appear to be the case.

Indeed, one RF engineer who has worked on more than 3,000 rooftop sites found vast evidence of non-compliance. Marvin Wessel estimates that "10 to 20% exceed allowed radiation standards."[20] With 30,000 rooftop antenna sites across the U.S. that would mean that as many as 6,000 are emitting radiation in violation of FCC standards. Often, these emissions can be 600% or more of allowed exposure levels, according to Wessel.

Antenna standards allow for higher exposure to workers. In the case of rooftop sites, such workers could be roofers, painters, testers and installers of heating and air conditioning equipment, to cite just a few examples. But many sites, according to Wessel, emit radiation at much higher levels than those permitted in occupational standards. This is especially true of sites where service providers keep adding new antenna units to expand their coverage. “Some of these new sites will exceed ten times the allowable occupational radiation level,” said Wessel.[21] Essentially, he adds, this means that nobody should be stepping on the roof.

“The FCC is not enforcing its own standard,” noted Janet Newton, who runs the EMF Policy Institute, a Vermont-based non-profit. That group several years ago filed 101 complaints on specific rooftop sites where radiation emissions exceeded allowable levels. “We did this as an exercise to hold the FCC’s feet to the fire,” she said. But the 101 complaints resulted in few responsive actions, according to Newton.[22]

Former FCC official Bob Weller confirms the lax—perhaps negligible is the more appropriate word—FCC activity in enforcing antenna standards. “To my knowledge, the enforcement bureau has never done a targeted inspection effort around RF exposure,” he said.[23] Budget cuts at the agency have hurt, limiting the FCC’s ability to perform field inspections, he added. But enforcement, he adds, would do wonders to insure industry compliance with its limited regulatory compliance requirements. “If there were targeted enforcement and fines issued the industry would pay greater attention to ensuring compliance and self-regulation,” he allowed.

Insurance is where the rubber hits the road on risk. So it is interesting to note that the rating agency A.M. Best, which advises insurers on risk, in 2013 topped its list of “emerging technology-based risks” with RF Radiation:

> *“The risks associated with long-term use of cell phones, although much studied over the past 10 years, remain unclear. Dangers to the estimated 250,000 workers per year who come in close contact with cell phone antennas, however, are now more clearly established. Thermal effects of the cellular antennas, which act at close range essentially as open microwave ovens can include eye damage, sterility and cognitive impairments. While workers of cellular companies are well trained on the potential dangers, other workers exposed to the antennas are often unaware of the health risks. The continued exponential growth of cellular towers will significantly increase exposure of these workers and others coming into close contact with high-energy cell phone antenna radiation,”* A.M. Best wrote.[24]

So what has the FCC done to tighten enforcement? Apparently, not very much. Though it does follow up on many of the complaints filed against sites alleged to be in violation of standards it takes punitive actions very rarely. (The FCC did not provide answers to written questions on details of its tower enforcement policies.)

The best ally of industry and the FCC on this (and other) issues may be public ignorance.

An online poll conducted for this project asked 202 respondents to rate the likelihood of a series of statements.[25] Most of the statements were subject to dispute. Cell phones raise the risk of certain health effects and brain cancer, two said. There is no proof that cell phones are harmful, another declared. But among the six statements there was one statement of indisputable fact: “The U.S. Congress forbids local communities from considering health effects when deciding whether to issue zoning permits for wireless antennae,” the statement said.

Though this is a stone cold fact that the wireless industry, the FCC and the courts have all turned into hard and inescapable reality for local authorities, just 1.5% of all poll respondents replied that it was “definitely true.”

Public ignorance didn’t take much cultivation by the wireless industry on the issue of local zoning. And maybe it doesn’t matter much, considering the enormous popularity of wireless devices. But let’s see how public ignorance has been cultivated and secured—with the FCC’s passive support—on the potentially more disruptive issue of mobile phone health effects.

Chapter Three: Wireless Bullies and the Tobacco Analogy

Issues of cable and net neutrality have recently attracted wide public attention (more on that in Chapter Six). Still, the bet here remains that future judgment of the FCC will hinge on its handling of wireless health and safety issues.

And while the tower siting issue is an egregious example of an industry-dominated political process run amuck, the stronger health risks appear to reside in the phones themselves. This is an issue that has flared up several times in recent years. Each time, industry has managed to beat back such concerns. But it's worth noting that the scientific roots of concern have not disappeared. If anything, they've thickened as new research substantiates older concerns.

The story of an FCC passively echoing an industry determined to play hardball with its critics is worth a further look. The CTIA's own website acknowledges the helpful hand of government's "light regulatory touch" in allowing the industry to grow.[26]

Former congressman Dennis Kucinich ventures one explanation for the wireless industry's success in dodging regulation: "The industry has grown so fast its growth has overtaken any health concerns that may have gained attention in a slow growth environment. The proliferation of technology has overwhelmed all institutions that would have attempted safety testing and standards," Kucinich said.[27]

But the core questions remain: Is there really credible evidence that cell phones emit harmful radiation that can cause human health problems and disease? Has the FCC done an adequate job in protecting consumers from health risks? Or has it simply aped industry stonewalling on health and safety issues?

Before wading into these questions, some perspective is in order.

First, there's simply no denying the usefulness and immense popularity of wireless technology. People depend on it for safety, information, entertainment and communication. It doesn't take a keen social observer to know that wireless has thoroughly insinuated itself into daily life and culture.

The unanswered question, though, is whether consumers would embrace the technology quite so fervently if health and safety information was not spun, filtered and clouded by a variety of industry tactics.

To gain some insight into this question, we conducted an online survey of 202 respondents, nearly all of whom own cell phones, on Amazon's Mechanical Turk Web platform (see Appendix). One striking set of findings: many respondents claim they would change behavior—reduce wireless use, restore landline service, protect their children—if claims on health dangers of wireless are true.

It is not the purpose of this reporter to establish that heavy cell phone usage is dangerous. This remains an extremely controversial scientific issue with new findings and revised scientific conclusions repeatedly popping up. Just months ago, a German scientist who had been outspoken in denouncing the view that cell phones pose health risks reversed course. In an April 2015 publication, Alexander Lerchl reported results confirming previous research on the tumor-promoting effects of electromagnetic fields well below human exposure limits for mobile phones. "Our findings may help to understand the repeatedly reported increased incidences of brain tumors in heavy users of mobile phones," the Lerchl team concluded.[28] And in May 2015, more than 200 scientists boasting over 2,000 publications on wireless effects called on global institutions to address the health risks posed by this technology.

But the National Cancer Institute still contends that no cell phone dangers have been established. A representative of NCI was the sole known dissenter among the 30 members of the World Health Organization's International Agency for Research on Cancer (IARC) when it voted to declare wireless RF "possibly carcinogenic."[29] If leading scientists still can't agree, I will not presume to reach a scientific conclusion on my own.

IARC RF working group: Official press release

International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 208

31 May 2011

IARC CLASSIFIES RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMANS

Lyon, France, May 31, 2011 -- The WHO/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as **possibly carcinogenic to humans (Group 2B)**, based on an increased risk for **glioma**, a malignant type of brain cancer, associated with wireless phone use.

But let's at least look at some of the incriminating clues that health and biology research has revealed to date. And let's look at the responses of both industry and the FCC.

The most widely cited evidence implicating wireless phones concerns gliomas, a very serious type of brain tumor. The evidence of elevated risk for such tumors among heavy cell phone users comes from several sources.

Gliomas account for roughly half of all malignant brain tumors, which are relatively rare. The annual incidence of primary malignant brain tumors in the U.S. is only 8.2 per 100,000 people, according to the International Radio Surgery Association.

Still, when projected over the entire U.S. population, the public health impact is potentially very significant.

Assuming roughly four new glioma cases annually in the U.S. per 100,000 people, yields over 13,000 new cases per year over a total U.S. population of 330 million. Even a doubling of that rate would mean 13,000 new gliomas, often deadly, per year. A tripling, as some studies have found, could mean as many as 26,000 more new cases annually. Indeed, the respected online site Medscape in January 2015 reported results of Swedish research under the headline: *Risk for Glioma Triples With Long-Term Cell Phone Use*.[30]

And here's some eye-opening quantitative perspective: the wars in Iraq and Afghanistan, waged now for more than a decade each, have together resulted in roughly 7,000 U.S. deaths.

Preliminary—though still inconclusive—research has suggested other potential negative health effects. Swedish, Danish and Israeli scientists have all found elevated risk of salivary gland tumors. One Israeli studied suggested elevated thyroid cancer risk. Some research has found that men who carry their phones in their pockets may suffer sperm count damage. One small study even suggests that young women who carry wireless devices in their bras are unusually vulnerable to breast cancer.

And while industry and government have never accepted that some portion of the population is unusually sensitive to electromagnetic fields, many people continue to complain of a broad range of symptoms that include general weakness, headaches, nausea and dizziness from exposure to wireless.

Some have suggested that the health situation with wireless is analogous to that of tobacco before court decisions finally forced Big Tobacco to admit guilt and pay up. In some ways, the analogy is unfair. Wireless research is not as conclusively incriminating as tobacco research was. And the identified health risks with wireless, significant as they are, still pale compared with those of tobacco.

But let's not dismiss the analogy outright. There is actually a very significant sense in which the tobacco-wireless analogy is uncannily valid.

People tend to forget that the tobacco industry—like the wireless industry—also adopted a policy of tone-deaf denial. As recently as 1998, even as evidence of tobacco toxicity grew overwhelming, cigarette maker Phillip Morris was writing newspaper advertorials insisting there was no proof smoking caused cancer.

It seems significant that the responses of wireless and its captured agency—the FCC—feature the same obtuse refusal to examine the evidence. The wireless industry reaction features stonewalling public relations and hyper aggressive legal action. It can also involve undermining the credibility and cutting off the funding for researchers who do not endorse cellular safety. It is these hardball tactics that look a lot like 20th century Big Tobacco tactics. It is these hardball tactics—along with consistently supportive FCC policies—that heighten suspicion the wireless industry does indeed have something to hide.

Begin with some simple facts issuing from meta-analysis of cellular research. Dr. Henry Lai, emeritus professor of bioengineering at the University of Washington, has reviewed hundreds of published scientific papers on the subject. He wanted to see how many studies demonstrated that non-ionizing radiation produces biological effects beyond the heating of tissue. This is critical since the FCC emission standards protect only against heating. The assumption behind these standards is that there are no biological effects beyond heating.

But Dr. Lai found that just over half—actually 56%—of 326 studies identified biological effects. And the results were far more striking when Dr. Lai divided the studies between those that were industry-funded and those that were independently funded. Industry-funded research identified biological effects in just 28% of studies. But fully 67% of non-industry funded studies found biological effects (Insert Slide—Cell Phone Biological Studies).

A study conducted by Swiss and British scientists also looked at how funding sources affected scientific conclusions on the possible health effects of cell phone usage. They found that of studies privately funded, publicly funded and funded with mixed sponsorship, industry-funded studies were "least likely to report a statistically significant result."[31] "The interpretation of results from studies of health effects of radiofrequency radiation should take sponsorship into account," the scientists concluded.[32]

So how does the FCC handle a scientific split that seems to suggest bias in industry-sponsored research?

In a posting on its Web site that reads like it was written by wireless lobbyists, the FCC chooses strikingly patronizing language to slight and trivialize the many scientists and health and safety experts who've found cause for concern. In a two page Web post titled "Wireless Devices and Health Concerns," the FCC four times refers to either "some health and safety interest groups," "some parties," or "some consumers" before in each case rebutting their presumably groundless concerns about wireless risk.[33] Additionally, the FCC site references the World Health Organization as among those organizations who've found that "the weight of scientific evidence" has not linked exposure to radiofrequency from mobile devices with "any known health problems."

Yes, it's true that the World Health organization remains bitterly divided on the subject. But it's also true that a 30 member unit of the WHO called the International Agency for Research on Cancer (IARC) was near unanimous in pronouncing cell phones "possibly carcinogenic" in 2011. How can the FCC omit any reference to such a pronouncement? Even if it finds reason to side with pro-industry scientists, shouldn't this government agency also mention that cell phones are currently in the same potential carcinogen class as lead paint?

Now let's look a bit more closely at the troublesome but presumably clueless crowd of "some parties" that the FCC so cavalierly hastens to dismiss? Let's begin with **Lennart Hardell**, professor of Oncology and Cancer Epidemiology at the University Hospital in Oreboro, Sweden.

Until recently it was impossible to gain any real sense of brain tumor risk from wireless since brain tumors often take 20 or more years to develop. But the cohort of long-term users has been growing. In a study published in the International Journal of Oncology in 2013, Dr. Hardell and Dr. Michael Carlberg found that the risk of glioma—the most deadly type of brain cancer—rose with cell phone usage. The risk was highest among heavy cell phone users and those who began to use cell phones before the age of 20.[34]

Indeed, those who used their phones at least 1640 hours (which would be roughly 30 minutes a day for nine years) had nearly three times the glioma incidence. Drs. Hardell and Carlberg also found that gliomas tend to be more deadly among heavy wireless callers.[35]

Perhaps of greatest long-term relevance, glioma risk was found to be four times higher among those who began to use mobile phones as teenagers or earlier. These findings, along with the established fact that it generally takes decades for tumors induced by environmental agents to appear, suggest that the worst consequences of omnipresent wireless devices have yet to be seen.

In a 2013 paper published in *Reviews on Environmental Health*, Drs. Hardell and Carlberg argued that the 2011 finding of the IARC that identified cell phones as a "possibly carcinogenic" needs to be revised. The conclusion on radiofrequency electromagnetic fields from cell phones should now be "cell phones are not just a possible carcinogen." They can now be "regarded as carcinogenic to humans" and the direct cause of gliomas (as well as acoustic neuromas, a less serious type of tumor).[36] Of course, these views are not universally accepted.

The usual spin among industry supporters when presented with research that produces troubling results is along the lines of: "We might pay attention if the results are duplicated." In fact, the Hardell results were echoed in the French CERENAT study, reported in May of 2014. The CERENAT study also found higher risk among heavy users, defined as those using their phones at least 896 hours (just 30 minutes a day for five years). "These additional data support previous findings concerning a possible association between heavy mobile phone use and brain tumors," the study concluded.[37]

Cell phones are not the only wireless suspects. Asked what he would do if he had policy-making authority, Dr. Hardell swiftly replied that he would "ban wireless use in schools and pre-schools. You don't need Wi-Fi," he noted.[38] This is especially interesting in view of the FCC's sharply hiked spending to promote and extend Wi-Fi usage, as well as its consistent refusal to set more stringent standards for children (more on all this later). But for now let's further fill out the roster of the FCC's unnamed "some parties."

Martin Blank is a Special Lecturer in Physiology and Cellular Biophysics at Columbia University. Unlike Dr. Hardell, who looks at broad epidemiological effects over time, Dr. Blank sees cause for concern in research showing there is biological response at the cellular level to the type of radiation emitted by wireless devices. "The biology tells you unequivocally that the cell treats radiation as a potentially damaging influence," Dr. Blank said in a late 2014 interview.[39]

"The biology tells you it's dangerous at a low level," he added. Though some results have been difficult to replicate, researchers have identified a wide range of cellular responses including genetic damage and penetration of the blood brain barrier. Dr. Blank specifically cited the "cellular stress response" in which cells exposed to radiation start to make proteins.

It is still not clear whether biological responses at the cellular level translate into human health effects. But the research seems to invalidate the basic premise of FCC standards that the only biological effect of the type of radiation produced by wireless devices is tissue heating at very high power levels. But the standards-setting agencies "ignore the biology," according to Dr. Blank. He describes the FCC as being "in industry's pocket."[40]

Sweden's Lund University is annually ranked among the top 100 universities in the world. **Leif Salford** has been chairman of the Department of Neurosurgery at Lund since 1996. He is also a former president of the European Association for Neuro-Oncology. In the spring of 2000, Professor Salford told me that wireless usage constituted "the world's largest biological experiment ever."[41]

He has conducted numerous experiments exposing rats to cellular-type radiation. Individual experiments have shown the radiation to penetrate the blood-brain barrier, essential to protecting the brain from bloodstream toxins. Professor Salford also found that rats exposed to radiation suffered loss of brain cells. "A rat's brain is very much the same as a human's. They have the same blood-brain barrier and neurons. We have good reason to believe that what happens in rat's brains also happens in humans," he told the BBC in 2003. Dr. Salford has also speculated that mobile radiation could trigger Alzheimer's disease in some cases but emphasized that much more research would be needed to establish any such causal relationship. Does this man deserve to be dismissed as one of a nameless and discredited group of "some parties?"

And what about the **American Academy of Pediatrics (AAP),** which represents 60,000 American doctors who care for children? In a December 12, 2012 letter to former Ohio Congressman Dennis Kucinich, AAP President Dr. Thomas McInerny writes: "Children are disproportionately affected by environmental exposures, including cell phone radiation. The differences in bone density and the amount of fluid in a child's brain compared to an adult's brain could allow children to absorb greater quantities of RF energy deeper into their brains than adults."[42]

In a subsequent letter to FCC officials dated August 29, 2013, Dr. McInerny points out that "children, however, are not little adults and are disproportionately impacted by all environmental exposures, including cell phone radiation." Current FCC exposure standards, set back in 1996, "do not account for the unique vulnerability and use patterns specific to pregnant women and children," he wrote. (Insert slide: A Plea from Pediatricians). Does an organization representing 60,000 practitioners who care for children deserve to be brushed off along with "some health and safety interest groups?"

So what is the FCC doing in response to what at the very least is a troubling chain of clues to cellular danger? As it has done with wireless infrastructure, the FCC has to this point largely relied on industry "self-regulation." Though it set standards for device radiation emissions back in 1996, the agency doesn't generally test devices itself. Despite its responsibility for the safety of cell phones, the FCC relies on manufacturers' good-faith efforts to test them. Critics contend that this has allowed manufacturers undue latitude in testing their devices.

Critics further contend that current standards, in place since cell phones were barely in use, are far too lax and do not reflect the heavy usage patterns that have evolved. Worse still, industry is allowed to test its own devices using an imprecise system that makes no special provision for protecting children and pregnant women. One 2012 study noted that the procedure widely used by manufacturers to test their phones "substantially underestimates" the amount of RF energy absorbed by 97% of the population, "especially children." A child's head can absorb over two times as much RF energy. Other persons with smaller heads, including women, are also more vulnerable. The authors recommend an alternative computer simulation technique that would provide greater insight into the impact of cellular radiation on children and on to the specific RF absorption rates of different tissues, which vary greatly.[43]

Acting on recommendations of the General Accounting Office, the FCC is now reconsidering its standards for wireless testing and allowed emissions. On the surface, this may seem to represent an effort to tighten standards to promote consumer health and safety. But many believe the FCC's eventual new standard will actually be weaker, intensifying any health risk from industry's self-reported emission levels. "They're under great pressure from industry to loosen the criteria," notes Joel Moskowitz, director of the Center for Family and Community Health at UC Berkeley's School of Public Health.[44] One fear is that the FCC could measure the allowed radiation absorption level (SAR) over a wider sample of tissue, effectively loosening the standard allowable energy absorption. One FCC official, who asked that his name not be used, contended that a decision had not yet been made to loosen the standard.

But to this point, there is little evidence the FCC is listening to anyone beyond its familiar friends in the wireless industry. Carl Blackman, a scientist at the Environmental Protection agency until retiring in 2014, notes that the FCC does rely to some degree on an inter-agency governmental group for advice on health matters. The group includes, for example, representatives from the EPA and the FDA.

Blackman served on that advisory group and he says that it has been divided. Though some government advisers to the FCC find evidence of wireless health risks convincing, others remain skeptical, said Blackman. Root of the skepticism: even though numerous researchers have found biological and health effects, the mechanism for action by non-ionizing radiation on the human body has still not been identified. “I don’t think there’s enough of a consensus within the Radio Frequency Inter-agency Working Group for them to come out with stricter standards,” he says.[45]

But political pressures also figure mightily in all this. The EPA, notably, was once a hub of research on RF effects, employing as many as 35 scientists. However, the research program was cut off in the late 80s during the Regan presidency. Blackman says he was personally “forbidden” to study health effects by his “supervisory structure.”[46] He termed it “a political decision” but recognized that if he wanted to continue to work at the EPA he would have to do research in another area.

Blackman is cautious in imputing motives to the high government officials who wanted his work at EPA stopped. But he does say that political pressure has been a factor at both the EPA and FCC: “The FCC people were quite responsive to the biological point of view. But there are also pressures on the FCC from industry.” The FCC, he suggests, may not just be looking at the scientific evidence “The FCC’s position—like the EPA’s—is influenced by political considerations as well.”[47]

Still, the FCC has ultimate regulatory responsibility and cannot indefinitely pass the buck on an issue of fundamental public health. Remarkably, it has not changed course despite the IARC classification of cell phones as possibly carcinogenic, despite the recent studies showing triple the glioma risk for heavy users, despite the floodtide of research showing biological effects, and despite even the recent defection of core industry booster Alex Lerchl. It is the refusal of both industry and the FCC to even acknowledge this cascade of warning signs that seems most incriminating.

Of course, industry behavior goes well beyond pushing for the FCC’s willful ignorance and inaction. Industry behavior also includes self-serving public relations and hyper aggressive legal action. It can also involve undermining the credibility of and cutting off the funding for researchers who do not endorse cellular safety. It is these hardball tactics that recall 20th century Big Tobacco tactics. It is these tactics that heighten suspicion that the wireless industry does indeed have a dirty secret. And it is those tactics that intensify the spotlight on an FCC that so timidly follows the script of the fabulously wealthy, bullying, billion-dollar beneficiaries of wireless.

Chapter Four: You Don't Need Wires To Tie People Up

So let's look a little more deeply at some of the actions of an industry group that boasts of 500 meetings a year with the FCC. Lobbying is one thing. Intimidation is another. CTIA has shown its skill at—and willingness to use—both.

Outright legal bullying is a favored tactic. The City of San Francisco passed an ordinance in 2010 that required cell phone manufacturers to display more prominently information on the emissions from their devices. This information was already disclosed—but often buried—in operator manuals and on manufacturer websites. The idea was to ensure that consumers saw information already mandated and provided.

Seeing this as a threat to its floodtide of business, the industry sued the City of San Francisco. The City, fearing a prolonged legal fight with an industry that generates hundreds of billions of dollars in annual revenue, backed down.

On May 12, 2015, Berkeley, California's City Council unanimously passed a similar ordinance. Joel Moskowitz, director of the Center for Family and Community Health at the University of California-Berkeley's School of Public Health, has been involved in the effort. Berkeley, he says, didn't want to run into the same legal threats that paralyzed San Francisco. So it tried to draft the most inoffensive and mild language possible. The proposed Cell Phone Right to Know ordinance: "To assure safety, the Federal Government requires that cell phones meet radio frequency (RF) exposure guidelines. If you carry or use your phone in a pants or shirt pocket or tucked into a bra when the phone is ON and connected to a wireless network, you may exceed the federal guidelines for exposure to RF radiation. This potential risk is greater for children. Refer to the instructions in your phone or user manual for information about how to use your phone safely."[48]

Sounds pretty inoffensive, no? Not to the CTIA, which indicated that it was prepared to sue, according to Berkeley City Attorney Zach Cowan.[49] (On June 8th, CTIA did indeed sue the City of Berkeley.)

Well, from the industry point of view, why not throw around your weight? Smash mouth legal tactics have been highly successful thus far as industry has managed to throttle several efforts to implicate manufacturers in cases where heavy users suffered brain tumors.

But one current case has advanced in district court in Washington to the point where the judge allowed plaintiffs to present expert witness testimony. The industry response: file a legal action seeking to invalidate long-held court methods for qualifying expert witnesses.

This is a very rich industry that does not hesitate to outspend and bully challengers into submission. Meanwhile, amidst the legal smoke and medical confusion, the industry has managed to make the entire world dependent on its products. Even tobacco never had so many hooked users.

Such sustained success in the face of medical doubt has required industry to keep a lid on critics and detractors. Many scientists who've found real or potential risk from the sort of microwave radiation emanating from wireless devices have learned there is a price to be paid for standing up to the industry juggernaut. A few prominent examples:

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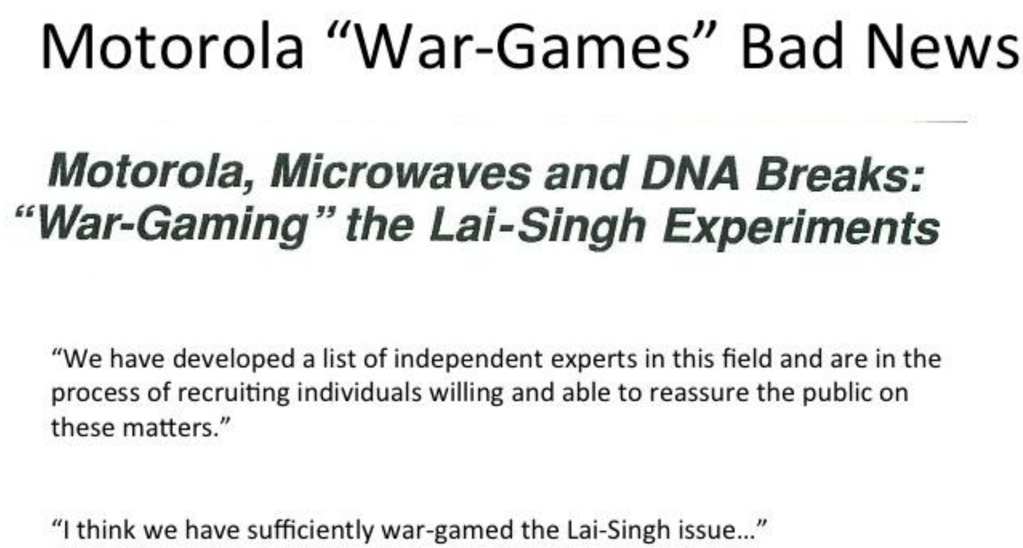
In 1994, University of Washington researchers Henry Lai and N.P. Singh found that rats exposed to microwave radiation suffered DNA damage to their brain cells. This was a scary finding since DNA damage can lead to mutations and possibly cancer.

The reaction from industry was swift. Motorola was at that time the U.S. market leader in cell phones. In a memorandum obtained by the journal Microwave News, Motorola PR honcho Norm Sandler outlined how the company could "downplay the significance of the Lai study." One step: "We have developed a list of independent experts in this field and are in the process of recruiting individuals willing and able to reassure the public on these matters," Sandler wrote. After outlining such measures, he concluded that Motorola had "sufficiently war-gamed" the issue. The practices of lining up industry-friendly testimony and "war-gaming" researchers who come up with unfavorable results have been persistent themes with this industry.



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After Lai's results were published, Motorola decided to sponsor further research on microwaves and DNA damage. Oftentimes, lab results cannot be reproduced by other researchers, particularly if experiments are tweaked and performed a bit differently. Non-confirming studies raise doubt, of course, on the original work.

Motorola lined up Jerry Phillips, a scientist at the Veteran's Administration Medical Center in Loma Linda, California, and Phillips tested the effect of radiation at different frequencies from those tested by Lai and Singh. Nevertheless, Phillips found that at some levels of exposure, DNA damage increased, while at other levels it decreased. Such findings were "consistent" with the sorts of effects produced by chemical agents, Phillips said in an interview.[50] In some cases, the radiation may have activated DNA repair mechanisms, reducing the overall microwave effect. But what was important, Phillips explained, is that there were *any* biological effects at all. The wireless industry has long contended—and the FCC has agreed—that there is no evidence that non-ionizing radiation at the frequencies and power levels used by cell phones is biologically active.

Understanding the potential impact of "biological effect" findings, Motorola again turned to damage control, said Phillips. He recalls receiving a phone call from a Motorola R&D executive. "I don't think you've done enough research,'" Phillips recalls being told. The study wasn't ready for publication, according to the Motorola executive. Phillips was offered more money to do further research without publishing the results of what he'd done.

But Phillips felt he'd done enough. Despite warnings for his own boss to "give Motorola what it wants," Phillips went ahead and published his findings in 1998. Since then, Phillips' industry funding has dried up. Meanwhile, as many other researchers report, government funding to do independent research on microwave radiation has dried up, leaving the field at least in the U.S. to industry-funded scientists. "There is no money to do the research," Said Phillips. "It's not going to come from government because government is controlled by industry."[51]

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Om P. Gandhi is Professor of Electrical and Computer Engineering at the University of Utah and a leading expert in dosimetry—measurement of non-ionizing radiation absorbed by the human body. Even before cell phones were in wide use, Professor Gandhi had concluded that children absorb more emitted microwave radiation. "The concentration of absorbed energy is 50 to 80% greater," he explained.[52]

These conclusions were not acceptable to Professor Gandhi's industrial sponsors. In 1998, he recalls, an executive from a cell phone manufacturer—which he did not want to identify—told him directly that if he did not discontinue his research on children his funding would be cut off. Professor Gandhi recalled replying: "I will not stop. I am a tenured professor at the University of Utah and I will not reject my academic freedom." Professor Gandhi also recalled some of his thought process: "I wasn't going to order my students to alter their results so that I can get funding." His industry sponsors cancelled his contract and asked for a return of funds.

Professor Gandhi believes that some cell phone users require extra protection because their heads are smaller and more absorptive. “Children, as well as women and other individuals with smaller heads absorb more concentrated energy because of the proximity of the radiating antenna to the brain tissue,” he said. And yet the FCC has not acted to provide special protection for these groups. Asked why not, Professor Gandhi conceded that he doesn’t know. He does note, however, that recent standards-setting has been dominated by industry representatives.[53]

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While the mobile industry refuses to admit to even the possibility that there is danger in RF radiation, giant insurance companies see things differently. Several insurers have in recent years issued reports highlighting product liability risk with cell phones. This is important because it is evidence that where money is on the line professionals outside the industry see the risk of legal liability.

Legal exposure could be one reason—perhaps the central one—the industry continues to stonewall. Should legal liability be established, one key question will be how much wireless executives knew—and at what point in time. Meanwhile, the combination of public relations denials, legal intimidation and the selective application of pressure on research follows a familiar pattern. “The industry is basically using the tobacco industry playbook,” UC Berkeley’s Moskowitz said in a recent radio interview.[54]

That playbook has thus far been highly successful in warding off attention, regulation and legal incrimination.

Chapter Five: $270 Billion . . . and Looking for Handouts

The FCC's network of corruption doesn't just shield industry from needed scrutiny and regulation on matters of public health and safety. Sometimes it just puts its hand directly into the public pocket and redistributes that cash to industry supplicants.

Such is arguably the case with the Universal Service Fund. Originally established to extend telephone service to rural and urban areas that industry would find difficult or uneconomical to wire, the USF is now shifting from subsidizing landline phone service to subsidizing the extension of broadband Internet. USF monies also support the Lifeline program, which subsidizes cell phone service to low-income consumers, and the E-Rate program, which subsidizes Internet infrastructure and service to schools and libraries.

Since 1998, more than $110 billion has been allocated to Universal Service programs, notes Charles Davidson, director of the Advanced Communications Law & Policy Institute at New York Law School. The FCC has allocated over $40 billion to the E-Rate program alone.

Who pays the freight for these high-cost programs? You do.

Technically, landline and wireless phone companies are assessed for the Universal Service fund's expenditures. But the FCC also allows those companies to pass on such charges to their subscribers, which they do. Both landline and wireless subscribers pay a monthly Universal Service charge that is tacked on to their phone bills. That charge has been rising and recently amounted to a 16% surcharge on interstate calls.

Consumers who pay for these programs might be interested to learn that both the E-Rate and Lifeline programs have been riddled with fraud. Government watchdogs have repeatedly found the programs to be inefficient and prone to inflated and fraudulent claims. But the programs have been a windfall for tech and telecom industry beneficiaries. Wherever the FCC presides, it seems, these industries reap a windfall.

The General Accounting Office (GAO) has issued several reports citing fraud, waste and mismanagement, along with inadequate FCC oversight of the subsidy program. Bribery, kickbacks and false documentation can perhaps be expected in a handout program mandated by Congress and only indirectly supervised by the FCC.

But the scope of fraud has been impressive. The most striking corruption has marred the E-Rate program, which subsidizes Internet hardware, software and service for schools and libraries, and the Lifeline cell phone subsidies.

In recent years, several school districts have paid fines to settle fraud cases involving bribery, kickbacks, non-competitive bidding of contracts and false documentation in the E-Rate program. More eye opening perhaps are the settlements of fraud claims by tech giants like IBM, Hewlett Packard and AT&T. The HP case, for example, involved some colorful bribery allegations, including gifts of yachts and Super Bowl tickets. HP settled for $16 million. An HP official and a Dallas Independent School District official both received jail sentences.

The Lifeline program has also been riddled with fraud. A Wall Street Journal investigation of the five top corporate beneficiaries of Lifeline showed that 41% of more than 6 million subsidy claimants "couldn't demonstrate their eligibility or didn't respond to requests for certification."[55] AT&T, Verizon, and Sprint Nextel were three of the major Lifeline beneficiaries.

The FCC has initiated several efforts to clean up USF programs and seems honestly determined to bring greater accountability and efficiency to its subsidy efforts. Nevertheless, problems with fraud persist, as reported recently by the FCC's own top investigator.

Congress established the FCC's Office of Inspector General in 1989 to "provide objective and independent investigations, audits and reviews of the FCC's programs and operations." Here's what the FCC's internal investigative unit said in a September 30, 2014 report to Congress about its Office of Investigation (OI): "*The bulk of the work of OI involves investigating and supporting civil and criminal investigations/prosecutions of fraud in the FCC's federal universal service program*."[56]

Office of Inspector General

OFFICE OF INVESTIGATION

The bulk of the work of OI involves investigating and supporting civil and criminal investigations/prosecutions of fraud in the FCC's federal universal service program.

Fraud—as pervasive and troubling as it has been—is just one of the problems with the programs of universal service. It may not even be the fundamental problem. More fundamental issues concern the very aim, logic and efficiency of programs to extend broadband and wireless technology at public expense. Though the aims of extending service to distant impoverished areas seem worthy on the surface, there are many reasons to think the major beneficiaries of these programs are the technology companies that win the contracts.

Lobbyists have long swarmed over the FCC looking to get an ever-growing piece of the USF honeypot. An FCC report on meetings with registered lobbyists details a 2010 meeting with representatives of the International Society for Technology in Education and other education lobbyists. Topics discussed, according to the FCC report, included “the need to raise the E-Rate’s annual cap.”[57]

The CTIA, leaving no stone unturned in its efforts to pump up member revenues, last year responded to a House hearing on the USF by grousing that “current USF-supported programs skew heavily toward support of wireline services. . . . The concentration of USF monies to support wireline services is inconsistent with technological neutrality principles and demonstrated consumer preferences,” CTIA wrote..[58] An industry that generates hundreds of billions of dollars in equipment and service revenues annually bellies up for a bigger slice of the $8 billion a year USF.

The grousing has paid off. The FCC recently announced that it will raise spending on E-Rate from what had been a cap of $2.4 billion a year to $3.9 billion. A significant portion of new outlays will go to Wi-Fi—yet another wireless industry victory at the FCC. But the CTIA is by no means the only industry group pressing the FCC.

Leading the roster of active lobbyists on E-Rate issues is the Software and Information Industry Association. Beginning in 2006, SIAA led all lobbyists with 54 mentions of E-Rate in its filings, according to the Center for Responsive Politics. SIAA board members include executives from tech heavyweights Google, Oracle and Adobe Systems.

Tech business leaders—many of them direct beneficiaries of FCC programs—made a direct pitch to FCC Chairman Wheeler last year to hike E-Rate funding. “The FCC must act boldly to modernize the E-Rate program to provide the capital needed to upgrade our K-12 broadband connectivity and Wi-Fi infrastructure within the next five years,” the executives wrote.[59]

There were dozens of corporate executive signees to this letter, including the CEOs of many Fortune 500 giants. But let’s just consider the participation of three: top executives of Microsoft, Google and HP all joined the call to expand E-Rate subsidies. Consider the simple fact that these three tech giants alone had revenues of $270 billion—more than a quarter of a trillion dollars—in a recent four-quarter period. Together, they produced nearly $40 billion in net income. And yet their top executives still thought it necessary to dun the FCC—and really, they were surreptitiously hitting up the public—for ramped-up spending on what was then a $2.4 billion a year program.

Is that greed? Arrogance? Or is it simply behavior conditioned by success in repeatedly getting what they want at the public trough? Almost never mentioned in these pleas for higher subsidies is the fact that ordinary American phone subscribers are the ones footing the bill for the E-Rate program—not the FCC or the telecom industry.

Much of the added spending, as noted, will go towards the installation of wireless networks. And yet Wi-Fi does not have a clean bill of health. When Lennart Hardell, professor of Oncology and Cancer Epidemiology at the University Hospital in Orebro, Sweden, was asked what he would do if given policy authority over wireless health issues, he replied swiftly that he would "ban wireless use in schools and pre-school." Noting that there are wired alternatives, Professor Hardell flatly stated: "You don't need Wi-Fi."[60] And yet the FCC, prodded by an industry ever on the lookout for incremental growth opportunities, is ignoring the health of youngsters to promote expanded Wi-Fi subsidies in schools across the U.S.

And what about the merit of the program itself? Overlooking the fraud and lobbying and Wi-Fi safety issues for a moment, shouldn't schools and libraries across the country be equipped with the best electronic gear, accessing the Internet at the fastest speeds? Doesn't the government owe that to its younger citizens, especially those disadvantaged by the long-referenced digital divide?

Well, maybe. But answers to these questions hinge on even more fundamental question: Do students actually learn more or better with access to the latest high-speed electronic gadgetry?

It would be foolish to argue that nobody benefits from access to high-speed Internet. But the benefits are nowhere near as broad or rich as corporate beneficiaries claim. Some researchers, for example, have concluded that computers don't seem to have positive educational impact—they may even have negative impact—when introduced into the home or freely distributed to kids from low income backgrounds.

Duke University researchers Jacob Vigdor and Helen Ladd studied the introduction of computers into North Carolina homes. They found that the academic performance of youngsters given computers actually declined. *"The introduction of home computer technology is associated with modest but statistically significant and persistent negative impacts on student math and reading test scores,"* the authors wrote in a National Bureau of Economic Research Working Paper.[61] The impact was actually most negative on the poorer students.

A study in the Journal of International Affairs examined the impact of the global One Laptop Per Child Program (OLPC), which has distributed millions of computers to children around the world. Researchers Mark Warschauer and Morgan Ames conclude: *"The analysis reveals that provision of individual laptops is a utopian vision for the children in the poorest countries, whose educational and social futures could be more effectively improved if the same investments were instead made on more proven and sustainable interventions. Middle- and high-income countries may have a stronger rationale for providing individual laptops to children, but will still want to eschew OLPC's technocratic vision. In summary, OLPC represents the latest in a long line of technologically utopian schemes that have unsuccessfully attempted to solve complex social problems with overly simplistic solutions*."[62]

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Can One Laptop Per Child Save the World's Poor?

"…In summary, One Laptop Per Child represents the latest in a long line of technologically utopian development schemes that have unsuccessfully attempted to solve complex social problems with overly simplistic solutions."

Access to computers in the home may not work educational magic. But what about computers in the classroom? Don't they have educational value there?

The anecdotal evidence is mixed at best. Consider how students in Los Angeles, newly equipped with flashy iPads at a mind-boggling taxpayer cost of more than $1 billion, went about using the new tools to improve their educational performance. "Instead of solving math problems or doing English homework, as administrators envisioned, more than 300 Los Angeles Unified School District students promptly cracked the security setting and started tweeting, posting to Facebook and playing video games."[63]

But let's cut through the self-serving corporate claims and the troubling anecdotes to hear from someone who actually has had extensive and unique field experience. Kentaro Toyama was co-founder of Microsoft's research lab in India. Over more than five years he oversaw at least a dozen projects that sought to address educational problems with the introduction of computer technology. His conclusion: "The value of technology has been over-hyped and over-sold."

The most important factor in improving schools, says Toyama, now the W.K Kellogg Associate Professor of Community Information at the University of Michigan, is good teachers. Without good, well-trained teachers, adequate budgets and solid school administration, technology does little good. "Technology by itself never has any kind of positive impact," he said.[64]

The only schools in his experience that benefited from increased technology investment were those where "the teachers were very good, the budgets adequate." The richer schools, in essence. But as both Vigdor and Warschauer found, the introduction of technology has by itself little if any positive effect. For a public conditioned to believe in the virtues of new technology, such testimony is a bracing dose of cold reality.

But what about cost? Doesn't technology in the schools more efficiently replace alternative investments? Cost reductions are often the most persuasive argument for technology, Toyama agrees. But even these have been overstated. The costs of introducing new technology run far beyond initial hardware and software investments, said Toyama. In reality, the total costs of ownership—including maintenance, training, and repair—typically run to five or ten times the initial cost, according to Toyama. He said of the investment in technology for cost benefits: "I would say that in the long run—and even in the medium run and the short-run—that's probably the worst and most misguided conclusion to come to."[65]

He adds: "The inescapable conclusion is that significant investments in computers, mobile phones and other electronic gadgets in education are neither necessary nor warranted for most school systems. In particular, the attempt to use technology to fix underperforming class rooms . . . is futile. And for all but wealthy, well-run schools, one-to-one computer programs cannot be recommended in good conscience."[66]

But that doesn't keep industry lobbyists from recommending them. And it hasn't kept the FCC for spending scores of billions subsidizing technology to the very groups least likely to benefit from it.

Unmoved by the arguments of researchers and educators like Vigdor, Warschauer, and Toyama, the FCC keeps moving to increase technology subsidies. Ignoring research that disputes the value of technology in closing the so-called "digital divide," the FCC has even pioneered a new slogan: "the Wi-Fi gap."

In announcing that it was lifting E-Rate's annual budget from $2.4 billion to $3.9 billion and stepping up investment in wireless networking, FCC chairman Wheeler exulted that "10 million students are going to experience new and better opportunities."[67] The impact on consumer pocketbooks (and potentially on youngsters' health from daily Wi-Fi exposure) were not mentioned.

The two Republican members of the FCC did at least recognize the pocketbook impact. "It always seems easier for some people to take more money from the American people via higher taxes and fees rather than do the hard work," said Commissioner Michael O'Reilly.[68]

The subsidized provision of high-speed Internet service is yet another pet project of the FCC. Julius Genachowski, chairman from 2009 to 2013, championed the transition of the USF from landline phone service to broadband. Universal broadband Internet connections would begin to absorb the monies collected from consumers to extend basic phone service.

As with government subsidies for cell phone service, classroom technology, and Wi-Fi, there are basic questions about the wisdom of subsidizing broadband. Charles Davidson and Michael Santorelli of the New York Law School found that spending billions to extend broadband is a flawed approach since there are many largely ignored reasons people choose not to adopt broadband. “Everybody is pushing broadband non-stop,” noted Davidson, director of the Law School’s Advanced Communications Law and Policy Institute. “I think the FCC is focused on the wrong set of issues,” he said.[69]

Already, he explained, over 98% of Americans have access to wired or wireless broadband. The issue is not one of supply. It’s one of demand. Many people—for a variety of reasons—don’t really care about broadband, he contends. Price is one issue. Also powerful factors—but given almost no attention—are privacy and security concerns. “In our view, they should be focused on barriers to meaningful broadband utilization: privacy and security,” said Davidson.[70]

But consumer privacy (more on this subject in Chapter Seven) has no well-funded lobby with limitless access to the FCC.

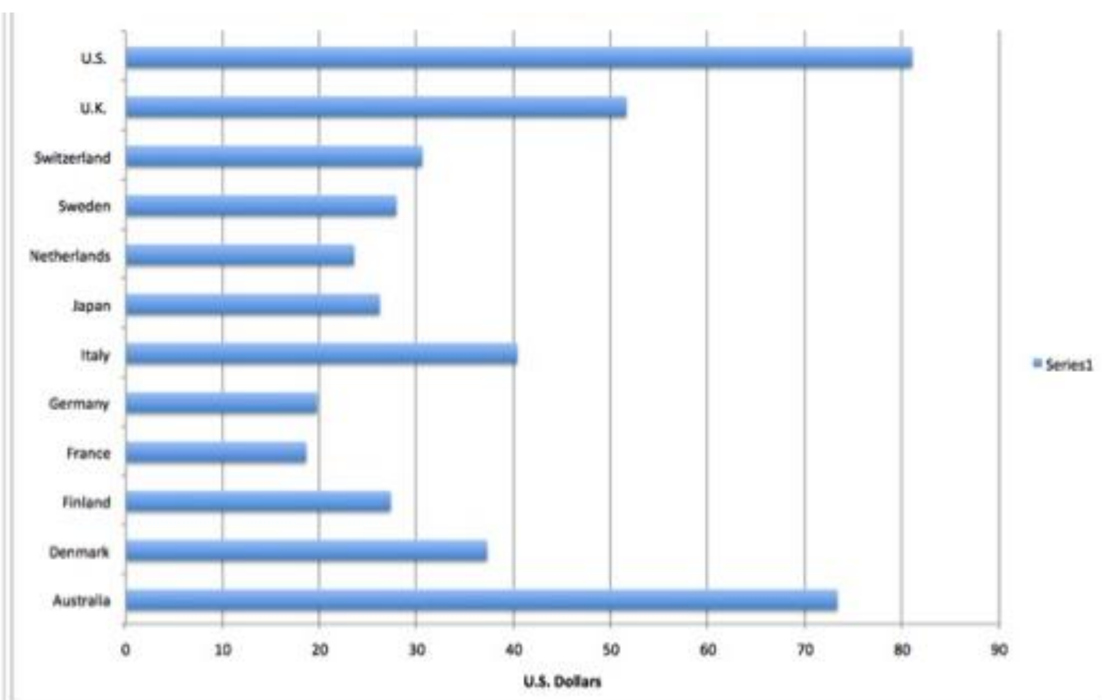
Chapter Six: The Cable Connection

The network has also been active in diluting FCC control of the cable television industry. Over the years, cable has devolved into major de facto local monopolies. Comcast and Time Warner Cable, whose merger proposal was dropped in April, are dominant forces in both cable television and broadband Internet subscriptions. Somehow, though, they have managed to steer clear of one another in specific markets, giving each pricing power where it faces little local competition.

It's interesting that cable companies annually rank in consumer polls among the "most hated" or "most disliked" American corporations. Indeed, Comcast and Time Warner Cable often top the "most hated" list.[71] Why would these companies—providers of the TV programming that has so expanded consumer options in recent decades—be so widely scorned? After all, the U.S. has been a leader in developing both cable technology and diverse television programming.

The problem is that it hasn't been anything close to a leader in bringing down subscriber prices. Industry consultants typically measure pricing by the metric of average revenue per subscriber. Industry trackers at IHS compared the price of U.S. pay television (which includes satellite services) to those in more than 60 other countries. U.S. prices were the highest, with only Australia even coming close. The average revenue per subscriber in the U.S. in 2013 was $81. But in France it was just $18.55. In Germany it was $19.68. In Japan it was just over $26.

Pay TV Monthly Revenue Per Person:



And U.S. cable prices have risen in recent years at rates three or more times the rate of inflation. This has been going on for some time. From 1995 to 2013 cable rates increased at a 6.1% annual clip. The Consumer Price Index, by contrast, rose by just 2.4% annually. Former FCC commissioner Michael Copps says the FCC shares a major part of the blame. “The FCC is as culpable for allowing that as much as the companies for imposing it,” he said.[72]

One area where the FCC has contributed to the problem is in its traditional rubber-stamping of merger agreements. The proposed Comcast/Time Warner Cable deal has been shelved, largely because of Justice Department reservations. But a long run of earlier FCC-sanctioned deals allowed Comcast and Time Warner Cable to grow to the market dominance—and attendant pricing power—they currently command.

Lofty monthly cable bills pinch consumers. But it’s more than that. Subscribers paying $80 a month are often paying for a lot of channels they don’t watch and don’t want. The FCC has never required cable operators to charge for what consumers actually want to watch. Kevin Martin, who chaired the FCC from 2005 to 2009, pushed to “debundle” programming in hopes of lowering bills. But the issue was never resolved. Only recently have viable competitive alternatives to cable’s “bundled” packages become available. The satellite service Dish, for example, months ago introduced its Sling offering that enables consumers to opt for smaller and cheaper packages.

In fairness to cable operators, it should be pointed that programmers often require operators to take unwanted or fledgling channels along with their stars. New York cable operator Cablevision Systems filed suit against Viacom in 2013, charging that in order to get popular channels like MTV and Nickelodeon it was also forced to take low-rated channels like Nicktoons and VH1 Soul. But the simple truth is that no matter who is to blame, the cable consumer pays high prices, typically for some programming he doesn’t want. As it often does when powerful interests pursue dubious practices, the FCC has for the most part idly stood by.

Still, the FCC isn’t entirely to blame. Some factors in the growth of the cable giants cannot be laid at its doorstep. Local municipalities often granted monopoly or duopoly status in granting franchises to cable network builders. With the huge capital investments required to cable metropolitan areas, this once seemed to make sense.

And over the years, the cable giants have used a variety of tactics to weaken what little local competition they may have had. Active lobbyists on the local level, the cable giants have managed to convince a growing number of states to outlaw municipal systems that could threaten private corporate incumbents. The FCC for many years declined to tangle with the states in this matter, partly due to the opposition of Republican commissioners. But the Wheeler-led Commission did vote recently to override state laws that limit the build-out of municipal cable systems.

Still, many years of industry subservience will be difficult to swiftly undo. One linchpin merger shows how FCC decision-making has been thoroughly undermined by the revolving door, lobbying, and carefully targeted campaign contributions. All conspired in Comcast's pivotal 2011 buyout of NBC Universal, a deal which reinforced Comcast's domination of both cable and broadband access. This deal also set the stage for the recent headline-grabbing acrimony over the issue of net neutrality.

In 2011, mighty Comcast proposed to acquire NBC Universal. A series of mergers including the 1986 acquisition of Group W assets and the 2002 acquisition of AT&T's cable assets had already vaulted Comcast into cable market leadership. In bidding for NBC Universal, a huge step towards vertical integration, Comcast was once again raising the stakes. NBC Universal would give Comcast a treasure trove of programming, including valued sports content like NFL football and the Olympics.

Suddenly, the issue was not just cable subscriber base size—where Comcast had already bought its way to dominance. NBC Universal would also allow Comcast to consolidate its growing power as a broadband Internet provider. And with NBC Universal's programming assets, Comcast would gain new leverage when negotiating prices to carry the competing programming content of rivals. This would prompt a new round of debate over net neutrality. Couldn't a programming-rich Comcast slow down rival services—or charge them more to carry their programming?

To short-circuit any potential opposition to the merger, Comcast assembled a superstar cast of lobbyists. As Susan Crawford reports in her 2013 book, "Comcast hired almost eighty former government employees to help lobby for approval of the merger, including several former chiefs of staff for key legislators on congressional antitrust committees, former FCC staffers and Antitrust Division lawyers, and at least four former members of Congress.[73] Such "profligate hiring," Crawford observes, pretty much silenced the opposition to the deal. If Comcast had already retained one member of a lobbying firm, the firm could not under conflict of interest rules object to the deal. And Comcast had locked up key lobbying shops. Money was both weapon and silencer.

Of course, Comcast had always been a big spender on lobbying, with outlays exceeding $12 million every year since 2008. Lobbying costs peaked in 2011 at $19.6 million, according to the Center for Responsive Politics.

For its part, the FCC had a long history of approving most media mergers. So it was hardly a great surprise when the agency, after exacting some relatively minor concessions from Comcast, rubber-stamped the deal. Comcast would thus broaden its footprint as local monopoly distributor of cable. And with its new programming assets, it would enhance its leverage in negotiating deals to carry its rivals' programming. It would also fortify its position of growing strength as broadband Internet gatekeeper.

The most telling footnote to the deal would come just four months later. FCC Commissioner Meredith Atwell Baker, who voted to approve the merger in January 2011, left the FCC to become a top-tier Comcast lobbyist in May. It was the ultimate—and perhaps most telling—glide of the revolving door.

Baker's was a high-profile defection. But it was neither the first nor the last. Comcast had successfully convinced other FCC officials to take their expertise and government contacts to the cable giant. Comcast has long been a master at spinning the revolving door to its own advantage. "Comcast has been very good at hiring everyone who is very smart," said Crawford.[74]

Approval of the NBC Universal deal was another in the long string of FCC merger approvals that made Comcast a nationwide monopolist that could dictate both pricing and viewer programming choice.

But the deal may have had another unintended consequence. It set the stage for Comcast's subsequent battles on net neutrality. "Those mergers gave additional oomph to the issue of net neutrality," noted former commissioner Copps. Speaking specifically of Comcast's buyout of NBC Universal, IHS senior analyst Eric Brannon agreed. "That merger laid the grounds for net neutrality."

In allowing Comcast to acquire major programming assets, the deal would sharpen questions about the power of gatekeepers like Comcast to control the flow of traffic from rival Web services. So in bowing to lobbyist pressure, the FCC would bring on itself a whole new set of pressures by focusing public attention on the issue of net neutrality.

With activists rounding up comments from the public and hip TV personalities like HBO's John Oliver also beating the drums, net neutrality quickly grew into a popular issue that won the support of President Obama, and by proxy, his hand-picked appointee Tom Wheeler. When the FCC ruled in February of 2015 that it would seek Title II authority to regulate the Internet and presumably block any favoritism by broadband gatekeepers, it seemed to finally cast its lot with the public against steamrolling corporate interests

The issue had simmered for years but reached full boil when movie purveyor Netflix, which had argued that its service was slowed down by Comcast, signed a side deal ensuring better download speeds for its wares. This triggered an outburst of public concern that Comcast was now in position to operate "fast" and "slow" lanes, depending on whether a rival programmer could afford to ensure that Comcast provide adequate download speed.

With nearly 4 million comments—many supplied or encouraged by public interest groups—filed to the FCC, net neutrality was a bankable political issue. And there's no question, net neutrality attracted public interest because it gave cable viewers—long furious at the treatment by the monopolists who send them monthly bills—issues of both viewing pleasure and economics.

But it also fed into the longstanding sentimental but increasingly unrealistic view of the Internet as the last bastion of intellectual freedom. Internet romanticists have long seen the Web as a place that somehow deserves special rules for breaking the stranglehold of traditional media and offering exciting new communications, information retrieval and shopping efficiencies.

Yes, the Internet is a modern marvel. This is beyond dispute. But some of the favors it has won from government over the years have had unfortunate unintended consequences.

In the 1990s, for example, net access providers were repeatedly exempted as an “infant industry” from paying access charges to the Baby Bells even though they had to connect users through local phone networks. The long distance companies were then paying as much as $30 billion a year for the privilege. But the Internet was exempted.

As the late 90s approached, the Internet was no longer an infant industry. Still, the exemption from access charges was extended. That exemption essentially allowed AOL in the late 90s to offer unlimited unmetered online time, a key factor in boosting usage and siphoning advertisers from print media. Why buy an ad in print that might get viewed with the transitory flip of a page when you can get round-the-clock attention online?[75] FCC decisions to grant the Internet access-charge exemptions arguably accelerated the decline of print media and much of the quality journalism print advertising could once support.

Meanwhile, retailers on the Internet were making inroads into brick and mortar retail business with the help of a Supreme Court-sanctioned exemption from collecting sales tax.[76] This judicial coddling of the Internet was the death knell for many smaller mom and pop local businesses, already challenged to match online pricing. And that’s not all. The special favors continue virtually every year, as Congress proposes and/or passes legislation to extend special tax exemptions to Internet services.

Well, maybe tax breaks aren’t such a bad idea for such an innovative and transformational emerging technology. For all its faults, the Internet—gateway to all goods, repository of all things, wizardly guide to all knowledge, enabler of universal self-expression—is undeniably cool.

But let’s not deny that the combination of tax advantages and deregulation was toxic. Allow an industry to emerge with advantages over useful existing industries that largely play by the rules—well, maybe that can be rationalized. But then fail to hold the upstart industry to the same rules, allowing it more leeway to trample fundamental rights because it has the technical capacity to do so. Well, then you have a cruel Faustian bargain.

With the see-no-evil deregulatory gospel loosing all constraints, the Web would devolve into a playground for corporate snoops and criminals. For all its wonders, the Internet comes at a cost: the loss of control over personal data, the surrender of personal privacy, sometimes even the confiscation of identity.

Perhaps the most favorable consequence of net neutrality—and one that has gotten surprisingly little attention—is that it could set the stage for privacy reform. (More on this in Chapter Seven). The FCC can now choose to exercise its Title II powers to enforce privacy standards over broadband Internet. Privacy is one area where the FCC has done a pretty good job in the past.

Worth remembering, though, is that the hard-fought public victory over Net Neutrality may be transitory. AT&T and others have threatened to go to court to upend the FCC rules. And there's a fair chance a Republican Congress will legislate against Title II.

Meanwhile, though, one supreme irony has begun to unfold in the marketplace.

Modern-day laissez fair ideologues love to invoke the wisdom of markets as represented by the "mysterious hand" of Adam Smith. Unfortunately, in the absence of effective regulation, the putatively wise "mysterious hand" generally seems to work its magic for those with huge financial resources and the political access it buys.

In the current cable situation, however, the mysterious hand may actually be working in consumer-friendly ways. Years of regulation that favored the cable companies have now backfired as the market reacts to monopolistic pricing and content control.

Whereas cable giants have commanded premium monthly subscriber prices to deliver packages of largely unwatched channels, the market is now beginning to burst with new "debundled" options that are whittling away at cable's vast subscriber base.

Satellite service Direct TV, as noted, now offers its streaming video Sling TV package of popular networks that includes live sports and news. Amazon, Apple, CBS, HBO, Netflix, Sony, and others offer a variety of streaming video options that allow viewers to cut the cable cord. Suddenly, consumers have the cherry-picking capability that bundled—and expensive—cable packages have never allowed.

In this case, at least, the unintended consequences of the FCC's pro-industry policies may be producing an unexpected pro-consumer twist.

Chapter Seven: What about Privacy?

Has any issue gotten as much lip service—and as little meaningful action?

For all the various congressional bills, corporate self-regulatory schemes and presidential Privacy Bill of Rights proposals, the simple truth remains that no personal information is safe on the Internet. Data brokers have built a multi-billion dollar business exchanging information used to build profiles of Net users. Your shopping and surfing habits, your health history, your banking data, your network of social ties, perhaps even your tax filings are all potentially exposed online. Both legal and criminal enterprises amass this information. And it doesn't go away.

At any given moment people you don't know somehow know where you are. They may very well know when you made your last bank deposit, when you had your last asthma attack or menstrual period. Corporations encourage and pay for every bit of information they can use or sell. Creepy? Perhaps, but as Jeff Chester, president of the Center for Digital Democracy points out: "The basic business model that drives online is advertising."[77]

The FCC largely escapes blame on this one. It is the Federal Trade Commission that has had primary responsibility for protecting Internet privacy. The FCC does have some limited authority, which, some critics say, could have been exercised more vigorously. But for the most part the FCC is not to blame for the rampant online abuse of personal privacy and identity.

The FCC does however have privacy authority over the phone, cable and satellite industries. Until recently, at least, the FCC has kept privacy issues at bay among the companies in these industries. "The FCC has generally taken privacy very seriously," noted Harold Feld, a senior vice president at the non-profit Public Knowledge.[78]

But dynamics now in place suggest that privacy may be the next great testing ground for the FCC. A new chance, perhaps, to champion public interest. Even before the opportunity for privacy enforcement under Title II regulatory powers, the FCC faces new challenges from phone companies, now itching to monetize their vast consumer data stashes the way Net companies have. The commonly used term is "Google envy."

"Until now, ISPs (Internet Service Providers) have mostly not gotten into hot water on privacy—but that's changing," observed Jonathan Mayer, a fellow at the Center for Internet and Society.[79] Verizon and AT&T, major providers of mobile Internet access, have each introduced "super cookies" that track consumer behavior even if they try to delete older, less powerful, forms of cookies. AT&T is actually charging its customers an extra $30 a month *not* to be tracked.

Showdowns loom.

In adopting Title II to enforce net neutrality, the FCC has made broadband Internet access a telecom service subject to regulation as a "common carrier." This reclassification means that the FCC could choose to invoke privacy authority under Title II's Section 222. That section, previously applied to phone and cable companies, mandates the protection of consumer information. Such information—called CPNI for Customer Proprietary Network Information—has kept phone companies from selling data on whom you call, from where you call and how long you spend on the phone. Consumers may have taken such protection for granted on their phone calls. But they have no such protection on their Internet activity—which, as noted, has been a multi-billion dollar safe house hideaway for corporate and criminal abusers of personal privacy.

Now, though, the FCC could put broadband Internet communications under Section 222 protection. To Scott Cleland, a telecom industry consultant who has often been ahead of the analytic pack, this would be a momentous decision.

When the smoke clears—and it hasn't yet—the FCC could make consumer identifiers like IP addresses the equivalent of phone numbers. Suddenly, the Internet companies that have trafficked in all that personal data would be subject to the same controls as the phone and cable companies.

Cleland argues that the risk for privacy abuses extends beyond broadband access providers like Comcast and Verizon to Internet giants like Google and Facebook that have until now flourished with all that personal data. "They are at risk and they are going to live under the uncertainty their business model could be ruled illegal by the FCC," Cleland said.[80]

Much has been written about the legal challenges broadband access providers intend to mount against the FCC's new rules. But Cleland argues that a very different type of legal action could engulf companies that have benefited from the use and sale of private data. Trial lawyers, he argues, will see opportunity in rounding up massive class action suits of Internet users whose privacy has been violated. What sorts of privacy abusers face legal action? Anyone who has "collected CPNI via some type of cookie," according to Cleland.

"Right now, edge providers like Google, Facebook and Twitter are at risk of being sued by trial lawyers," he said.[81]

Sounds great for consumers who care about privacy on the Internet and how it has been abused. But the FCC, Cleland was reminded, has never been a consumer advocate. "Bingo," replied Cleland. That's what makes the FCC's potential move into privacy protection so important and so surprising, he suggests.

There are other signs that the FCC under Tom Wheeler might actually become more consumer-friendly on the issue of data privacy. While Wheeler has brought some former associates from lobbying groups to the FCC, he has also peppered his staff with respected privacy advocates. Indeed, he named Gigi Sohn, longtime president of the non-profit Public Knowledge, as Counsellor to the Chairman in April.

Another appointee with a privacy background is Travis LeBlanc, head of the FCC's Enforcement Bureau. In previous employment in California's Office of the Attorney General, LeBlanc was active in enforcing online privacy. LeBlanc has stated an interest in privacy and has already taken action against two firms that exposed personal information—including social security numbers—on unprotected Internet servers.

But many aspects of LeBlanc's approach to regulating Internet privacy under Title II remain unclear. Unfortunately, the FCC declined repeated requests to make LeBlanc available for an interview. (It also declined to answer written questions on its enforcement intentions in both privacy and cell tower infrastructure emissions.)

It remains to be seen if LeBlanc and his superiors at the FCC are really willing to take on privacy enforcement. Such a stance would require great courage as the entire Internet infrastructure is built around privacy abuse. It is also questionable whether the FCC would have the courage to challenge Google—a rare corporate ally in the battles over Net Neutrality.

Chapter Eight: Dependencies Power the Network of Corruption

As a captured agency, the FCC is a prime example of institutional corruption. Officials in such institutions do not need to receive envelopes bulging with cash. But even their most well-intentioned efforts are often overwhelmed by a system that favors powerful private influences, typically at the expense of public interest.

Where there is institutional corruption, there are often underlying dependencies that undermine the autonomy and integrity of that institution. Such is the case with the FCC and its broader network of institutional corruption.

As noted earlier, the FCC is a single node on a corrupt network that embraces Congress, congressional oversight committees and Washington social life. The network ties the public sector to the private through a frictionless revolving door—really no door at all.

Temptation is everywhere in Washington, where moneyed lobbyists and industry representatives throw the best parties and dinners. Money also allows industry to control other important factors, like the research agenda. All of this works together to industry's advantage because—as with other instances of institutional corruption—there are compromising dependencies. Policy makers, political candidates and legislators, as well as scientific researchers are all compromised by their dependence on industry money.

Dependency #1 – So much of the trouble here comes back to the core issue of campaign finance. Cable, cellular and educational tech interests know where to target their funds for maximum policy impact. And the contributions work, seemingly buying the silence of key committee congressmen—even those with past records as progressives. Key recipients of industry dollars include Massachusetts Senator Ed Markey and, until he retired, California Democrat Henry Waxman. Though they have intermittently raised their voices on such issues as data privacy and cellular health and safety, neither has shown any great inclination to follow through and take up what would have to be a long and tough fight on these issues.

Dependency #2 – Democrats might be expected to challenge industry now and then. They traditionally have done so, after all. But this is the post-*Citizens United* era where the Supreme Court has turned government into a giant auction house.

Bid the highest price and you walk home with the prize—your personal congressman, legislative loophole, even an entire political party.

Such is the case with technology industries and the Democrats. The communications/electronics industry is the third largest industry group in both lobbying and campaign contributions, according to the Center for Responsive Politics. In just 2013 and 2014, this industry sector spent well over $750 million on lobbying.[82]

Only the finance/insurance/real estate and health industries outspend the tech sector on lobbying. But those industry groups lean Republican. Over 62% of the finance/insurance/real estate campaign contributions go to the GOP. Health contributions lean Republican 57% to 43%. But the technology group leans sharply to Democrats, who got 60% of contributions in the 2013-2014 election cycle.[83] The two next largest industry groups—energy/natural resources and agribusiness—also lean heavily Republican. So of the top five industry groups whose money fuels and often tilts elections four are strongly Republican. The Democrats need the tech industry—and they show that dependence with consistent support, rarely raising such public interest issues as wireless health and safety and Internet privacy.

Dependency #3 – Spectrum auctions give the wireless industry a money-making aura. In recent Congressional testimony, an FCC official reminded legislators that the FCC has over the years been a budget-balancing revenue-making force.[84] Indeed, the auctions of electromagnetic spectrum, used by all wireless communications companies to send their signals, have yielded nearly $100 billion in recent years. The most recent auction to wireless providers produced the unexpectedly high total of $43 billion. No matter that the sale of spectrum is contributing to a pea soup of electromagnetic "smog" whose health consequences are largely unknown. The government needs money and Congress shows its appreciation with consistently pro-wireless policies.

Dependency #4 – Science is often the catalyst for meaningful regulation. But what happens when scientists are dependent on industry for research funding? Under pressure from budget cutters and deregulators, government funding for research on RF health effects has dried up. The EPA, which once had 35 investigators in the area, has long since abandoned its efforts.[85] Numerous scientists have told me there's simply no independent research funding in the U.S. They are left with a simple choice: work on industry-sponsored research or abandon the field.

Chapter Nine: A Modest Agenda for the FCC

Nobody is proposing that cell phones be banned. Nor does anyone propose the elimination of the Universal Service program or other radical reforms. But there are some steps—and most are modest—that the FCC can take now to right some of the wrongs that result from long years of inordinate industry access and influence:

1. Acknowledge that there may be health risks in wireless communications. Take down the dismissive language. Maturely and independently discuss the research and ongoing debate on the safety of this technology.

2. In recognition of this scientific uncertainty, adopt a precautionary view on use of wireless technology. Require prominent point-of-sale notices suggesting that users who want to reduce health risks can adopt a variety of measures, including headphones, more limited usage and storage away from at-risk body parts.

3. Back off the promotion of Wi-Fi. As Professor Lennart Hardell has noted, there are wired alternatives that do not expose children to wireless risk.

4. Petition Congress for the budgetary additions needed to expand testing of emissions on antenna sites. It was Congress after all that gave industry carte blanche for tower expansion so long as they comply with FCC standards. But there is evidence of vast non-compliance and Congress needs to ensure that tower infrastructure is operating within the law.

5. Acknowledge that children and pregnant women may be more vulnerable to the effects of RF emissions and require special protection.

6. Promote cable debundling as a way to lighten consumer cable bills, especially for those customers who don't care about high-cost sports programming.

7. Apply more rigorous analysis to properly assess the value of technology in education. Evidence continues to pile up that technology in education is not as valuable as tech companies claim. Pay less attention to tech CEOs—pay more attention to the researchers who've actually studied the impact of trendy technology fixes on learning

8. Take over enforcement of personal privacy rights on the Internet. Of all the basic suggestions here, this would require the most courage as it would involve challenging many of the entrenched powers of the Internet.

Chapter Ten: Stray Thoughts

Some concluding thoughts:

Why do so many of the most dubious FCC policies involve technology?

In large part, of course, because the FCC has authority over communications and that is a sector that has been radically transformed—along with so many others—by technology.

Let's be clear, though. The problem is not technology, which unarguably brings countless benefits to modern life. The problem is with the over-extension of claims for technology's usefulness and the worshipful adulation of technology even where it has fearful consequences. Most fundamentally, the problem is the willingness in Washington—for reasons of both venality and naïveté—to give technology a free pass.

Personally, I don't believe that just because something can be done it should heedlessly be allowed. Murder, rape and Ponzi schemes are all doable—but subject to prohibition and regulation. Government regulators have the responsibility to examine the consequences of new technologies and act to at least contain some of the worst. Beyond legislators and regulators, public outrage and the courts can also play a role—but these can be muffled indefinitely by misinformation and bullying.

There are precedents for industries (belatedly perhaps) acting to offset the most onerous consequences of their products. In responding to a mix of litigation, public demand and regulatory requirement, the auto industry, for example, has in the last 50 years substantially improved the safety and environmental footprint of its products.

Padded instrument panels, seat belts, air bags, and crumple zones have all addressed safety issues. Environmental concerns have been addressed with tightened emissions and fuel consumption standards. The response to new safety challenges is ongoing. Before side air bags were widely deployed, sedan drivers side-swiped by much larger SUVs were at vastly disproportionate risk of death and dismemberment.[86] But the deployment of side air bags has "substantially" reduced the risk of collision deaths.[87] Overall, auto fatality rates per 100,000 persons have dropped by nearly 60% in the U.S. since 1966.[88] Today, automakers continue to work on advanced safety features like collision avoidance.

It can be argued that most of these safety improvements came decades after autos were in wide usage and only in response to outrage at Ralph Nader's 1965 revelations on the auto industry.[89] No matter the catalysts. The simple truth remains that the auto industry—and its regulators—have for the last half-century been addressing safety and environmental issues.

But with the overwhelming application of money and influence, information and communications technologies have almost totally escaped political scrutiny, regulatory control, and legal discipline.

Should the Internet have been allowed to develop into an ultra-efficient tool for lifting personal information that includes financial records, health histories and social security numbers? Should wireless communications be blindly promoted even as new clues keep suggesting there may be toxic effects? Should local zoning authorities and American citizens be stripped of the right to protect their own health? Should education be digitized and imposed just because technology companies want to develop a new market and lock in a younger customer base?

All these questions can perhaps be rolled up in one: do we all just play dead for the corporate lobbyists and spinners who promote the unexamined and unregulated application of their products?

Finally, a word about the structure of the FCC. With five commissioners—no more than three from the same party—the structure seems to make some kind of sense.

But in practice, it works out poorly. The identification of commissioners by party tends to bring out the worst in both Republicans and Democrats. Instead of examining issues with clear-sighted independence, the commissioners seem to retreat into the worst caricatures of their parties. The Republicans spout free market and deregulatory ideology that is most often a transparent cover for support of business interests. The Democrats seems satisfied if they can implement their pet spending programs—extension of broadband wireless to depressed urban and rural schools, cell phone subsidies for low income clients. The result is a Commission that fulminates about ideology and spends heavily to subsidize powerful interests.

Perhaps one solution would be to expand the Commission to seven by adding two public interest Commissioners. The public interest only rarely prevails at the FCC. So it would represent vast improvement if both Republican and Democrat commissioners had to vie for support of public interest representatives in order to forge a majority. The public interest, in other words, would sometimes carry the swing votes.

It's very hard to believe, though, that Congress would ever approve such a plan. It simply represents too much of a threat to the entrenched political power of the two parties. Why would they ever agree to a plan that dilutes that power?

It's also worth noting that the public interest is not always easy to define. Sometimes there are arguably conflicting definitions. Still, an FCC with public interest commissioners is an idea worth consideration. It would at least require party apologists to defend how they so consistently champion the moneyed interests that have purchased disproportionate access and power in Washington.

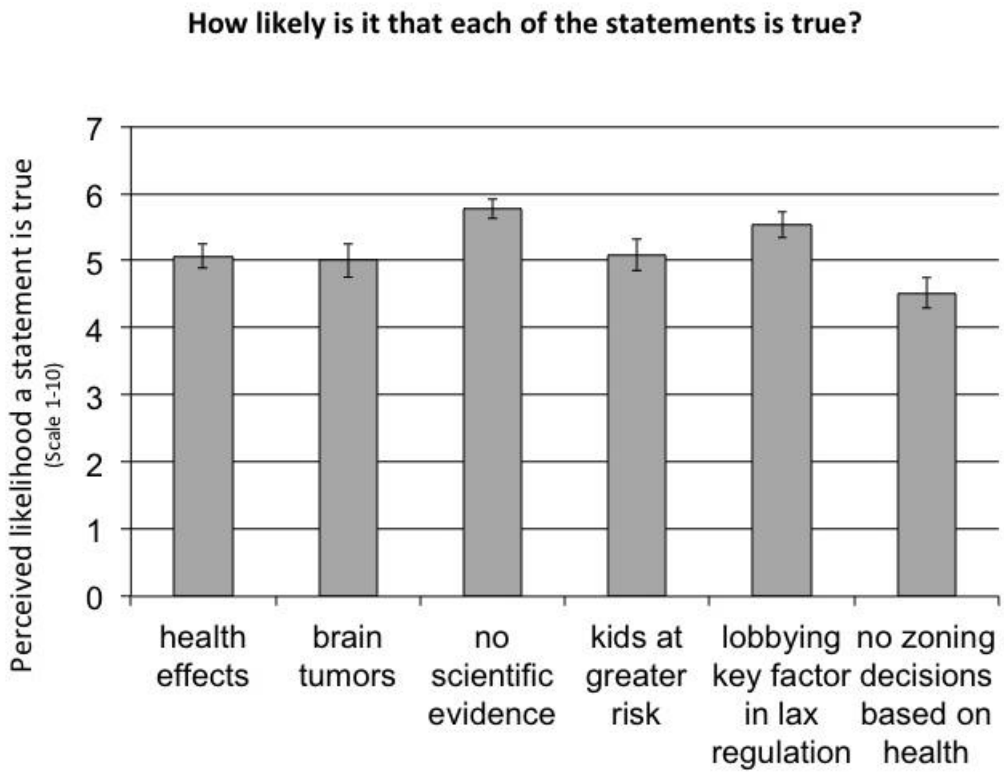
Appendix—Survey of Consumer Attitudes

What does the public believe about the science and politics of wireless health research? Under what conditions would people change wireless usage patterns? Is the FCC currently trusted to protect public health? How would confirmation of health risks affect trust in the FCC?

These are some of the questions Ann-Christin Posten[90] and Norm Alster[91] hoped to answer with an April 2015 online survey of 202 respondents. Participants were recruited through Amazon's Mechanical Turk online platform. All were U.S. residents and had achieved qualifying approval rates in prior Mechanical Turk surveys.

Participants were asked how likely they believed the following statements to be true:

> Statement 1. Prolonged and heavy cell phone use can have a variety of damaging effects on health.
>
> Statement 2. Prolonged and heavy cell phone use triples the risk of brain tumors.
>
> Statement 3. There is no scientific evidence that proves that wireless phone usage can lead to cancer or a variety of other problems.
>
> Statement 4. Children and pregnant women are especially vulnerable to radiation from wireless phones, cell towers and Wi-Fi
>
> Statement 5. Lobbying and campaign contributions have been key factors in keeping the government from acknowledging wireless hazards and adopting more stringent regulation.
>
> Statement 6. The U.S. Congress forbids local communities from considering health concerns when deciding whether to issue zoning permits for wireless antennae.

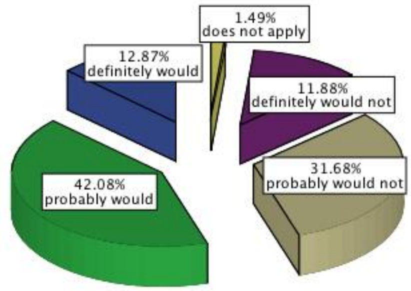


Two findings seem especially interesting:

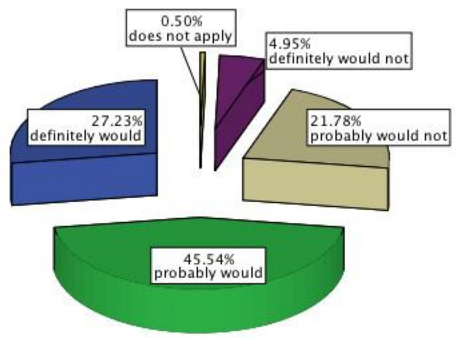
1. Statement 3 received a higher credibility rating than Statements 1 and 2. The different credibility levels are statistically significant. Respondents are more likely to trust in wireless safety than to believe there are general or specific health risks.

2. The only statement that is a matter of uncontested fact is Statement 6 on the outlawing of opposition to antenna sites on health grounds. (All other statements have been both proclaimed and denied.) And yet Statement 6 was least likely to be believed. Just 1.5% of respondents recognized this as an “absolutely true” statement. Over 14% thought this statement was “not true at all.” Answers to this question would seem to reflect public ignorance on the political background to wireless health issues.

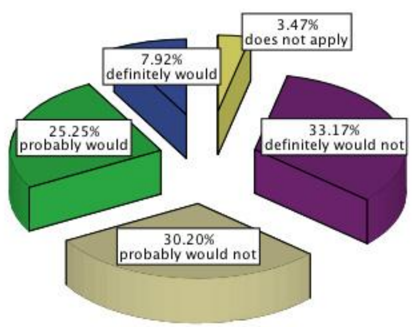
Participants were also asked how they would change behavior if claims of wireless health risks were established as true:



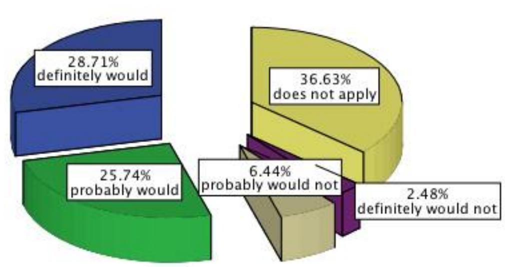
If statement 1 was true,
I would start using headphones.



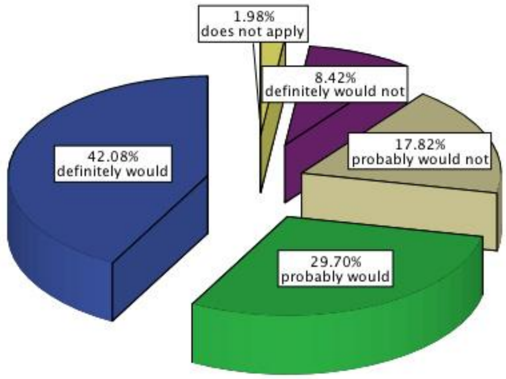
If statement 1 was true,
I would restrict the amount of time
I spend on the phone.



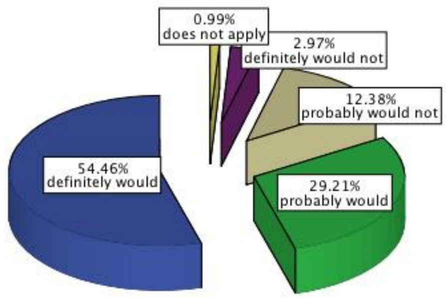
If statement 1 was true,
I would start up a new land line
account for home use.



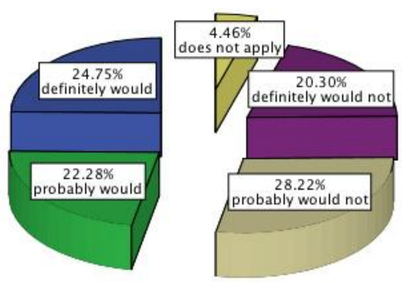
If statement 1 was true,
I would restrict my children's cell phone use.



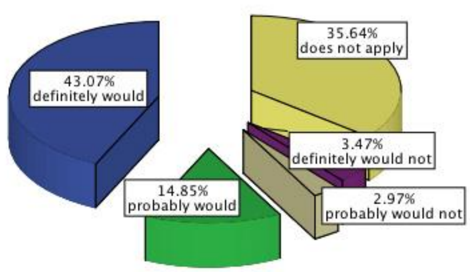
If statement 2 was true,
I would start using headphones.



If statement 2 was true,
I would restrict the amount of time
I spend on the phone.



If statement 2 was true,
I would start up a new land line
account for home use.



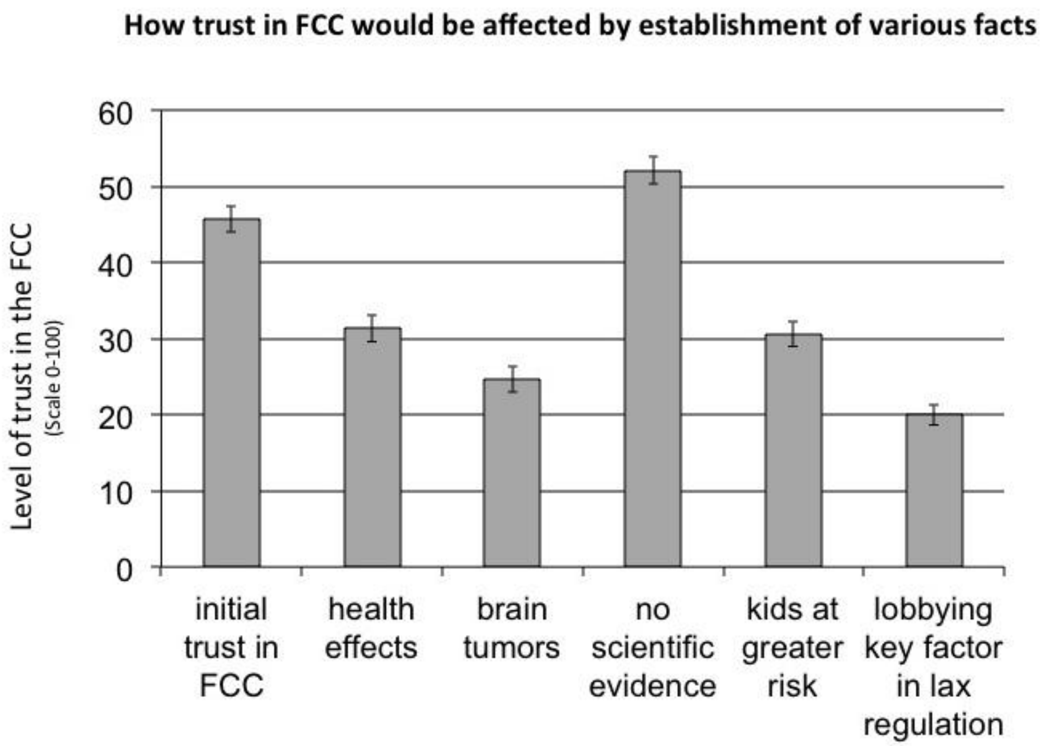
If statement 2 was true,
I would restrict my children's cell phone use.

The greatest impact on behavior came when respondents were asked to assume it is true that prolonged and heavy cell phone use triples the risk of brain tumors. More than half said they would “definitely” restrict the amount of time spent on the phone. Just over 43% would “definitely” restrict their children’s phone use. Perhaps most surprisingly, close to 25% would “definitely” start up a new landline phone account. (This last response suggests it may be foolishly premature for the phone giants to exit the landline business just yet.)

The inclination of consumers to change behavior should negative health effects be confirmed suggests the stakes are enormous for all companies that derive revenue from wireless usage.

This survey points to—but cannot answer—some critical questions: Do wireless companies better protect themselves legally by continuing to deny the validity of all troublesome research? Or should they instead be positioning themselves to maintain consumer trust? Perhaps there is greater financial wisdom in listening to the lawyers right now and denying all chance of harm. If so, however, why would anyone seriously concerned about health listen to the industry—or to its captured agency? That’s a question the FCC will eventually need to answer.

Trust could eventually become a central issue. Respondents were initially asked to describe their level of trust in the wireless industry and in the FCC as its regulator. Not surprisingly, establishment of any of the presumed health risks—or confirmation of inordinate industry pressure—resulted in statistically significant diminution of trust in both the industry and the FCC.



On a scale of 1 to 100, the FCC had a mean baseline trust level of 45.66. But if the tripling of brain tumor risk is established as definitely true, that number falls all the way to 24.68. If "lobbying and campaign contributions" have been "key factors" in keeping the government from acknowledging wireless hazards, the trust level in the FCC plummets to 20.02. All results were statistically significant.

It's clear that at this point confirmation of health dangers—or even of behind-the-scenes political pressures—from wireless will substantially diminish public trust in the FCC. Skeptics might argue that this gives the FCC motive to continue to downplay and dismiss further evidence of biological and human health effects. Those of a more optimistic bent might see in these findings reason to encourage an FCC concerned about public trust to shake itself loose from special interests.

Endnotes

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[10] B. Blake Levitt and Henry Lai, "Biological Effects from Exposure to Electromagnetic Radiation Emitted By Cell Tower Base Stations and Other Antenna Arrays," NRC Research Press Web site, November 5, 2010.

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[13] S. Sivani and D. Sudarsanam, "Impacts of Radio-Frequency Electromagnetic Field (RF_EMF) from Cell Phone Towers and Wireless Devices on Biosystem and Ecosystem – A Review," *Biology and Medicine* 4.4 (2013): 202.

[14] Id., 206-208.

[15] January 2015 interview with Robert Weller.

[16] Letter from Michelle C. Farquhar, Chief of the FCC's Wireless Telecommunications Bureau, to Thomas Wheeler, President and CEO of the Cellular Telecommunications Industry Association, January 13, 1997.

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[20] January 2015 interview with Marvin Wessel.

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[30] Medscape, "Brain Cancer CME Learning Center," http://www.medscape.org/resource/brain-cancer/cme.

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[32] Id.

[33] Federal Communications Commission, “Wireless Devices and Health Concerns,” http://www.fcc.gov/guides/wireless-devices-and-health-concerns.

[34] Lennart Hardell, Michael Carlberg, Fredrik Soderqvist, and Kjell Hansson Mild, “Case-Control Study of the Association between Malignant Brain Tumours Diagnosed between 2007 and 2009 and Mobile and Cordless Phone Use,” *International Journal of Oncology* 43.6 (2013): 1833-1845.

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[40] Id.

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[44] November 2014 interview with Joel Moskowitz.

[45] February 2015 interview with Carl Blackman.

[46] Id.

[47] Id.

[48] Lawrence Lessig, Roy L. Furman Professor of Law and Leadership at Harvard Law School, helped to draft the Right to Know ordinance and has offered pro bono legal representation to the city of Berkeley. Professor Lessig was director of the Lab at Harvard’s Safra Center for Ethics, from which the Project on Public Narrative was spun off in November of 2014.

[49] May 2015 interview with Berkeley City Attorney Zach Cowan

[50] December 2014 interview with Jerry Phillips.

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[53] Id.

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[65] Id.

[66] Id.

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[70] Id.

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[74] October 2014 interview with Susan Crawford.

[75] Norm Alster, "A Little Help from the Feds," *BusinessWeek,* January 24, 2000, 42.

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[77] February 2015 conversation with Jeff Chester**.**

[78] April 2015 interview with Harold Feld.

[79] March 2015 interview with Jonathan Mayer.

[80] April 2015 interview with Scott Cleland.

[81] Id.

[82] Center for Responsive Politics.

[83] Id.

[84] "Testimony of Jon Wilkins, Managing Director, Federal Communications Commission," Before the Committee on Energy and Commerce, Subcommittee on Communications and Technology, U.S. House of Representatives, March 4, 2015.

[85] Alster, "Cell Phones: We Need More Testing," 39.

[86] Danny Hakim and Norm Alster, "Lawsuits: This Year's Model," *New York Times,* May 30, 2004, http://www.nytimes.com/2004/05/30/business/lawsuits-this-year-s-model.html.

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[91] Investigative Journalism Fellow, Project on Public Narrative at Harvard Law School.

Scientific and Policy Developments in Radiofrequency Radiation

December 2019 through November 29, 2021

Selected Research Publications Showing Adverse Effects Since the FCC Issued its Determination December 2019 Not to Update its 1996 Standards for Evaluating Wireless Radiation from Cell Phones, Electronic Devices and Networks

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New Scientific and Policy Developments in Radiofrequency Radiation

A Sampling of Research Publications Showing Adverse Effects Since the FCC Issued its Determination Not to Update its 1996 Standards for Evaluating Wireless Radiation from Cell Phones, Electronic Devices and Networks

More than 75 new important scientific developments, expert reports and recommendations have been published since the FCC issued its determination to not initiate a rulemaking proceeding to update its regulatory limits for human exposure to wireless radiofrequency radiation (RFR) in December 2019.

This report showcases a small sampling of the last two years of scientific publications that have documented adverse effects of RFR exposure. Studies include impacts to wildlife and the environment, the unique vulnerability of children and the fetus, DNA damage, oxidative stress, nervous and reproductive system impacts and brain development. New experimental and epidemiological evidence for cancer tied to RFR has been published as well as papers detailing how cancers can arise from non-ionizing radiation.

Further, recent publications have documented significant health and environmental implications arising from 5G network related millimeter wave frequencies and all current and new wireless air interfaces' use of modulation, pulsation and other waveform manipulation. Wireless telecommunications signals are complex and FCC regulations do not address the biological impact of different modulations nor consider the numerous unique characteristics of real world telecommunication signals. We highlight how new landmark papers document the science indicating the urgent need to consider modulation and pulsation, rather than simply power density.

The evidence is now clear that RF emissions within the Commission's guidelines have significant negative adverse biological effects.

WILDLIFE/ENVIRONMENT

The FCC's current FCC radiofrequency radiation (RFR) emissions limits apply to human exposures.They do not address wildlife, plants or trees. Birds perch and nest on cell towers. Bats and bees and other airborne species occupy air space in close proximity to transmitting cell antennas. Wireless network densification increases RFR levels (El-Hajj & Naous, 2020) and with over 800,000 new cell sites projected[1] for the 5G buildout, environmental effects need to be properly examined because ambient RFR is increasing in wildlife habitat.

A landmark three-part research review on effects to wildlife was published in R*eviews on Environmental Health in 2021* by U.S experts, including former U.S. Fish and Wildlife senior biologist Albert Manville. The authors reviewed and cited more than 1,200 scientific references. These experts concluded that the evidence was adequate to trigger urgent regulatory action. The review found adverse biological effects to wildlife from even very low intensity non-ionizing

[1] Remarks of FCC Chairman Ajit Pai White House 5G Summit Washington DC, September 28, 2018

radiation emissions at multiple orders of magnitude below current FCC-allowed levels (Levitt et al., 2021a, Levitt et al., 2021b, Levitt et al., 2021c).

Comprehensive documentation of the biological effects of non-ionizing electromagnetic radiation to flora and fauna has never before been undertaken to this degree in any previous publication. These three experts divide their science and findings with urgent warnings into three parts: **Part 1** identifies ambient EMF adverse effects on wildlife, and notes a particular urgency regarding millimeter wave emissions and the pulsation/modulation used in 5G technologies. **Part 2** explores natural and man-made fields, animal magnetoreception mechanisms, and pertinent studies to all wildlife kingdoms. **Part 3** examines current exposure standards, applicable laws, and future directions. Their conclusions after this expansive review of the science are neither equivocal nor speculative. This environmental research review is a clarion call to develop regulations that ensure wildlife and its habitat are protected. The abstract summarizes the findings:

> “Numerous studies across all frequencies and *taxa* indicate that low-level EMF exposures have numerous adverse effects, including on orientation, migration, food finding, reproduction, mating, nest and den building, territorial maintenance, defense, vitality, longevity, and survivorship. Cyto-toxic and geno-toxic effects have long been observed. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as ‘habitat’ so EMF can be regulated like other pollutants. Wildlife loss is often unseen and undocumented until tipping points are reached. A robust dialog regarding technology’s high-impact role in the nascent field of electroecology needs to commence. Long-term chronic low-level EMF exposure standards should be set accordingly for wildlife, including, but not limited to, the redesign of wireless devices, as well as infrastructure, in order to reduce the rising ambient levels.”

Numerous individual studies on impacts to flora and fauna have been published over the last two years, notably several on pollinators and insects.

Two studies used scientific simulations to quantify the amount of power absorbed into the bodies of various insects for different RFR frequencies. In January 2020 researchers published “Radio-frequency electromagnetic field exposure of Western Honey Bees” in *Scientific Reports* on the absorption of RFR into honey bees at different developmental stages with phantoms simulating worker bees, a drone, a larva, and a queen (Thielens et al., 2020). The simulations were combined with measurements of environmental RF-EMF exposure near beehives in Belgium in order to estimate realistic exposures. They found absorbed RF-EMF power increases by factors of up to 16 to 121 when the frequency is increased from 0.6 GHz to 6 GHz for a fixed incident electric field strength. The implications of the impacts to such an ecologically and economically important insect species bees would be widespread and consequential.

In October 2021 a second simulation study with far-reaching implications “Radio-frequency exposure of the yellow fever mosquito (*A. aegypti*) from 2 to 240 GHz” published in *PLOS Computational Biology* simulated the far field exposure of a mosquito between 2 and 240 GHz and found power absorption is 16 times higher at 60 GHz than at 6 GHz at the same incident field strength. This increase is even larger (by a factor of 21.8) for 120 GHz when compared to 6 GHz. The authors conclude “higher absorption of EMF by yellow fever mosquitoes, which can cause dielectric heating and have an impact on behaviour, development and possibly spread of the insect.”

In 2020, a report by Alain Hill of the biological effects of non-ionizing radiation on insects found that mobile communications were a critical factor in weakening the insect world along with pesticides and habitat loss. (Khan et al., 2021) found the Apis Cerana bee becomes very passive at a certain level of frequencies and power.

In May 2021, biologistb Alfonso Balmori published “Electromagnetic radiation as an emerging driver factor for the decline of insects” in *Science of The Total Environment. concluding* that electromagnetic radiation threatens insect biodiversity worldwide. He documents sufficient evidence of non-thermal, effects of non-ionizing radiation on insects at levels well below the limits allowed by FCC guidelines, and warns that action must be taken now before significant deployment of new technologies (like with 5G) is undertaken. He cautions that the loss of insect diversity and abundance will likely provoke cascading effects on food webs and ecosystem services.

A November 2021 review of the effects of millimeter waves, ultraviolet, and gamma rays on plants found many non-thermal effects specifically from millimeter waves (Zhong et al. 2021). (The paper examined the millimeter range 30 to 300 GHz which overlaps with FCC’s limits 300 kHz to 100 GHz.) Millimeter-wave irradiation stimulated cell division, enzyme synthesis, growth rate, and biomass. The review highlights how different doses and durations provoked dynamic morphophysiological effects in plants. Seed pretreatment with weak microwaves or millimeter wave irradiation altered root physiology. Different effects were observed in different plants and the authors state that, “the discordance of proteomic changes in different plants is reasonable, since different plants have a distinct tolerance to stress. Moreover, the cell tissues from soybeans and chickpeas used for proteomic analysis were different, which implies that tissue-specific or organ-specific responses of plants under millimeter-wave irradiation might exist and require further investigation.” This review adds to the published analysis confirming non thermal effects from RFR. While these frequencies may have beneficial uses in agriculture, the adverse impact to trees and plants in close vicinity to transmitting antennas must be addressed.

CHILDREN

Children are proportionally more exposed to RF-EMF than adults because their brain tissue is more conductive, their skulls are thinner, and their bodies are smaller. Children are known to be at greater risk than adults when exposed to any carcinogen because of their rapidly dividing cells. Because the average latency time between first exposure and diagnosis of a tumor can be decades, tumors induced in children from RFR may not be diagnosed until adulthood. Even more importantly, children and the developing fetus are more vulnerable to RFR because their brains and organs are still developing and more sensitive. Research over the last two years has added critical new science on children's vulnerability to health impacts from RFR and supports the acute need to reduce exposures..

To start, the Environmental Working Group published a landmark study in *Environmental Health* analyzing the findings of increased tumors and heart damage from the National Toxicology Program study and concluded that FCC limits should be strengthened by 200 to 400 times to protect children according to current risk assessment guidelines (Uche, 2021). "The analysis presented here supports a whole-body SAR limit of 2 to 4 mW/kg for adults, an exposure level that is 20- to 40-fold lower than the legally permissible limit of 0.08 W/kg for whole-body SAR under the current U.S. regulations. A ten-fold lower level of 0.2–0.4 mW/kg whole-body SAR may be appropriate for young children. Both technology changes and behavior changes may be necessary to achieve these lower exposure levels. Simple actions, such as keeping the wireless devices farther away from the body, offer an immediate way to decrease RFR exposure for the user."

(Cabré-Riera et al., 2020) investigated RFR doses in preadolescents at 9 – 12 years old. In "Estimated whole-brain and lobe-specific radiofrequency electromagnetic fields doses and brain volumes in preadolescents" published in *Environment International* the authors reveal their findings that although whole-brain and lobe-specific RF-EMF doses from all RF-EMF sources together, from mobile and DECT phone calls and far-field sources were not associated with global, cortical, or subcortical brain volumes, a higher whole-brain RF-EMF dose from mobile phone use for internet browsing, e-mailing, text messaging, tablet use, and laptop use while wirelessly connected to the internet was indeed associated with a smaller caudate volume. The caudate nucleus plays an important role in procedural learning, associative learning and inhibitory control of action and it is also one of the brain structures comprising the reward system. Analysis of cognitive impacts in another analysis (Cabré-Riera et al., 2020) found higher overall whole-brain RF-EMF doses from all RF-EMF sources together and from phone calls were associated with lower non-verbal intelligence score in Dutch and Spanish preadolescents.

Yet another publication by the same group (Cabré-Riera et al., 2021) investigated the association of estimated all-day and evening whole-brain radiofrequency electromagnetic field (RF-EMF) doses with sleep disturbances and objective sleep measures in preadolescents. The researchers, publishing their findings in *Environmental Research*, found preadolescents with high evening whole-brain RF-EMF dose from phone calls had a shorter total sleep time compared to preadolescents with zero evening whole-brain RF-EMF dose from phone calls.

A 2020 research review from the Department of Pediatrics, Hanyang University School of Medicine, Seoul, Korea (Moon, 2020) recommends precaution and minimizing EMF exposure to children, cautioning that the nervous systems of children are more vulnerable to the effects of electromagnetic waves than those of adults.

PREGNANCY

Using a mobile phone for calls for more than 30 minutes per day during pregnancy was associated with a negative impact on fetal growth (Boileau et al., 2020). Mobile phone use during pregnancy was associated with night-wake of infants (Weng et al., 2020). (Bektas et al., 2020) concluded that mobile phone exposure during pregnancy could cause oxidative stress and DNA damage in cord blood and placenta. Finally, the combined effects of Wi-Fi plus mobile phone exposure could have a higher potential to cause synergistic effects.

Recent animal research includes a study that found Wi-Fi signals increase lipid peroxidation, SOD activity (oxidative stress), apoptosis and CDKN1A and GADD45a overexpression in mice placenta tissue (Vafaei et al., 2020). A study on pregnant rats found damage to cells in the cerebellum. The authors conclude that prenatal mobile phone radiation might lead to the damage of axon, the nerve fiber, and myelin, the sheath that forms around nerves, with activity of astrocytes in cerebellum of male rat offspring (Yang et al., 2020).

CHARACTERIZING RFR EXPOSURES DURING CHILDHOOD AND PREGNANCY

Current FCC exposure levels were set in 1996 without a complete understanding of how RFR is absorbed into the fetus, pregnant women or children. Research published in 2020 and 2021 adds critical new data regarding these exposures. For example, (Foroutan et al., 2020) studied the absorption of WiFi and LTE frequencies into a 43-year-old pregnant woman model carrying a 24-week baby to allow scientists to better understand health impacts due to the interaction between electromagnetic fields and human tissue. (Psenakova et al., 2020) states "numerical results have shown that the obtained maximal SAR values in AustiWoman model is higher than are maximum values determined according to maximum SAR in European standards limit."

In "Electromagnetic Field in Vicinity of Electronic Baby Monitor" published by IEEE, (Gombarska et al., 2020) found exposures from a baby monitor to be regulation-compliant but the authors warn, "Some caution should be exercised when using such devices, in particular regarding keeping a safe distance from the little children." These and other new studies confirm the urgent need to reduce exposures, especially for children and pregnant women.

FERTILITY

Environmental Research published "A meta-analysis of in vitro exposures to weak radiofrequency radiation exposure from mobile phones (1990–2015)" describing 1127 experimental observations in cell-based in vitro models on RFR. It found less differentiated cells such as epithelium and spermatozoa are more sensitive to RF (Halgamuge et al., 2020). This study also confirms observations from the REFLEX project, Belyaev and others that cellular response varies with signal properties.

Several reviews on RFR impacts to sperm and reproduction were published over the last two years analyzing the body of evidence. A systematic review and meta-analysis (Sungjoon et al., 2021) evaluated 18 studies and found exposure to mobile phones is associated with reduced sperm motility, viability and concentration. (Yu et al., 2021) found mobile phone RFR exposure could decrease the motility and viability of mature human sperm *in vitro* and the pooled results of animal studies showed that mobile phone RF-EMR exposure could suppress sperm motility and viability. A systematic review on the effects of RFR to male reproductive hormones (Maluin et al., 2021) found that wireless can impact testosterone. The authors detail how testes are one of the most vulnerable organs to RF-EMR. Testicular tissues are more susceptible to oxidative stress due to a high rate of cell division and mitochondrial oxygen consumption.

(Okechukwu, 2020) reviewed human and animal studies published from 2003 to 2020 investigating RFR from cell phones and male fertility, publishing their findings "Does the Use of Mobile Phone Affect Male Fertility? A Mini-Review" in *Journal of Human Reproductive Sciences*. They found evidence in both animal and human spermatozoa of reduced motility, structural anomalies, and increased oxidative stress due to overproduction of reactive oxygen species after RFR exposure. The authors assert that scrotal hyperthermia and increased oxidative stress might be the key mechanisms through which EMR affects male fertility.

As an example of the experimental studies published over the last two years, an animal study on 4G found kidney inflammation and damage to the testes in mice (Hasan et al., 2021). The researchers concluded that fourth-generation cell phone radiation exposure may affect blood hemostasis and inflammation of mice's kidney and testis tissue and they warn that "based on these studies, it is important to increase public consciousness of potential adverse effects of mobile phone radiofrequency electromagnetic radiation exposure."

(Hassanzadeh-Taheri et al., 2021) assessed the effects of cell phone RFR on sperm parameters, DNA fragmentation, and apoptosis in normozoospermic and found higher apoptotic sperms and DNA fragmentation in the RFR exposed. The authors conclude: "it is recommended to keep the cell phone away from the pelvis as much as possible."

ELECTROSENSITIVITY

The International Journal of Molecular Sciences published "Electrohypersensitivity (EHS) as a Newly Identified and Characterized Neurologic Pathological Disorder: How to Diagnose, Treat, and Prevent It" (Belpomme & Irigaray, 2020). This paper documents the data and shows EHS is a neurologic pathological disorder which can be diagnosed, treated, and prevented. Utilizing a database of over 2000 electrohypersensitivity (EHS) and/or multiple chemical sensitivity (MCS) self-reported cases, they found EHS can be clinically characterized by a similar symptomatic picture to multiple chemical sensitivity by low-grade inflammation and an autoimmune response involving autoantibodies against O-myelin. According to the authors: "80% of the patients with EHS present with one, two, or three detectable oxidative stress biomarkers in their peripheral blood, meaning that overall these patients present with a true objective somatic disorder."

"The Critical Importance of Molecular Biomarkers and Imaging in the Study of Electrohypersensitivity. A Scientific Consensus International Report" in the *International Journal of Molecular Sciences* is a scientific consensus international report authored by 32 scientists. They call for the acknowledgement of electrohypersensitivity as a distinct neuropathological disorder and for inclusion in the WHO International Classification of Diseases (*e.g.*, distinct from the current grouping within other ICD codes addressing exposure to non-ionizing radiation) (Belpomme et al., 2021). The paper presents the French teams' EHS/MCS physiopathological model based on low-grade neuroinflammation and oxidative/nitrosative stress-induced blood–brain barrier disruption, which attempts to account for the mechanisms through which pathophysiological effects could take place in the brain of EHS and/or MCS patients and how EHS and/or MCS pathogenesis may consequently occur. The paper also documents the methodological defects that make provocation tests unsuitable for sham versus EMF exposure analysis in EHS-bearing patients. The paper documents how EHS patients' RFR exposure has been found to increase plasma glucose levels, affect heart rate variability and in multiple sclerosis-bearing patients RFR exposure can worsen symptoms, meaning that RFR can induce objective, bioclinical alterations in humans.

BRAIN/NEUROLOGY

(Hasan et al., 2021) found long-term exposure to 2400 MHz 4G impacted the structural integrity of the hippocampus and increased anxiety-like behavior in mice. (Hu et al., 2021) published "Effects of Radiofrequency Electromagnetic Radiation on Neurotransmitters in the Brain" in *Frontiers in Public Health,* offering a review that summarizes the effects of EMR on the neurotransmitters in the brain. The nervous system is an important target organ system and is sensitive to EMF. They document research that suggests that long-term exposure to EMR may lead to abnormal norepinephrine and epinephrine contents in the brain, metabolic disorders of monoamine neurotransmitters in the brain and excitatory amino acid neurotransmitters in the hippocampus, "which may affect the excitatory-inhibitory balance of neurons, thus causing a decline in learning and memory ability." The authors also considered the underlying mechanism as "EMR exposure does increase the intracellular calcium and the formation of ROS, which would alter the cellular function eventually and lead to numerous biological effects including neurotransmitter imbalance." The authors call for more research to clarify effects.

A systematic review (Bertagna et al., 2021) published in *Annals of the New York Academy of Sciences* found that neuronal ion channels are particularly affected by EMF exposure. Changes in calcium homeostasis, attributable to the voltage-gated calcium channels, were the most commonly reported result of EMF exposure. EMF effects on the neuronal landscape appear to be diverse and greatly dependent on parameters like the field's frequency, exposure time, and intrinsic properties of the irradiated tissue, such as the expression of VGCs. The researchers systematically clarify how neuronal ion channels are particularly affected and differentially modulated by EMFs at multiple levels, such as gating dynamics, ion conductance, concentration in the membrane, and gene and protein expression. Ion channels represent a major transducer for EMF-related effects on the CNS.

(Tan et al., 2021) evaluated the acute effects of 2.856 GHz and 1.5 GHz microwaves to male rats and found exposures induced a decline in spatial memory.

“Exposure of Radiofrequency Electromagnetic Radiation on Biochemical and Pathological Alterations” in *Neurology India* (Sharma et al., 2020) found 800 MHz frequency at a SAR of 0.433 W/kg in male Wistar rats led to neurochemical and pathophysiological damage by initiating the inflammatory process in various brain regions, especially in hippocampus and cerebral cortex. The authors conclude that since the hippocampus involves storing and retaining information during the learning process, RFR exposure negatively affects the memory and learning process and “could be a huge risk of induction of brain damage.”

(Hinrikus et al., 2021) review “Threshold of radiofrequency electromagnetic field effect on human brain” in the *International Journal of Radiation Biology* found the threshold for EEG effects is far lower than the level deemed safe by the U.S. FCC. The lowest level of RF EMF at which the effect in EEG was detected is 2.45 V/m (SAR = 0.003 W/kg). The authors state the changes in EEG caused by RF EMF appeared similar in the majority of analyzed studies and similar to those found in depression. They conclude that the “possible causal relationship between RF EMF effect and depression among young people is [a] highly important problem.”

(Luo et al., 2021) in their paper “Electromagnetic field exposure-induced depression features could be alleviated by heat acclimation based on remodeling the gut microbiota” published in *Ecotoxicology and Environmental Safety* share their findings that pulsed electromagnetic fields (2450 MHz) caused gut microbiota and metabolites disturbance similar to depression model. “In our study, EMF induced disturbance in the metabolite profiles of serum samples. Significantly different metabolites included cholesterol, D-fructose and fumaric acid and these were associated with depression (Xiong et al., 2020). Based on KEGG classification, the metabolites involved in neurotransmitters and steroids were altered significantly.”

They concluded that “our study demonstrated that EMF exposure could not only lead to neurobehavioral disorders such as depression, but also cause gut microbiota imbalance.” The researchers also referenced how “growing evidence indicates that the gut microbiota affects not only gastrointestinal function but also central nervous system (CNS) physiology and behavior by regulating the microbiota-gut-brain axis.”

OXIDATIVE STRESS

More recently published studies demonstrate consistency for the induction of oxidative stress. Oxidative DNA damage can lead to mutations, chromosomal translocations, and genomic instability, which are cellular events that can result in cancer development. Induction of oxidative stress, which is a key characteristic of many human carcinogens including ionizing radiation and asbestos, may also lead to the genotoxicity and carcinogenicity of non-ionizing

RFR. Oxidative stress caused by EMFs is thought to be due to the altering of recombination rates of short-lived radical pairs leading to increases in free radical concentrations. Thus, even without causing direct DNA damage, RFR may induce oxidative DNA damage and thereby initiate or promote tumor development.

(Schuermann & Mevissen, 2021) published a major review on oxidative stress, "Manmade Electromagnetic Fields and Oxidative Stress – Biological Effects and Consequences for Health" in *International Journal of Molecular Sciences*. The authors found increased oxidative stress in the majority of animal studies and cell studies, many with exposures compliant with FCC and ICNIRP regulatory limits. Increased oxidative stress caused by RF-EMF and ELF-EMF were reported in the majority of the animal studies and in more than half of the cell studies. Investigations in Wistar and Sprague-Dawley rats provided consistent evidence for oxidative stress occurring after RF-EMF exposure in the brain and testes and some indication of oxidative stress in the heart. Observations in Sprague-Dawley rats also seem to provide consistent evidence for oxidative stress in the liver and kidneys. "A trend is emerging, which becomes clear even when taking these methodological weaknesses into account, i.e., that EMF exposure, even in the low dose range, may well lead to changes in cellular oxidative balance." The authors explain that pre-existing conditions like diabetes and neurodegenerative diseases compromise the body's defense mechanisms, including antioxidant protection processes, and individuals with pre-existing conditions are more likely to experience health effects. Further, very young or old individuals can react less efficiently to oxidative stress. This puts them at greater risk of health impacts.

"Effects of different mobile phone UMTS signals on DNA, apoptosis and oxidative stress in human lymphocytes" (Gulati et al., 2020) published in *Environmental Pollution* comparatively analyzed genotoxic effects of UMTS signals at different frequency channels used by 3G mobile phones (1923, 1947.47, and 1977 MHz) and found a relatively small but statistically significant induction of DNA damage in dependence on UMTS frequency channel with maximal effect at 1977.0 MHz, supporting the notion that each specific signal used in mobile communication should be tested.

"Effects of pulse-modulated radiofrequency magnetic field (RF-EMF) exposure on apoptosis, autophagy, oxidative stress and electron chain transport function in human neuroblastoma and murine microglial cells" published by (Zielinski et al., 2020) in *Toxicology in Vitro* investigated the effects of ELF-modulated 935 MHz RF-EMF on apoptosis, autophagy, oxidative stress and electron exchange in human neuroblastoma and murine microglial cells. The authors found effects indicating that "short-time RF-EMF at SAR levels accepted by today's safety guidelines might cause autophagy and oxidative stress with the effect being dependent on cell type and exposure duration. Further studies are needed to evaluate possible underlying mechanisms involved in pulse-modulated RF-EMF exposure."

(Singh et al., 2020) exposed male Wistar rats to RFR for 16 weeks (2 h/day) and observed oxidative stress, an inflammatory response, and HPA axis deregulation. "Effect of mobile phone radiation on oxidative stress, inflammatory response, and contextual fear memory in Wistar rat" was published in *Environmental Science and Pollution Research International.* The study shows that chronic exposure to MP-RF-EMF radiation emitted from mobile phones may induce oxidative stress, inflammatory response, and HPA axis deregulation.

(Hussien et al., 2020) found a significant decrease in plasma nesfatin-1 level and thyroid functions with an increase in oxidative stress and apoptosis. Further, there was a correlation between nesfatin-1 level and markers of thyroid function, oxidative stress and apoptosis. The researchers conclude that Nesfatin-1 plays a role in thyroid dysfunctions of rats exposed to mobile phone radiation. The authors' "Decreased level of plasma nesfatin-1 in rats exposed to cell phone radiation is correlated with thyroid dysfunction, oxidative stress, and apoptosis" published in *Archives of Physiology and Biochemistry* details these findings.

GENOTOXICITY/ DNA DAMAGE

Major studies using validated experimental protocols published in 2020 and 2021 associate non-ionizing RFR exposure with DNA damage.

In February 2020, U.S. government scientists published landmark findings of "significant increases in DNA damage" in groups of male mice, female mice and male rats after just 14 to 19 weeks of non-thermal cell phone RFR exposure as part of the large scale National Toxicology Program cell phone animal studies (Smith-Roe et al., 2020). "Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure" published in *Environmental and Molecular Mutagenesis* details the much-anticipated results of the comet assay showing significant increases in DNA damage in the frontal cortex of male mice (both modulations), leukocytes of female mice (CDMA only), and hippocampus of male rats (CDMA only). Increases in DNA damage judged to be equivocal were observed in several other tissues of rats and mice. "In conclusion, these results suggest that exposure to RFR is associated with an increase in DNA damage." In short, DNA damage was found at non-thermal RFR levels, levels the FCC regulatory limits presume are harmless.

The authors explain that the NTP studies were designed to evaluate non-thermal effects of cell phone RFR exposure, which meant that body temperature could not change more than 1° C and therefore the NTP scientists considered it unlikely that thermal effects were a confounding factor for these genetic toxicity tests. Thus, this data again adds to the large body of evidence confirming that the assumption that non-ionizing radiation does not cause any adverse health effects other than by heating is wrong. The study is a game changer because the NTP exposures were carefully controlled and NTP studies are considered the gold standard in animal testing.

In "Genetic effects of non-ionizing electromagnetic fields" published in *Electromagnetic Biology and Medicine,* (Lai, 2021) reviewed the research on the genetic effects of non-ionizing electromagnetic fields and found many studies reported effects in cells and animals after exposure to EMF at intensities similar to those in the public and occupational environments. Approximately 70% of reviewed studies showed effects including DNA strand breaks, micronucleus formation, and chromosomal structural changes. Lai highlights how the effects are waveform and cell-type specific.

Dr. Lai's findings underscore the complexity of interactions between EMF and biological tissues, and may partially explain why effects were observed in some studies but not others. Lai states it is essential to understand why and how certain wave-characteristics of an EMF are more effective than other characteristics in causing biological effects, and why certain types of cells are more susceptible to EMF effects. Very significantly, Dr. Lai asserts that "there are different biological effects elicited by different EMF wave-characteristics" and this is a critical proof for the existence of non-thermal effects.

The review explains how genetic effects depend on various factors, including field parameters and characteristics (frequency, intensity, wave-shape), cell type, and exposure duration. Lai also found non-ionizing EMFs interact synergistically with different entities on genetic functions. These interactions, particularly with chemotherapeutic compounds, raise the possibility of using EMF as an adjuvant for cancer treatment to increase the efficacy and decrease side effects of traditional chemotherapeutic drugs.

Lai explains that since the energy level is not sufficient to cause direct breakage of chemical bonds within molecules, the effects are probably indirect and secondary to other induced chemical changes in the cell. He suspects that biological effects are caused by multiple inter-dependent biological mechanisms. He states that the mechanism remains to be uncovered, "but, knowing the mechanism is not necessary to accept that the data are valid. It is also a general criticism that most EMF studies cannot be replicated. I think it is a conceptual and factual misstatement. Replication is also not a necessary and sufficient condition to believe that certain data are true." Lai then states that, "to prove an effect, one should look for consistency in data. Genetic damage studies have shown similar effects with different set-up and in various biological systems. And, the gene expression results (Supplement 3) also support the studies on genetic damages. Expression of genes related to cell differentiation and growth, apoptosis, free radical activity, DNA repair, and heat-shock proteins have been reported. These changes could be consequences of EMF-induced genetic damages."

An October 2021 review "Human-made electromagnetic fields: Ion forced-oscillation and voltage-gated ion channel dysfunction, oxidative stress and DNA damage (Review)" in the *International Journal of Oncology* describes the cascade of effects from non-ionizing EMFs that lead to DNA damage. (Panagopoulos et al., 2021) documents the scientific research base indicating EMF exposures lead to ion channel dysfunction. According to the ion forced-oscillation mechanism for dysfunction of VGICs, human-made (polarized and coherent) ELF/ULF EMFs or the ELF/ULF modulation/pulsing/variability components of modern RF/WC EMFs can alter intracellular ionic concentrations by irregular gating of VGICs on cell membranes. This leads to immediate oxidative stress by ROS [oxidative stress that cause damage to lipids, proteins and DNA] (over)production in the cytosol and/or the mitochondria, which can damage DNA when cells are unable to reinstate electrochemical balance (normal intracellular ionic concentrations). Consequently, DNA damage can lead to reproductive disabilities, neurodegenerative diseases, aging, genetic alterations and cancer.

Moreover, the review addresses how, in addition to polarization and coherence, ELFs are a common feature of almost all human-made EMFs. The authors suggest that the non-thermal biological effects attributed to RF EMFs are actually due to their ELF components. The researchers conclude that, “The long-existing experimental and epidemiological findings connecting exposure to human-made EMFs and DNA damage, infertility and cancer, are now explained by the presented complete mechanism. The present study should provide a basis for further research and encourage health authorities to take measures for the protection of life on Earth against unrestricted use of human-made EMFs.”

NEW GOVERNMENT REPORTS AND RECOMMENDATIONS

The European Union

In July 2021, the European Parliament Panel for the Future of Science and Technology European Parliamentary Research Service Report “Health Impact of 5G” offered a review of the epidemiological and experimental evidence which has significantly increased since 2011 when the International Agency for Research on Cancer (IARC) classified radiofrequency (RF) EMF as “possibly carcinogenic to humans” (Group 2B). Due to the post-2011 published research, the IARC advisory group has now recommended RF exposure for re-evaluation “with high priority” (IARC, 2019). The report concludes that the body of evidence now indicates that the frequencies of 450 to 6,000 MHz are “probably carcinogenic for humans, in particular related to gliomas and acoustic neuromas.”

For non-cancer effects the EU Report concludes that there was sufficient evidence of reproductive/developmental adverse effects in experimental animals and “these frequencies clearly affect male fertility and possibly female fertility too. They may have possible adverse effects on the development of embryos, foetuses and newborns.” In regards to 5G’s higher frequencies (24.25-27.5 GHz), and frequencies 24 to 100 GHz the systematic review found there was an inadequate base of studies either in humans or in experimental animals with which to even substantiate a conclusion one way or the other regarding a carcinogenic effect or any other non-thermal effect.

The report makes several policy recommendations, including:

- Adopting stricter RFR limits for mobile phone devices and reducing RFR exposure with devices that emit lower energy and “if possible only working when at a certain distance from the body”.
- Revisiting RFR exposure limits for the public and the environment in order to reduce RF-EMF exposure from cell towers through more stringent limits such as those used in Italy, Switzerland, China, and Russia - all of which are significantly lower than those recommended by ICNIRP and the FCC.

- Adopting measures to incentivise the reduction of RF-EMF exposure which include using optic-fibre cables to connect schools, libraries, workplaces, houses, public buildings, and all new buildings etc. “Public gathering places could be 'no RF-EMF' areas (along the lines of no-smoking areas) so as to avoid the passive exposure of people not using a mobile phone or long-range transmission technology, thus protecting many vulnerable elderly or immune-compromised people, children, and those who are electro-sensitive.”
- Promoting a multidisciplinary scientific research effort to assess the long-term health effects of 5G millimeter waves (MMW) in order to rule out the risk that tumours and adverse effects on reproduction and development may occur upon exposure to 5G MMW, and to exclude the possibility of synergistic interactions between 5G MMW networks and other frequencies and networks that are already being used. Research is needed on the biological effects of 5G MMW at frequencies between 6 and 300 GHz not only for humans but also for the flora and fauna of the environment, e.g. non-human vertebrates, plants, fungi, and invertebrates.
- Promoting research to identify an adequate method of monitoring exposure to 5G because there is currently inadequate monitoring of the actual exposure of the population.
- Promoting a public educational awareness campaign on the potential harms of RFR at all levels, beginning with schools. This campaign should include the potential health risks, opportunities for digital development, safer infrastructure alternatives, and strategies to reduce exposure to wireless phones.

The report concludes that the gaps in knowledge in regards to 5G’s higher frequencies justify the call for a moratorium on 5G millimeter wave networks, pending completion of adequate research, “before exposing the whole world population and environment.” The report’s conclusion carries a very clear warning: “Implementing MMW 5G technology without further preventive studies would mean conducting an 'experiment' on the human population in complete uncertainty as to the consequences.”

In 2020, the European Parliament briefing Effects of 5G wireless communication on human health reviewed the various policies and reports in Europe including: 1) the 2011 Council of Europe Parliamentary Assembly Resolution 1815 that recommended reducing RFR exposure; the fact that the European Environment Agency (EEA) has long advocated precaution concerning EMF exposure; 2) the European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) 2015 opinion and the organizations that suggest many members of SCENIHR could have conflict of interests, as they had professional relationships with or received funding from various telecom companies; 3) the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), replacing the former Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) evaluated the scale, urgency and interactions (with ecosystems and species) of possible hazard from 5G *as high as “*there could be biological consequences from a 5G environment.”

The briefing also highlighted the biological impacts from pulsations and modulations stating, “Studies show that pulsed EMF are in most cases more biologically active and therefore more dangerous than non-pulsed EMF. Every single wireless communication device communicates at least partially via pulsations, and the smarter the device, the more pulsations. Consequently, even though 5G can be weak in terms of power, its constant abnormal pulse radiation can have an effect. Along with the mode and duration of exposures, characteristics of the 5G signal such as pulsing seem to increase the biologic and health impacts of exposure, including DNA damage, which is considered to be a cause of cancer. DNA damage is also linked to reproductive decline and neurodegenerative diseases."

A review of occupational EMF exposures (Stam, 2021) of the National Institute for Public Health and the Environment of the Netherlands pointed to the need for exposure guidelines and regulation to incorporate new technology developments, especially in regards to 5G applications. Although ICNIRP's thermally-based RFR limits were used as the action level in this article (and adverse biological effects have been found at non-thermal levels as documented in this report), this paper highlights the critical need to characterize occupational exposures and better assess health effects because of the new wireless networks found in the modern workplace.

In April 2020, the Swiss Parliament refused to weaken their RFR radiation limits. In September 2020, the Netherlands issued a 5G and Health Advisory Report that recommended measuring environmental levels of RFR (an action the FCC does not take) and importantly, the Report also recommended *against* using the 26 GHz frequency band for 5G "for as long as the potential health risks have not been investigated."

Starting in July 2020, new French government policy ensures that wireless companies label tablets, laptops, Wi-Fi routers, DECT phones and other wireless connected electronics with RFR SAR exposure levels at point of sale and in all advertising. Legislation in the country has long ensured labeling cell phones for SAR levels, but this did not apply to other wireless devices. Now all wireless devices used close to the head and body are potentially covered.The ANFR (The National Frequency Agency) SAR Regulation Guide lists the equipment qualified as radio equipment that required SAR testing. One category includes mobile phones, tablets equipped with a 3G or 4G/5G SIM card, connected watches that contain a mobile phone SIM card, 3G or 4G/5G pocket format routers, Maritime Portable VHF, laptops (3G or 4G/5G); and the second category includes DECT cordless phones, walkie-talkies or equivalent devices (PMR), tablets operating using Wi-Fi or bluetooth, wireless microphones, radio controls used for drones or model making, connected motorcycle helmets and Wi-Fi laptops. ANFR states that technological evolutions in connected objects may lead to the extension of this labeling to include radio frequency belts, connected glasses ("smart glasses"), wireless headphones or headsets, portable safety sensors (distance sensors) and virtual reality headsets.

Expert Recommendations to Minimize Exposure to Children

Since the COVID pandemic, there have been several new expert recommendations to reduce RFR exposure for children in virtual education on computers for 7 hours or more a day. For example, in April 2020 the Cyprus National Committee on Environment and Children's Health released recommendations for parents on how to set up wired internet. In March 2020, the Scientific Research Institute of Hygiene and Children's Health of the Russian Ministry of Health and the Russian National Committee on Non-Ionizing Radiation Protection also released recommendations for distance learning including restricting cell phones, using wired connections rather than Wi-Fi, reading real books and writing in real notebooks to support learning objectives. In November 2020, the Switzerland Doctors for Environmental Protection (AefU) released "Consistently apply the precautionary principle in mobile communications" demanding a reduction in exposure for children and youth.

Expert Appeals

Expert recommendations to reduce public and environmental exposures have escalated over the last two years. The 2020 Consensus Statement of UK and International Medical and Scientific Experts and Practitioners on Health Effects of Non-Ionising Radiation (NIR) was signed by over 3500 medical doctors cautioning: "Hundreds of peer-reviewed scientific studies have demonstrated adverse biological effects occurring in response to a range of NIR [non-ionizing radiation] exposures below current safety guidelines; however emissions continue to escalate. Medical evidence of harm has now reached the critical mass necessary to inspire the medical community to step out of their usual roles, stand up and speak out regarding their concern."

Expert groups have continued to organize and call for urgent action in various countries. For example, in October 2020 a letter signed by 135 health professionals in Chile requested a moratorium on the deployment of 5G technology, and a 5G Appeal was launched in support of a new 5G petition: "Apoya con tu firma la carta de solicitud de moratoria al 5G en Chile enviada al Ministro Paris"; English Translation: "With your signature, support the letter requesting a moratorium on 5G in Chile sent to Minister Paris".

In France, a September 2020 petition addressed to the Prime Minister was signed by over 60 elected officials urging the government to assess environmental effects before deploying 5G. In Canada, the Urgent Appeal to the Government of Canada to Suspend the 5G Rollout and to Choose Safe and Reliable Fiber Connections was launched by Canadians for Safe Technology (C4ST) in May 2020. The Appeal calls for a systematic review of the scientific evidence of health effects of RFR as well as binding guidelines to protect wildlife and the environment from RFR. The CEO of C4ST calling for this review is Frank Clegg, the former Chairman of Microsoft Canada.

Medical Conference on EMF

In 2021, the EMF Medical Conference 2021 presented evidence based information on the prevention, diagnosis and treatment of EMF associated illness featuring leading EMF experts in science, medicine, health and assessment. These proceedings are available as online courses for continuing medical education credits for medical doctors and health professionals. See www.emfconference2021.com

Expert Recommendations in the USA

The New Hampshire State Commission released its 2020 Report on 5G Health and Environment with 15 recommendations that included reducing public exposure to RFR via wired (not Wi-FI) internet connections in schools and libraries; software changes to phones and wireless devices to minimize exposure; informing the public about RFR exposures via educational campaigns and public posting of RFR levels; government measuring of RFR exposures; developing updated safety standards to protect the public and environment; and ensuring independent scientific review of the research.

On June 17th, 2020, over U.S. 400 medical professionals wrote the FCC a letter calling for consideration of non-thermal biological impacts. The Alliance of Nurses for Healthy Environments (ANHE), a national organization of nurses, also sent a 2020 letter calling for the FCC to address the science on children's vulnerability.

Over the last two years, several U.S. cities have passed resolutions and policies to halt increased RFR exposure and to ensure adequate scientific review of the health effects of RFR radiation. For example, Hawai'i County (July 2020), Easton Connecticut (May 2020), Keene New Hampshire (March 2020) and Farragut Tennessee (May 2020) have passed resolutions to halt 5G. The Coconut Creek Florida Commission adopted a Resolution on 5G and radiofrequency radiation (November 2020) "imploring the US Congress to allocate funding and direct a cross discipline federal agency study of the effects caused by exposure to current and proposed electromagnetic spectrum and radiofrequency commissions on human health and the environment in light of the recent implementation of fifth generation technology and to use those findings to create science based laws or rules regarding limiting human and environmental exposure."

On April 2, 2021 Montgomery County Maryland Council President Hucker and County Executive Elrich sent a letter to U.S. Senator Chris Van Hollen that included two specific requests regarding RFR:

> *"Request responsibility for setting RF standards be transferred from the Federal Communications Commission (FCC) - a regulatory agency - to the National Institute of Standards and Technology (NIST) - a standards setting body. Direct NIST to complete a review of credible published papers on the health effects of RF emissions on humans, including women and children, and tests to measure biological impact on humans, and thermal and biological tests of RF at different frequencies within 6 months. Further direct NIST to create and update thermal and biological standards for smartphones, small cells, and household Internet-of-Things (IoT) devices, Wi-Fi, and Bluetooth devices within 2 years and review and update standards every 5 years thereafter.*

Environmental Groups

Internationally and in the USA, environmental groups have issued statements and positions calling for protections for the environment before allowing wireless network proliferation. For example, in 2021, a major environmental group in Spain, Ecologistas en Accion or Ecologists in Action issued a position on 5G calling for precaution. They propose information campaigns, reducing exposure, monitoring compliance and requiring transparency, impartiality and plurality in health risk assessments. They also recommend wireless networks are replaced with wired connections and the recognition of electrohypersensitivity syndrome as an environmental disease with protections that include the creation of EMF-free zones.

In February 2021, the Green Party of California issued a Statement on 5G Wireless Technology advocating for “robust and independent scientific environmental review of 4G/5G wireless exposure” and to reduce exposures per the As Low As Reasonably Achievable (ALARA) principle. It is notable that environmental organizations are also issuing statements regarding the increased energy consumption of 5G. For example, Greenpeace France’s “What is Digital Pollution” addresses how 5G will increase “digital pollution.” Several investigative articles have been published on the environmental impacts including “How Green is 5G?” published November 2021 in Envirotech Magazine; “What Will 5G Mean for the Environment?” published January 2020 by Clair Curran of the Henry M. Jackson School of International Studies; and “Is Wireless Technology an Environmental Health Risk?” published January 2021 by Katie Alvord in the journal of the Society of Environmental Journalists.

5G NETWORKS AND MILLIMETER WAVE FREQUENCIES

The review paper “Adverse health effects of 5G mobile networking technology under real-life conditions” (Kostoff et al., 2020) published in *Toxicology Letters* identified a wide range of adverse systemic effects from 5G network deployment when real life conditions are considered such as the information content of signals along with the carrier frequencies and other toxic stimuli that can act in combination with the exposure. Many experiments do not include the real-life pulsing and modulation of the carrier signal. The vast majority of experiments do not account for synergistic adverse effects of other toxic stimuli with wireless radiation. 5G mobile networking technology will affect the skin and eyes and has adverse systemic effects. “In aggregate, for the high frequency (radiofrequency-RF) part of the spectrum, these reviews show that RF radiation below the FCC guidelines can result in: carcinogenicity (brain tumors/glioma, breast cancer, acoustic neuromas, leukemia, parotid gland tumors), genotoxicity (DNA damage, DNA repair inhibition, chromatin structure), mutagenicity, teratogenicity, neurodegenerative diseases (Alzheimer’s Disease, Amyotrophic Lateral Sclerosis), neurobehavioral problems, autism, reproductive problems, pregnancy outcomes, excessive reactive oxygen species/oxidative stress, in ammation, apoptosis, blood-brain barrier disruption, pineal gland/melatonin production, sleep disturbance, headache, irritability, fatigue, concentration difficulties, depression, dizziness, tinnitus, burning and flushed skin, digestive disturbance, tremor, cardiac irregularities, adverse impacts on the neural, circulatory, immune, endocrine, and skeletal systems.” The authors conclude that “Superimposing 5G radiation on an already imbedded toxic wireless radiation environment will exacerbate the adverse health effects shown to exist. Far more research and testing of potential 5G health effects under real-life conditions is required before further rollout can be justified."

In "Absorption of 5G Radiation in Brain Tissue as a Function of Frequency, Power and Time" published in *IEEE Access* (Gultekin & Siegal, 2020) examines the beam penetration, absorption and thermal diffusion at representative 4G and 5G frequencies and shows that RF heating increases rapidly with frequency due to decreasing RF source wavelength and increasing power density with the same incident power and exposure time.

(Trillo et al., 2021) in their paper "Effects of the signal modulation on the response of human fibroblasts to in vitro stimulation with subthermal RF currents" published in *Electromagnetic Biology and Medicine* found the modulated signal was more efficient in inducing Hsp27 and decorin overexpression and promoting cell proliferation. "These data indicate that the cellular response is dependent on the RF signal modulation…"

5G human exposure studies include (Kim & Nasim, 2020). In their paper "Human Electromagnetic Field Exposure in 5G at 28 GHz" published in *IEEE Consumer Electronics Magazine* the authors compared the human EMF exposure in a 5G system to previous-generations of cellular systems. They suggest a minimum separation distance between a transmitter and a human user in order to keep exposure compliant with regulatory limits.

In their paper "Human RF-EMF Exposure Assessment Due to Access Point in Incoming 5G Indoor Scenario" published in *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology* (Bonato et al., 2021) simulated the exposure to an adult and child from an indoor 5G access points (3.7 GHz and at 14 GHz) to evaluate how beamforming and the higher frequency use could impact exposure levels and found the reciprocal position between the antenna and the model head and the frequency range and the distance are factors that could greatly influence the exposure levels.

"Physiological effects of millimeter-waves on skin and skin cells: an overview of the to-date published studies" published in *Reviews on Environmental Health* is an overview of the physiological effects of millimeter waves on skin and skin cells (Leszczynski, 2020) by Dr. Leszczynski, one of the IARC working group members who voted 29 to 1 in May 2011 to classify RF-EMF as a 2B or "possible human" carcinogen. The author explains how the skin and eyes are directly exposed to the millimeter-waves from 5G and yet the current body of research on millimeter-waves is insufficient to devise science-based exposure limits and policies. He recommends precautionary measures such as postponing or limiting 5G deployment in residential areas until adequate research studies scientifically establish safety thresholds.

In "Limiting liability with positioning to minimize negative health effects of cellular phone towers" published in *Environmental Research* (Pearce, 2020) summarizes the peer-reviewed literature on the effects of RFR from cellular phone base stations and concludes that, "to protect cell phone tower firms, companies should seek to minimize human RFR exposure" because there is "already enough medical-scientific evidence to warrant long-term liability concerns."

In "Millimeter (MM) wave and microwave frequency radiation produce deeply penetrating effects: the biology and the physics" published in *Reviews on Environmental Health*, (Pall, 2021) highlights three very important findings “rarely recognized in the EMF scientific literature: coherence of electronically generated EMFs; the key role of time-varying magnetic fields in generating highly penetrating effects; the key role of both modulating and pure EMF pulses in greatly increasing very short term high level time-variation of magnetic and electric fields. It is probable that genuine safety guidelines must keep nanosecond timescale-variation of coherent electric and magnetic fields below some maximum level in order to produce genuine safety. These findings have important implications with regard to 5G radiation.”

STANDARDS

The Environmental Working Group modeled the health effects incidence data from the National Toxicology Program (NTP) cell phone radiation studies to estimate departure points for exposure guidelines in a landmark analysis published in *Environmental Health*. The NTP study reported an increased incidence of cardiomyopathy in female and male rats and increased incidences of various neoplasms in male rats. They concluded that FCC limits should be strengthened by 200 to 400 times to protect children according to current risk assessment guidelines concluding that ”the analysis presented here supports a whole-body SAR limit of 2 to 4 mW/kg for adults, an exposure level that is 20- to 40-fold lower than the legally permissible limit of 0.08 W/kg for whole-body SAR under the current U.S. regulations. A ten-fold lower level of 0.2–0.4 mW/kg whole-body SAR may be appropriate for young children.

Both technology changes and behavior changes may be necessary to achieve these lower exposure levels. In “Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach” published in *Environmental Health*, the authors suggest: “Simple actions such as keeping the wireless devices farther away from the body offer an immediate way to decrease RFR exposure for the user.” (Uche, 2021)

In April 2020, Barnes and Greenebaum published “Setting Guidelines Electromagnetic Exposures Research Needs”, in *Bio Electro Magnetics* about the fact that current limits for exposures to non-ionizing electromagnetic fields do not address long-term exposures but are instead based on relatively short-term exposures. “What is missing in the current guidelines or regulations are guidelines for long‑term exposure to weak EMF.” The authors document the science substantiating their recommendations for next steps regarding research and approaches for more protective exposure guidelines. They conclude that the science is sufficient indicating biological impacts at low levels:

> *“However, over the last 20 years the evidence has become extremely strong that weaker EMF over the whole range for frequencies from static through millimeter waves can modify biological processes. There is now solid experimental evidence and supporting theory showing that weak fields, especially but not exclusively at low frequencies, can modify reactive free radical concentrations and that changes in radical concentration and that of other signaling molecules, such as hydrogen peroxide and calcium, can modify biological processes…”*

The authors posit with copious scientific documentation how non-ionizing EMFs can impact cancer cell growth rates, membrane potentials, concentrations of calcium, reactive oxygen species (ROS), superoxide ($O2-$), nitric oxide (NO), hydrogen peroxide (H2O2), and intercellular pH, specifically highlighting the issue of oxidative stress as long-term elevations ``are associated with cancer, aging, and Alzheimer's." They highlight how funding for research into the effects of EMF in the United States "is close to nonexistent" and make numerous recommendations for research studies. They also recommend, for example, that guidelines be set at three levels: the individual user, local company, and national or international level and posit that recommended limits could well be a function of frequency, amplitude, and modulation systems as well as be dependent on the condition of the person being exposed. Barnes and Greenebaum acknowledge, "There seem to be a smaller number of 'hypersensitive people' who have very real and serious problems" from exposure to weak RF fields.

The co-authors conclude: "We believe a carefully targeted program of federal research funds is called for, supplemented by communications system operators and corporations that manufacture equipment, under independent scientific management. Both governmental and private entities that emit RF signals would be well advised to fund research to elucidate and define threshold signal levels for the generation of long-term biological effects."

CANCER

The evidence that RFR is a human carcinogen has continued to increase with the publication of several new research studies and papers. Furthermore, cancer incidence is rising among children and young adults. The latest U.S. Annual Report to the Nation on the Status of Cancer (a collaborative effort among the American Cancer Society, the Centers for Disease Control and Prevention, the National Cancer Institute, part of the National Institutes of Health; and the North American Association of Central Cancer Registries) published in *Journal of the National Cancer Institute* found higher overall cancer incidence rates in children and young adults in almost all racial/ethnic groups, with increasing trends for the most common cancer types among children including leukemia, brain and other nervous system cancers, and lymphoma.

In November 2020 a systematic review and meta-analysis of case-control studies by (Choi et al., 2020), "Cellular Phone Use and Risk of Tumors: Systematic Review and Meta-Analysis", was published in *Environmental Research and Public Health.* The authors found evidence that linked cellular phone use to increased tumor risk. The meta-analysis established that 1,000 or more hours of cell phone use, or about 17 minutes per day over 10 years, was associated with a statistically significant 60% increase in brain tumor risk.

In their paper "Genetic susceptibility may modify the association between cell phone use and thyroid cancer: A population-based case-control study in Connecticut" published in *Environmental Research* (Luo et al., 2020), the Yale researchers with support from the American Cancer Society found cell phone use was significantly associated with thyroid cancer in people with a type of common genetic variation. The association increased as cell phone use duration and frequency increased. The authors conclude that their findings "provide more evidence for RFR carcinogenic group classification."

Regarding the impact of EMFs to the thyroid, a 2021 review by California Institute of Behavioral Neurosciences & Psychology researchers (Alkayyali et al., 2021) focused on thyroid hormones and thyroid gland histopathology documented studies indicating that RFR could be associated with alterations in hormone levels and impacts such as the hyperstimulation of thyroid gland follicles, causing oxidative stress and apoptosis of follicular cells. In "An Exploration of the Effects of Radiofrequency Radiation Emitted by Mobile Phones and Extremely Low Frequency Radiation on Thyroid Hormones and Thyroid Gland Histopathology" published in *Cureus*, the researchers found studies correlated thyroid impacts to the exposure duration, intensity, and SAR value of the RFR exposure. The authors state that "non-ionizing EMF radiation might be responsible for the recent increase in the incidence of thyroid insufficiency and cancer in the general population."

In "The Effect of Continuous Low-Intensity Exposure to Electromagnetic Fields from Radio Base Stations to Cancer Mortality in Brazil" (Rodrigues et al. 2020) published their findings in the *International Journal of Environmental Research and Public Health* linking higher exposure to radio frequency radiation from cell antenna installations in Brazil to increased deaths from cancers. For all cancers and for the specific types investigated (breast, cervix, lung, and esophagus cancers), the higher the exposure, the higher the median of mortality rate.

The last two years of research has significantly increased the scientific evidence that RFR can increase oxidative stress, a hallmark of cancer, addressed earlier in this document. However, in addition, there are other endpoints associated with cancer that have been published in the last two years increasing the evidence related to the carcinogenicity of RFR. For example, (Ghandehari et al. 2021) found increased cell phone usage significantly correlated with a higher frequency of the micronucleus containing buccal mucosa cells and a higher frequency of micronucleus in each cell in the buccal mucosa. In "Micronucleus Assay in Cell Phone Users: Importance of Oral Mucosa Screening" published in *International Journal of Preventive Medicine*, the authors surmise, "Based on these results, it can be concluded that human buccal cells are likely to show increased micronucleus cells as a result of the genotoxic effects of cell phone waves which have been chronically exposed."

Micronuclei are biomarkers of disease and they play an active role in tumor biology (Kwon et al. 2020). (Yao et al. 2021), in "The biological effects of electromagnetic exposure on immune cells and potential mechanisms" published in *Electromagnetic Biology and Medicine*, undertake a review of the biological effects of electromagnetic exposure on immune cells. The researchers found: "Accumulated data suggested that electromagnetic exposure could affect the number and function of immune cells to some extent, including cell proportion, cell cycle, apoptosis, killing activity, cytokines contents…"; and the authors conclude that, "knowledge of the biological effects on immune cells associated with electromagnetic fields is critical for proper health hazard evaluation, development of safety standards, and safe exploitation of new electromagnetic devices and applications."

(Hardell & Carlberg, 2021) published “Lost opportunities for cancer prevention: historical evidence on early warnings with emphasis on radiofrequency radiation” in *Reviews in Environmental Health*. This eloquent review gives insight into missed opportunities for cancer prevention exemplified by asbestos, tobacco, certain pesticides and now RF radiation. The authors highlight how economic considerations were favored instead of cancer prevention. “A strategy to sow doubt on cancer risks was established decades ago and is now adopted and implemented in a more sophisticated way by the telecom industry regarding RF-EMF risks to human beings and the environment. Industry has the economic power, access to politicians and media whereas concerned people are unheard.” The examples clearly show that if the scientific evidence on cancer risks had been taken seriously, many lives could have been saved.

The 2020 study “Increased Generational Risk of Colon and Rectal Cancer in Recent Birth Cohorts under Age 40 - the Hypothetical Role of Radiofrequency Radiation from Cell Phones” published in *Annals of Gastroenterology and Digestive Disorders* by Davis et al. presented data from the U.S. Centers for Disease Control and Prevention, the U.S. Surveillance Epidemiology and End-Results Program and Iranian cancer registries on the staggering increases in colon and rectal cancer in those under age 50. Those born in the U.S. in the 1990s have a doubled risk of colon cancer and a fourfold increase in rectal cancer by the time they reach age 24 compared to those born six decades ago. The researchers document experimental studies indicating that cells from the colon and rectum of Sprague-Dawley rats are exquisitely sensitive to RFR and assert that these cancer increases could be due to the way people carry cell phones close to their bodies in front and back pockets. They reference how the French government frequency testing agency (ANFR) found that 9 out of 10 phones exceeded the safety guidelines when held against the body by factors of 1.6-3.7 times for the European standard or by factors as high as 11 if 1-g SAR values were to be measured as required by the U.S. FCC. “It appears prudent to promote policies to reduce exposures to radiofrequency radiation and encourage ALARA during pediatric CT procedures, while continuing to promote advances in software and hardware of phones and scanners that can lower exposures to non-ionizing radiation during normal operations. In addition, major public educational programs should be developed to promote awareness of the need to practice safer technology, especially for the young, who may well be at greater risk of developing cancer due to their immunological immaturity.”

In March 2021, Christopher Portier, Ph.D., formerly the Director of the United States National Center for Environmental Health at the Centers for Disease Control and Prevention (CDC) in Atlanta and the Director of the Agency for Toxic Substances and Disease Registry submitted a comprehensive review of the scientific research in a major cell phone/brain cancer lawsuit where he concludes: “The evidence on an association between cellular phone use and the risk of glioma in adults is quite strong.” Portier further states in his Expert Report: “In my opinion, RF exposure probably causes gliomas and neuromas and, given the human, animal and experimental evidence, I assert that, to a reasonable degree of scientific certainty, the probability that RF exposure causes gliomas and neuromas is high.”

A important paper was published in *Health Physics* in 2020 by longtime NIH scientist Dr. Ronald Melnick entitled “ICNIRP’S Evaluation of the National Toxicology Program’s Carcinogenicity Studies on Radiofrequency Electromagnetic Fields” addressing numerous criticisms of the NTP findings. Melnick documents one by one how these criticisms include false claims and “several incorrect statements that appear to be written to justify retaining exposure standards that were established more than 20 years ago.” He presents the scientific documentation that each of these criticisms are unfounded stating “ICNIRP’s misrepresentation of the methodology and interpretation of the NTP studies on cell phone RF radiation does not support their conclusion that “limitations preclude drawing conclusions about carcinogenicity in relation to RF EMFs.”

Melnick explains that the utility of the NTP studies for assessing human health risks is undermined by the incorrect statements and misinformation in the ICNIRP critique. Melnick describes how the ICNIRP note failed to recognize that focal hyperplasias (proliferative lesions) of glial cells in the brain and of Schwann cells in the heart are putative preneoplastic lesions that may progress to malignant glioma or to cardiac schwannoma tumors, respectively.

Further, Melnick documents how the ICNIRP note focused on the carcinogenicity but ignored other adverse biological effects observed in the NTP studies, including reduced birth weights, DNA strand breaks in brain cells (which is supportive of the cancer findings), increased incidences of proliferative lesions (tumors and hyperplasia) in the prostate gland, and exposure-related increases in the incidence of cardiomyopathy (a type of tissue damage) of the right ventricle of the heart in male and female rats.

“After all, it was the US Food and Drug Administration that requested the NTP studies of cell phone radiation in experimental animals to provide the basis to assess the risk to human health. The NTP studies show that the assumption that RF radiation is incapable of causing cancer or other adverse health effects other than by tissue heating is wrong. If ICNIRP’s goal is truly aimed at protecting the public from potential harm, then it would be appropriate for this group to quantify the health risks associated with exposure to RF-EMFs and then develop health-protective guidelines for chronic exposures, especially for children, who are likely to be more susceptible than adults to adverse effects of RF radiation.”

These studies are a small sampling of the numerous studies that have documented adverse effects from RFR.

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Health impact of 5G

STUDY

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Health impact of 5G

Current state of knowledge of 5G-related carcinogenic and reproductive/developmental hazards as they emerge from epidemiological studies and in vivo experimental studies

The upcoming deployment of 5G mobile networks will allow for significantly faster mobile broadband speeds and increasingly extensive mobile data usage. Technical innovations include a different transmission system (MIMO: use of multiple-input and multiple-output antennas), directional signal transmission or reception (beamforming), and the use of other frequency ranges. At the same time, a change is expected in the exposure to electromagnetic fields (EMF) of humans and the environment. In addition to those used to date, the 5G pioneer bands identified at EU level have frequencies of 700 MHz, 3.6 GHz (3.4 to 3.8 GHz) and 26 GHz (24.25 to 27.5 GHz). The first two frequencies (FR1) are similar to those used for 2G to 4G technologies and have been investigated in both epidemiological and experimental studies for different end points (including carcinogenicity and reproductive/developmental effects), while 26 GHz (FR2) and higher frequencies have not been adequately studied for the same end points.

The International Agency for Research on Cancer (IARC) classified radiofrequency (RF) EMF as 'possibly carcinogenic to humans' (Group 2B) and recently recommended RF exposure for re-evaluation 'with high priority' (IARC, 2019). Since 2011 a great number of studies have been performed, both epidemiological and experimental. The present review addresses the current knowledge regarding both carcinogenic and reproductive/developmental hazards of RF as exploited by 5G. There are various *in vivo* experimental and epidemiological studies on RF at a lower frequency range (450 to 6000 MHz), which also includes the frequencies used in previous generations' broadband cellular networks, but very few (and inadequate) on the higher frequency range (24 to 100 GHz, centimetre/MMW).

The review shows: 1) 5G lower frequencies (700 and 3 600 MHz): a) limited evidence of carcinogenicity in epidemiological studies; b) sufficient evidence of carcinogenicity in experimental bioassays; c) sufficient evidence of reproductive/developmental adverse effects in humans; d) sufficient evidence of reproductive/developmental adverse effects in experimental animals; 2) 5G higher frequencies (24.25-27.5 GHz): the systematic review found no adequate studies either in humans or in experimental animals.

Conclusions: 1) cancer: FR1 (450 to 6 000 MHz): EMF are probably carcinogenic for humans, in particular related to gliomas and acoustic neuromas; FR2 (24 to 100 GHz): no adequate studies were performed on the higher frequencies; 2) reproductive developmental effects: FR1 (450 to 6 000 MHz): these frequencies clearly affect male fertility and possibly female fertility too. They may have possible adverse effects on the development of embryos, foetuses and newborns; FR2 (24 to 100 GHz): no adequate studies were performed on non-thermal effects of the higher frequencies.

AUTHOR

This study has been written by Dr Fiorella Belpoggi, BSC, PhD, International Academy of Toxicologic Pathology Fellow (IATPF), Ramazzini Institute, Bologna (Italy), at the request of the Panel for the Future of Science and Technology (STOA) and managed by the Scientific Foresight Unit, within the Directorate-General for Parliamentary Research Services (EPRS) of the Secretariat of the European Parliament.

The scoping review search was performed by Dr Daria Sgargi, PhD, Master in Biostatistics, and Dr Andrea Vornoli, PhD in Cancer Research, Ramazzini Institute, Bologna.

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ADMINISTRATOR RESPONSIBLE

Gianluca Quaglio, Scientific Foresight Unit (STOA)
To contact the publisher, please e-mail stoa@ep.europa.eu

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Executive summary

1. Background

Recent decades have seen an unparalleled development of technologies known as information and communications technologies (ICT), which include wireless communication used for mobile telephones and, for example, Wi-Fi using radiofrequency (RF) electromagnetic fields (EMF).

The first generation of handheld mobile phones was available in the late 1980s. Subsequently, the second (2G), third (3G) and fourth (4G, long-term evolution = LTE) generations dramatically increased their penetration rates in society, so that today in Europe there are more devices than inhabitants. In addition, Wi-Fi and other forms of wireless data transfer have become ubiquitous and are globally available. Nevertheless, there are new inequalities in terms of access to high-speed internet (even within high-income countries) and control by authoritarian regimes shows risks for democracy and European values.

The introduction of the next generation of RF, 5G, has begun on mobile networks. 5G is not a wholly new technology, but an evolution of already existing G1 to G4 technologies. 5G networks will work within several different frequency bands, the lower frequencies of which are being proposed for the first phase of 5G networks. Several of these frequencies have been or are currently being used for earlier mobile communication generations. There are also plans to use much higher radio frequencies at later stages of the 5G technology evolution. The new bands are well above the ultra high frequency (UHF) range, having wavelengths in the centimetre (3–30 GHz) or millimetre ranges (MMW) at 30-300 GHz. These latter bands have traditionally been used for radar and microwave links and very few have been studied for their impact on human health.

2. Methodology

This review of the currently available scientific evidence focuses on both the carcinogenic and the reproductive/developmental effects of RF from mobile phone telecommunications systems using 2G-5G networks, based on both in vivo animal studies and human epidemiological studies. The studies evaluated have been divided into two groups:

1) studies evaluating health effects due to RF at the lower frequency range (FR) (FR1: 450 to 6 000 MHz), which also includes the frequencies used in the existing 2-4 generations of the broadband cellular network. The current evidence from 2G-4G studies is the best evidence currently available. The studies were evaluated using *narrative* methods;

2) studies evaluating health effects due to RF at the higher FR (FR2: 24 to 100 GHz - MMW). The higher frequencies are new, not previously used for mobile communication and specific to the new 5G technology, which has particular physical characteristics and interactions with biological matter (lower penetration, higher energy, etc.): they were considered separately using a scoping review method.

Narrative review (FR1) will be distinguished from scoping review (FR2), but the selection and assessment criteria indicated for scoping reviews were adopted for both searches and for including/excluding studies on the cancer and reproductive/developmental biological end points.

In finally assessing the results of both epidemiological and experimental study, and of cancer and reproductive/developmental outcomes, consideration was given to the parameters indicated in the IARC Monograph Preamble (2019), tailored to the needs of the present report, and valid for both end points (i.e. cancer and reproductive/developmental effects):

Sufficient evidence: a causal association between exposure to RF-EMF and the specific adverse effect has been established. That is, a positive association has been observed in the body of evidence on exposure to the agent and the specific adverse effect in studies in which chance, bias, and confounding factors were ruled out with reasonable confidence.

Limited evidence: a causal interpretation of the positive association observed in the body of evidence on exposure to RF-EMF and the specific adverse effect is credible, but chance, bias, or confounding factors cannot be ruled out with reasonable confidence.

No evidence: there are no data available or evidence, suggesting lack of adverse effects (to be specified).

The overall evaluation for both cancer and reproductive/developmental effects was obtained by the integration of the human/animal evidence as follows:

Evidence in humans	Evidence in experimental animals	Evaluation based on strength of evidence
Sufficient	Not necessary	Clear association between exposure and the adverse effect
Limited	Sufficient	Probable association between exposure and the adverse effect
Limited	Less than sufficient	Possible association between exposure and the adverse effect
Inadequate	Inadequate or limited	Not classifiable

3. Exposure assessment

The question of exposure assessment with the introduction of 5G is complicated, above all concerning the monitoring of the continuous changes in activity of both base stations (BS) and user equipment (UE) related to MIMO (multiple input, multiple output) technology. Furthermore, the technical approach to exposure assessment in the future scenario, relating to 1G, 2G, 3G, 4G and 5G concurrent emissions, is still being formulated and is hence uncertain.

4. Non-thermal effects

The harmful effects of non-thermal biological interaction of RF-EMF with human and animal tissues have not been included in the determination of the ICNIRP 2020 guidelines (ICNIRP 2020a), despite the huge amount of available scientific publications demonstrating the harmfulness or potential harmfulness of those effects. Athermal bioresponses exist, and indeed some frequencies are being used for therapeutic purposes in a number of branches of medicine. Any drug, as we well know, even the most beneficial, may also entail some adverse effects. So, thermal as well as non-thermal effects of RF-EMF have to be considered in risk assessment.

5. State of the art of the research on RF-EMF

The introduction of wireless communication devices that operate in the RF region of the electromagnetic spectrum (450 to 6 000 MHz, lower frequencies) has triggered a considerable number of studies focusing on health concerns. These studies encompass studies on humans (epidemiological), on animals (rodent experimental studies), and on in-vitro cellular systems.

5G networks will increase the number of wireless devices, necessitating a lot more infrastructure, so as to allow for a higher mobile data volume per geographic area. Moreover, it is necessary to build up increased network density, as the higher frequencies required for 5G (24 to 100 GHz, MMW) have shorter ranges. The studies available on these frequencies are few in number and of mixed quality.

This raises thee questions as to whether these higher frequencies would have health and environmental effects different from those at lower ferquencies. Worldwide, assessments of RF safety have been performed at different levels, with the publication of scientific and policy papers.

With regard to cancer, the IARC 2011 analyis of the literature reviewed up to 2011 (Baan, 2011), published in 2013, and cited throughout as IARC (2013), defined RF-EMF in the frequency range from 30 kHz to 300 GHz as 'possibly carcinogenic' to humans, based on 'limited evidence of carcinogenicity' in human and in experimental animals. The studies available in 2011 examined RF in the range we here call FR1, that is from 450 to 6 000 MHZ. The FR2 frequencies (24 to 100 GHz) lie in the MMW range.

The IARC 2011 analysis evaluated RF-EMF. While there were no studies on 5G, some studies on high frequency occupational radar and microwave exposures were included.

The new MMW frequencies (FR2: 24 to 100 GHz) will be added to the lower frequencies already in use including in part by 5G. It follows that, for 5G in the range 450 to 6 000 MHz (FR1) there are many studies, many collected in the IARC Monograph in relation to cancer, while for 26 GHz and other MMW frequencies in general there is little literature exploring the possible adverse effects on health. The simple reason for this is that hitherto these frequencies have never been used for mass communication and hence there were few suitable populations exposed to these frequencies to study; there are likewise very few adequate studies on non-thermal effects on laboratory animals.

6. Results of the present review

Using PubMed and the EMF Portal database, and applying the scoping review methodology to our research, we found 950 papers on the carcinogenicity of RF-EMF in humans, and 911 papers on experimental rodent studies, totalling 1 861 studies. Regarding reproductive/developmental studies, we found 2 834 papers for epidemiology and 5 052 studies for experimental rodent studies, totalling 7 886 studies. From the present review of the literature and the considerations reported above, we come to the following conclusions:

6.1 Cancer in humans

FR1 (450 to 6 000 MHz): there is limited evidence for carcinogenicity of RF radiation in humans. Updating the results of the overall 2011 evaluation to 2020, positive associations have again been observed between exposure to radiofrequency radiation from wireless phones and both glioma (tumour of the brain) and acoustic neuroma, but the human evidence is still limited.

FR2 (24 to 100 GHz): no adequate studies were performed on the effects of the higher frequencies.

6.2 Cancer in experimental animals

FR1 (450 to 6 000 MHz): there is sufficient evidence in experimental animals of the carcinogenicity of RF radiation. New studies following the 2011 IARC evaluation showed a positive association between RF-EMF and tumours of the brain and Schwann cells of the peripheral nervous system, the same type of tumours also observed in epidemiological studies.

FR2 (24 to 100 GHz): no adequate studies were performed on the higher frequencies.

6.3 Reproductive/developmental effects in humans

FR1 (450 to 6 000 MHz): there is sufficient evidence of adverse effects on the fertility of men. There is limited evidence of adverse effects on fertility in women. There is limited evidence of developmental effects in offspring of mothers who were heavy users of mobile phones during pregnancy.

FR2 (24 to 100 GHz): no adequate studies were performed on the higher frequencies.

6.4 Reproductive/developmental effects in experimental animals

FR1 (450 to 6000 MHz): there is sufficient evidence of adverse effects on male rat and mouse fertility. There is limited evidence of adverse effects on female mouse fertility. There is limited evidence of adverse effects on the development in offspring of rats and mice exposed during embryo life.

FR2 (24 to 100 GHz): no adequate studies on non-thermal effects were performed on the higher frequencies.

7. Overall evaluation

7.1 Cancer

FR1 (450 to 6 000 MHz): these FR1 frequencies are probably carcinogenic to humans.

FR2 (24 to 100 GHz): no adequate studies were performed on the higher frequencies.

7.2 Reproductive/developmental effects

FR1 (450 to 6000 MHz): these frequencies clearly affect male fertility. They possibly affect female fertility. They possibly have adverse effects on the development of embryos, foetuses and newborns.

FR2 (24 to 100 GHz): no adequate studies were performed on non-thermal effects of the higher frequencies.

8. Policy options

8.1 Opting for novel technology for mobile phones that enables RF-EMF exposures to be reduced

The sources of RF emissions that seem at present to pose the greatest threat are mobile phones. Though transmitting installations (radiobase masts) are perceived by some people as providing the greatest risk, actually the greatest burden of exposure in humans generally derives from their own mobile phones, and epidemiological studies have observed a statistically significant increase in brain tumours and Schwann cell tumours of the peripheral nerves, mainly among heavy cell-phone users.

Accordingly, action is needed to ensure that safer and safer telephone devices are manufactured, emitting low energy and if possible only working when at a certain distance from the body. The cable earpiece solves much of the problem but is inconvenient and hence puts users off; on the other hand, it is not always possible to use speakerphone mode. The option of lowering RF-EMF exposure as much as possible in connection with telephones still applies whatever the frequencies being used, from 1G to 5G. Countries such as the US and Canada, which enforced stricter mobile phone SAR limits than in Europe, were still able to build efficient 1G,2G, 3G, 4G communications

(Madjar, 2016). Since 5G aims to be more energy-efficient than the previous technologies, adopting stricter limits in the EU for mobile phone devices would be at once a sustainable and a precautionary approach.

8.2 Revising exposure limits for the public and the environment in order to reduce RF-EMF exposure from cell towers

Recently, EU policies (European Commission, 2019) have promoted the sustainability of a new economic and social development model that uses new technologies to constantly monitor the planet's state of health, including climate change, the energy transition, agro-ecology and the preservation of biodiversity. Using the lowest frequencies of 5G and adopting precautionary exposure limits such as those used in Italy, Switzerland, China, and Russia among others, which are significantly lower than those recommended by ICNIRP, could help achieve these EU sustainability objectives.

8.3 Adopting measures to incentivise the reduction of RF-EMF exposure

Much of the remarkable performance of the new wireless lower frequency 5G technology can also be achieved by using optic-fibre cables and by adopting engineering and technical measures to reduce exposure from 1-4G systems (Keiser, 2003; CommTech Talks, 2015; Zlatanov, 2017). This would minimise exposure, wherever connections are needed in fixed sites. For example, optic fibre cables could be used to connect schools, libraries, workplaces, houses, public buildings, and all new buildings etc., and public gathering places could be 'no RF-EMF' areas (along the lines of no-smoking areas) so as to avoid the passive exposure of people not using a mobile phone or long-range transmission technology, thus protecting many vulnerable elderly or immune-compromised people, children, and those who are electro-sensitive.

8.4 Promoting multidisciplinary scientific research to assess the long-term health effects of 5G and to find an adequate method of monitoring exposure to 5G

The literature contains no adequate studies that would rule out the risk that tumours and adverse effects on reproduction and development may occur upon exposure to 5G MMW, or to exclude the possibility of some synergistic interactions between 5G and other frequencies that are already being used. This makes the introduction of 5G fraught with uncertainty concerning both health issues and forecasting and or monitoring the actual exposure of the population: these gaps in knowledge justify the call for a moratorium on MMW of 5G, pending completion of adequate research.

In light of these uncertainties, one policy option is to promote multidisciplinary team research into various factors concerning exposure assessment and also into the biological effects of 5G MMW at frequencies between 6 and 300 GHz, both on humans and on the flora and fauna of the environment, e.g. non-human vertebrates, plants, fungi, and invertebrates.

MMW will only be brought in with the final 5G protocol, i.e. not until three to five years' time. Given this time frame, one option is to study their effects before exposing the whole world population and environment.

Implementing MMW 5G technology without further preventive studies would mean conducting an 'experiment' on the human population in complete uncertainty as to the consequences. To restrict our scope to Europe, this could occur within a field like that of chemistry, currently governed by REACH (EC, 1907/2006).

REACH aims to improve the protection of human health and the environment through better and earlier identification of the intrinsic properties of chemical substances. EU REACH regulates the registration, evaluation, authorisation, and restriction of chemicals. It also aims to enhance the innovation and competitiveness of the EU chemicals industry. EU REACH is based on the principle of 'no data, no market', placing responsibility on industry to provide safety information on substances.

Manufacturers and importers are required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database in the European Chemicals Agency (ECHA). One policy option can be to apply the same approach to all types of technological innovation.

The results of these studies could form the basis for developing evidence-based policies regarding RF-EMF exposure of human and non-human organisms to 5G MMW frequencies. Further studies are needed to better and independently explore the health effects of RF-EMF in general and of MMW in particular.

8.5 Promoting information campaigns on 5G

There is a lack of information on the potential harms of RF-EMF. The information gap creates scope for deniers as well as alarmists, giving rise to social and political tension in many EU countries. Public information campaigns should therefore be a priority.

Information campaigns should be carried out at all levels, beginning with schools. People should be informed of the potential health risks, but also the opportunities for digital development, what infrastructural alternatives exist for 5G transmission, the safety measures (exposure limits) taken by the EU and Member States, and the correct use of mobile phones. Only with sound and accurate information can we win back citizen trust and reach a shared agreement over a technological choice which, if properly managed, can bring great social and economic benefits.

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List of abbreviations

1G , 2G, 3G, 4G, 5G	First-fifth generation of telecommunication
2-ME	2-methoxyethanol
3β HSD	3β-Hydroxysteroid dehydrogenase
17 β HSD	17β-Hydroxysteroid dehydrogenases
3GPP	3rd Generation Partnership Project
ABCD	Amsterdam-born children and their development study
AKR/J	mouse strain
ANSES	French Agency for Food, Environmental and Occupational Health and Safety
AOR	covariate-adjusted odds ratio
APD	annual power density
AR	acrosome reaction
ASP	annual summarised power
AUDIPOG	assessment of neonatal growth (score expressed as a percentile)
B6C3F1/N	mouse strain
BALB/c	mouse strain
BAX	Bcl-2-associated X
BCL-2	B-cell lymphoma 2
BCL-XL	B-cell lymphoma-extra large
BLL	blood lead level
BMI	body mass index
BS	base stations
C3H/HeA	transgenic mouse
C57BL/6	mouse strain
CANULI	From the danish 'cancer og social ulighed' (cancer and socal inequality), cohort study
CAT	catalase
CEFALO	multicentre case-control study
CERENAT	multicentre case-control study
CDF	cumulative distribution function
CDMA	code division multiple access
CGRP	calcitonin gene-related peptide
CI	confidence interval
CNS	central nervous system
CRP	C-reactive protein
CW	continuous wave
DECT	digital enhanced cordless telecommunications

DFI	DNA fragmentation index
DNA	neoxyribonucleic acid
DNBC	Danish national birth cohort
ECHA	European Chemicals Agency
EARTH	Environment and Reproductive Health Study
EMF	electromagnetic field
ENU	N-ethyl-N-nitrosourea
EPM	elevated-plus maze
EPRS	European Parliamentary Research Service
Erα	estrogen receptor alpha
Erβ	estrogen receptor beta
EU	European Union
Eμ-Piml	transgenic mouse
F	female
FCC	Federal Communications Commission
FOEN	Federal Office for the Environment
FOMA	freedom of mobile multimedia access
FR1	lower frequency band (450 MHz- 6 GHz)
FR2	higher frequency band (24 - 100 GHz)
FST	forced swimming test
GA	gallic acid
GADD45	growth arrest and DNA damage 45
GBD	global burden of diseases, injuries and risk factors
GD	gestational day
GERoNiMO	generalised EMF research using novel methods
GFAP	glia fibrilliary acidic protein
GHz	giga hertz
GIS	geographical information systems
GSH	glutathione
GSH-Px	glutathione peroxidase
GSM	global systems for mobile communications
GR	γ-radiation
H2O2	hydrogen peroxide
HSP70 (or 25, or 32): 70 (or 25, or 32)	kilodalton heat shock proteins
IARC	International Agency for Research on Cancer
IATPF	International Academy of Toxicologic Pathology Fellow
ICNIRP	International Commission on Non-Ionizing Radiation Protection

ICR	mouse strain
ICT	information and communications technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEMFA	International EMF Alliance
IL-6 (or 10, or 32)	interleukine-6 (or 10, or32)
ILO	International Labour Organization
INMA	Spanish Environment and Childhood Project
INTERPHONE	a set of international case-control studies
INTEROCC	international case-control study
IoT	internet of things
ISTISAN	Italian National Institute of Health (Istituto Superiore di Sanità) report
IRR	incidence rate ratio
ITA	Austrian Institute fur Technickfolken
IT'IS	Foundation for Research on Information Technologies in Society
JECS	Japan Environment and Children Study
kHz	kilohertz
LH	luteinising hormone
LTE	long-term evolution
M	male
MARHCS	Male Reproductive Health in Chongqing College students cohort study
MDA	malondialdehyde
MDI	mental development index
MEL	melatonin
MHz	megahertz
MIMO	multiple-input and multiple-output antennas
MMP2 (or 14)	matrix metallopeptidase 2 (or 14)
MMW(s)	millimeter wave(s)
MoBa	prospective population-based pregnancy cohort study
MOCEH	Korean Mothers and Children's Environmental Health Study
MOE	moringa extract
MPBS	mobile phone base stations
MW	millimeter waves
MWM	Morris water maze
NéHaVi	cohort study
NIR	non-ionising radiation
NMRI	mouse strain

NO	nitric oxide
NOS	nitric oxide synthase
NTP	national toxicology programme
NTP TR	national toxicology programme technical report
OECD	Organisation for Economic Co-operation and Development
OFT	open field test
OR	odd ratio
OSI	oxidative stress index
PARP	poly (ADP-ribose) polymerase
P21	cyclin-dependent kinase inhibitor 1
P450scc	cholesterol side-chain cleavage enzyme
P53	tumour protein P53
PCNA	proliferating cell nuclear antigen
PD	power density
PDI	psychomotor development index
PECO	population, exposure, comparator and outcome
PEM	personal exposure meter
PGE2	prostaglandin E2
PND	postnatal day
PRISMA-ScR	preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews
REACH	registration, evaluation, authorisation and restriction of chemicals
RF	radiofrequency
RFR	radiofrequency radiation
RF-EMF	radiofrequency electromagnetic field
RL	reference level
ROS	reactive oxygen species
RR	relative risk
RWTH	Rheinisch-Westfälische Technische Hochschule Aachen
SAR	specific absorption rate
SCENIHR	European Commission Scientific Committee on Emerging and Newly Identified Health Risks
SCHEER	Scientific Committee on Health, Environmental and Emerging Risks
SDQ	strengths and difficulties questionnaire
SEM	source-exposure matrix
SF1	splicing factor 1
SOD	superoxide dismutase
SPOCK3	PARC (osteonectin), cwcv and kazal-like domains proteoglycan 3

SSM	Swedish Radiation Safety Authority
SR	scoping review
StAR	steroidogenic acute regulatory protein
STOA	European Parliament's Panel for the Future of Science and Technology
TAC	total antioxidant capacity
TETRA	terrestrial trunked radio
TSC	total sperm count
TST	tail suspension test
UE	user equipment
UHF	ultra-high frequencies
UMTS	universal mobile telecommunications system
UK	United Kingdom
V/m	volt/meter
VEGF	vascular endothelial growth factor
W/kg	watt/kilogram
WHO	World Health Organization

1. Introduction

1.1 Background

Recent decades have experienced an unparalleled development of technologies known as Information and Communications Technology (ICT), which include wireless communication used for mobile telephones and, for example, Wi-Fi using electromagnetic fields (EMF). The first generation of handheld mobile phones were available in the late 1980s. Subsequently, the second (2G), third (3G), and fourth (4G, Long-Term Evolution = LTE) generations dramatically increased their penetration rates in society, so that today there are more devices than inhabitants in Europe. In addition, Wi-Fi and other forms of wireless data transfer have become ubiquitous, and are globally available. At present we are starting to introduce the next generation of RF, 5G, on mobile networks. 5G is not new technology, but an evolution of already existing G1 to G4 technologies.

1.2 The exposure scenario

1.2.1 Present scenario of exposure

The different exposure situations that may occur with the intensive deployment of telecommunications was well described in Monograph 102 of the International Agency for Research on Cancer (IARC, 2013). Monograph 102 is concerned with non ionising radiation in the RF range of the electromagnetic spectrum, i.e. between 30kHz and 300 GHz, thus including the frequencies relevant to the present review.

The corresponding wavelengths (the distance between successive peaks of RF waves) range from 10 Km to 1mm, respectively. EMF generated by RF sources couple with the human body, which results in induced electric and magnetic fields and associated currents inside body tissues (IARC, 2013). Human exposures to radiofrequency electromagnetic fields (RF-EMF) can occur from use of personal devices (e.g. mobile telephones, cordless phones, Bluetooth, and amateur radios), from occupational sources (e.g. high-frequency dielectric and induction heaters, and high-powered pulsed radars), and from environmental sources such as mobile-phone base stations, broadcasting antennas, and medical applications.

For workers, most exposure to RF-EMF comes from near-field sources, whereas the general population receives the highest exposure from transmitters close to the body, such as handheld devices like mobile telephones. Exposure to high-power sources at work might involve higher cumulative RF energy deposited in the body than exposure to mobile phones, but the local energy deposited in the brain is generally lower.

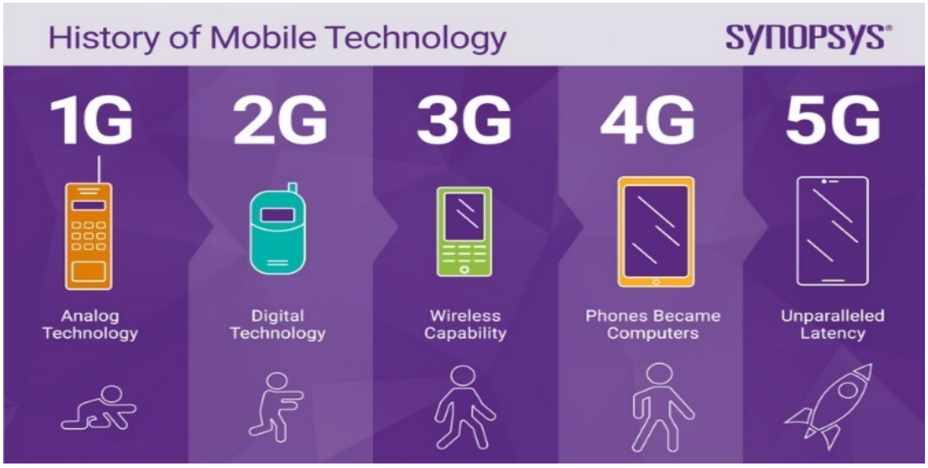
Typical exposures ofthe brain from rooftop or tower-mounted mobile-phone base stations and from TV and radio stations are several orders of magnitude lower than those from global systems for mobile communications (GSM) handsets. The average exposure from use of digital enhanced cordless telecommunications (DECT) phones is around five times lower than that measured for GSM phones, and third-generation (3G) phones emit, on average, about 100 times less RF energy than GSM phones, when signals are strong. Similarly, the average output power of Bluetoothwireless hands-free kits is estimated to be around 100 times lower than that of mobile phones.

EMFs generated by RF sources couple with the body, resulting in induced electric and magnetic fields and associated currents inside tissues. The most important factors that determine such induced fields are the distance of the source from the body and the output power level (IARC, 2013). The near field and far field are regions of the EMF around an object, such as a transmitting antenna, or the result of radiation scattering off an object. Non-radiative near-field behaviours dominate close to the antenna or scattering object (mobile phone), while electromagnetic radiation far-field behaviours dominate at greater distances (BC Center for Disease Control, 2013).

Additionally, the efficiency of coupling, and resulting field distribution inside the body, strongly depends on the frequency, polarisation, and direction of wave incidence on the body, and anatomical features of the exposed person, including height, bodymass index, posture, and dielectric properties of the tissues. Induced fields within the body are highly non-uniform,varying over several orders of magnitude, with local hotspots. Holding a mobile phone to the ear to make a voice call can result in high specific RF energy absorption-rate (Specific Absorption Rate = SAR) values in the brain, depending on the design and position of the phone and its antenna in relation to the head, how the phone is held, the anatomy of the head, and the quality of the link between the base station and phone. When used by children, the average RF energy deposition is two times higher in the brain and up to ten times higher in the bone marrow of the skull, compared with mobile phone use by adults. Use of hands-free kits lowers exposure to the brain to below 10% of the exposure from use at the ear, but it might increase exposure to other parts of the body (IARC, 2013).

1.2.2 The 5G scenario of exposure

Figure 1 – History of mobile technology



With the upcoming deployment of 5G mobile networks, significantly faster mobile broadband speeds and increasingly extensive mobile data usage will be ensured. Technical innovations include a different transmission system (MIMO: multiple-input and multiple-output antennas), directional signal transmission or reception (beamforming), and the use of other frequency ranges. This is made possible by the use of additional higher frequency bands (millimetre waves = MMW). 5G is intended to be the intersection of communications, from virtual reality to autonomous vehicles to the industrial internet and smart cities. In addition, 5G is considered the basic technology for the Internet of Things (IoT), where machines communicate with machines. At the same time, a change is expected in the exposure to EMF of humans and the environment (Figures 1 and 2).

Figure 2 – 3G vs 4G vs 5G

	3G	4G	5G
Deployment	2004-05	2006-10	2020
Bandwidth	2mbps	200mbps	>1gbps
Latency	100-500 milliseconds	20-30 milliseconds	<10 milliseconds
Average Speed	144 kbps	25 mbps	200-400 mbps

The 5G networks will work within several different frequency bands, of which the lower frequencies are being proposed for the first phase of 5G networks. Several of these frequencies (principally below 1 GHz - Ultra-High Frequencies, UHF) have been or are currently being used for earlier mobile communication generations. Furthermore, much higher RF are also planned to be used at later stages of the evolution of the technology.

The operating frequencies at low and mid bands can overlap with the current 4G band at 6 GHz or below. The biological effects of RF radiations at these lower-frequency bands are thus likely to be comparable to 2G, 3G or 4G. However, the scenarios of high band 5G, especially for 24 GHz to 60 GHz in the MMW region for high-capacity, short-range wireless data communications, are relatively recent new arrivals, and pose considerable challenge to health-risk assessment (Lin, 2020). These latter bands have traditionally been used for radar and microwave links (Simkò and Mattsonn, 2019) and very few have been studied for their impact on human health.

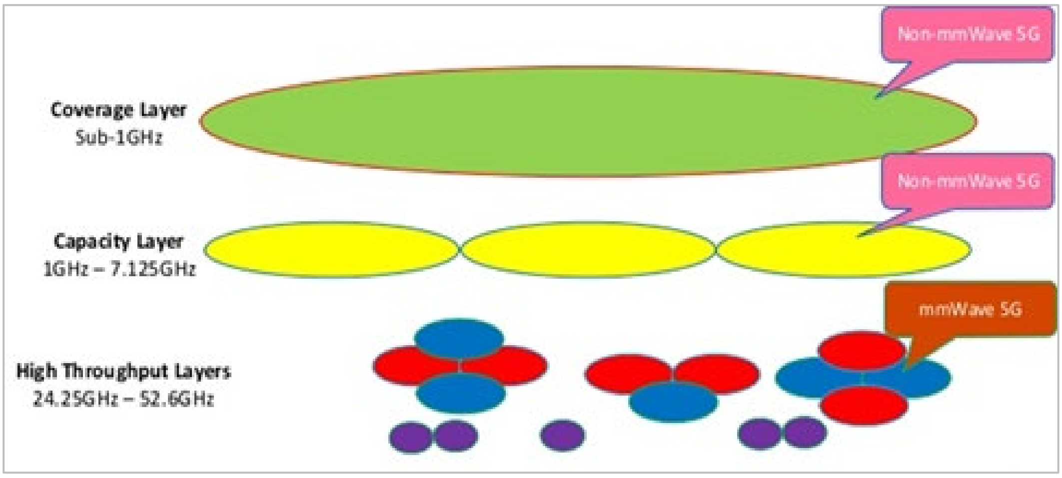
1.2.3 5G: beam forming and MIMO

The recent increase in cell-phone traffic over the microwave frequency band has shifted attention towards the broad MMW spectrum, which has hitherto been under-used. Up until 4G technology, cellular communication used frequencies below 3GHz and the idea that higher frequencies (greater than 3 GHz) incur more attenuation by physical obstacles tended to make the lesser frequencies seem more reliable. However, intelligent beamforming is improving the coverage and cutting interference to a minimum. The technique of dynamic radio masts employing beamforming, combined with multi-user MIMO (MU-MIMO), forms the basis of 5G NR (New Radio); working together they will enable over 1,000 more devices per square metre to be supported than with 4G, sending many more users ultra-fast data with high precision and low latency.

MIMO was originally developed for Single-User (SU-MIMO) applications so as to improve the efficiency of LTE (4G) networks. It was soon realised that such technology could be extended to Multi-User applications with a view to reducing or avoiding the problem of interference within a cell. This led to a series of solutions known as MU-MIMO (David and Viswanath, 2005). On the other hand, implementation of these inevitably raised queries as to the health impact. The European Parliament tackled the issue in a 2019 document concerning the state of advancement of 5G distribution in Europe, the US and Asia:

"Significant concern is emerging over the possible impact on health and safety arising from potentially much higher exposure to radiofrequency electromagnetic radiation arising from 5G. Increased exposure may result not only from the use of much higher frequencies in 5G but also from the potential for the aggregation of different signals, their dynamic nature, and the complex interference effects that may result, especially in dense urban areas. The 5G radio emission fields are quite different to those of previous generations because of their complex beamformed transmissions in both directions – from base station to handset and for the return. Although fields are highly focused by beams, they vary rapidly with time and movement and so are unpredictable, as the signal levels and patterns interact as a closed loop system. This has yet to be mapped reliably for real situations, outside the laboratory" (Blackman and Forge, 2019).

Figure 3 – 5G needs different frequency bands



Source: Qualcomm, 2020

5G will use a broad range of radio spectra (Fig.4). They divide into three distinct levels according to user need:

- the "*coverage layer*", with frequencies lower than 1GHz, provides broad outdoor coverage and deep indoor coverage. It basically consists of a frequency band used by digital television that performs well in penetrating obstacles. This system does not use beamforming, and in terms of management is similar to Radio Base Stations (RBS) using 4G technology, though possibly applying a corrective factor (peak power reduction coefficient) which takes account of the mean power used by the transmitting system;

- the "*coverage and capacity layer*", between 1GHz and 6GHz, is one of the major novelties of 5G. It uses the Massive – MIMO system to ensure an optimum compromise between coverage and capacity, i.e. the speed of data transfer per unit of frequency. It includes the band C spectrum, around 3.5 GHz. This non-millimetre frequency band operates in beamforming mode so as to concentrate most of the radiated power upon the target terminal;

- the "*super data layer*", from 6GHz up to MMW frequencies of 30 GHz and over, offers the breadth of band and data speeds required by the top-performing International Telecommunication Union Radiocommunication Sector (ITU-R) of the International Mobile Telecommunications (IMT)-2020 standard. This frequency band also uses the beamforming technique.

The main frequency bands for 5G standards taken up globally5G technology will not just be geared to communication among people, but also to interconnected automated systems (Internet of Things) using electromagnetic waves on a frequency belonging to the band 26.5-27.5 GHz. The frequency of such electromagnetic waves is so high that they are unable to penetrate buildings or get past obstacles. So 'solving' that difficulty calls for installation of many small cells of sizes ranging from about 10 metres (indoor) to several hundred metres (outdoor) - greatly inferior in range to the macro-cells of previous technologies which may extend for several kilometres. In Europe, the general picture might be summarised as reported in Fig. 4, 5 and 6 (Source: Qualcomm, 2020).

Figure 4 – 5G spectrum status by dashboard and auctions in Europe

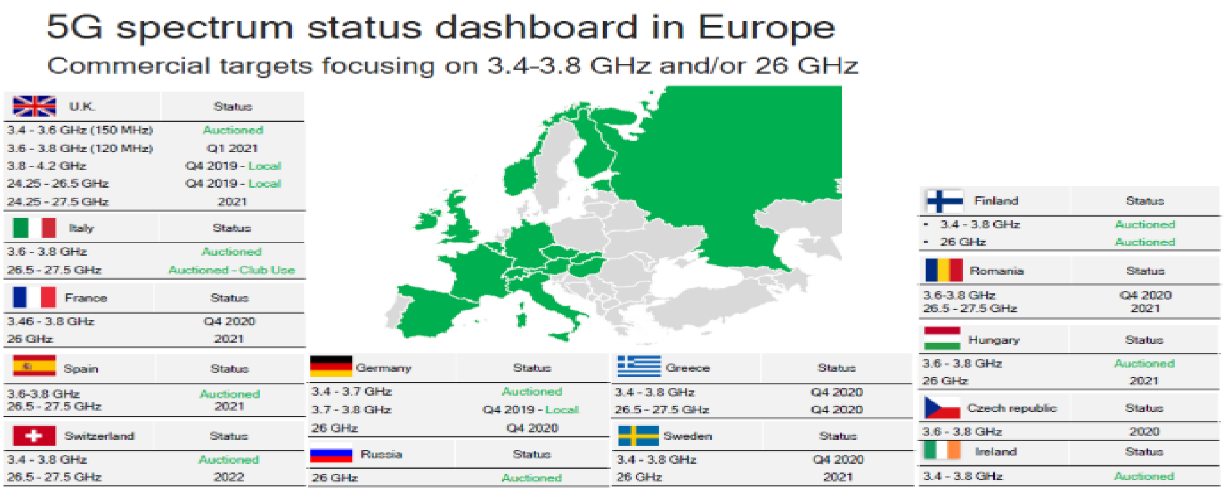


Figure 5 – 5G spectrum status by auctions in Europe (FR1: 700 MHz)

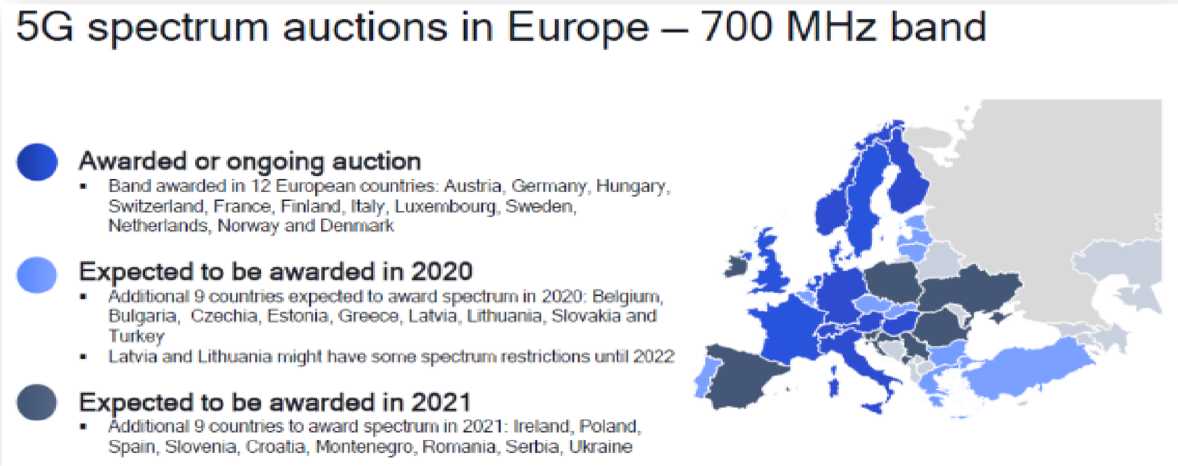


Figure 6 – 5G spectrum status by auctions in Europe (FR1: 3.4 -3.8 GHz)

Nasim and Kim (2017) simulates the possible exposure scenario to RF after 5G deployment using beamforming technology. The authors consider that at MMW frequencies, at which future mobile telecommunications systems will most likely operate, two changes that are likely to occur may increase concern as to the exposure of human users to RF fields. First, larger numbers of transmitters will operate. More base stations (BSs) will be deployed due to proliferation of small cells (Rappaport et al., 2013; Agiwal, 2016; Al-Saadeh, 2017) and mobile devices accordingly. This will increase the likelihood of human exposure to RF fields. Second, narrower beams will be used as a solution for the higher attenuation in higher frequency bands (Shakib, 2016; Zhang et al., 2017; Akdeniz et al., 2014). Very small wavelengths of MMW signals combined with advances in RF circuits enable very large numbers of miniaturised antennas. These multiple antenna systems can be used to form very high gains. The authors declare that their paper is motivated by the fact that previous works have not sufficiently addressed such a potential increase in risk. In their conclusions, the authors state*:*
"This paper has highlighted the significance of human RF exposure issue in downlink of a cellular communications system. This paper measured the exposure level in terms of PD and SAR, and compared them to those calculated in Release 9 as a representative of the current mobile communications technology. Unlike previous works that studied uplinks only, this paper has found that the downlinks of a 5G also yield significantly higher levels of PD and SAR compared to Release 9 [the present scenario of exposure]. Our results emphasized that the increase stems from two technical changes that will likely occur in 5G: (i)more access points (APs) due to deployment of smaller cells and (ii) morehighly concentrated RF energy per downlink RF beam due to use of larger phased arrays. As such, unlike prior work, this paper claims that RF fields generated in downlinks of 5G can also be dangerous inspite of far-field propagation. Therefore, the authors call for design of cellular communications and networking schemes that forcean AP to avoid generation of RF fields if pointed at a human user at an angle yielding a dangerous level of PD and SAR. To this end, the paper identifies as a future work developing the idea of techniques that reduce human exposure to RF fields in 5G downlinks" (Imtiaz and Seungmo, 2017).

It is noteworthy that this paper (Imtiaz and Seungmo, 2017) only referred to the 5G frequency of 28 GHz, one of the pioneer ones, with the simulation of only one user device connected, using the whole frequency band in static and stationary conditions.

Another paper (Baracca et al., 2018) from the Nokia group, taking into account massive MIMO base station (BSs), proposes a statistical approach for assessing the RF exposure conditions around massive MIMO BSs based on the 3D spatial channel model developed by the Third Generation Partnership Project (3GPP) and evaluates how the power is focused in a practical system when realistic assumptions regarding user equipment (UE) distribution and traffic models are taken into account. The methodology consists in performing system simulations that take into account realistic deployment scenarios in terms of installation height, user equipment, device distribution, and traffic, to evaluate the cumulative distribution function (CDF) of the BS actualtransmission power. "*The proposed statistical approach contributes to improve the calculation methods already defined by the International Electrotechnical Commission (IEC, 2017) and support the deployment of massive MIMO BSs for 5G and beyond cellular networks".*As a concluding remark, the Authors highlight that*: "All the statistical approaches including our own, although based on realistic assumptions, anyhow require complementary techniques, based for instance on power control and beamforming adaptation (*Sambo et al., 2015*), to ensure that the EMF constraints are met at the BSs for all the possible actual configurations*".

Regarding exposure assessment, Neufeld and Kuster (2018) issued a warning in a paper in Health Physics, urging that existing exposure standards be revised with shorter averaging times to address potential thermal damage from short and strong pulses: "*Extreme broadband wireless devices operating above 10 GHz may transmit data in bursts of a few milliseconds to seconds. Even though the time- and area-averaged power density values remain within the acceptable safety limits for continuous exposure, these bursts may lead to short temperature spikes in the skin of exposed people. ... [Our] results also show that the peak-to-average ratio of 1,000 tolerated by the ICNIRP guidelines may lead to permanent tissue damage after even short exposures, highlighting the importance of revisiting existing exposure guidelines*" (Neufeld and Kuster, 2018).

Kenneth Foster of the University of Pennsylvania, countered that their claims do not hold up: "*Because real-world communications technologies produce pulses of much lower fluence than the extreme pulses considered by Neufeld and Kuster, the resulting thermal transients from them will be very tiny in any event*" (Foster, 2019).

The Istituto Superiore di Sanità (Italian National Institute of Health) in the ISTISAN 2019 Report (available only in Italian) recognises that (translation by the author) : *"(…) on the basis of the technical characteristics of [5G] base stations, in order to correctly monitor the exposure, the mean value of measurements of electromagnetic fields should not be considered alone, but together with the maximum levels reached for short periods of exposure. This aspect calls for an updating of the national law which, up to now, has not considered short time exposures, but only continuous exposure as mean values within 6 minutes [20 V/m, occasional exposure] or 24 hrs [6V/m,residential/occupational exposure for more than 4hrs/day)"* (ISTSAN 19/11, 2019).

Uncertainty on exposure assessment remains unresolved. The above mentioned papers, shows that the question of exposure assessment with the introduction of 5G is complicated, above all concerning the monitoring of the continuous changes in activity of both base stations (BSs) and users (UEs) related to MIMO technology, while the technical position on exposure in the new scenario related to 2G, 3G, 4G, 5G emissions, is still being formulated and is hence uncertain. Exposure assessment constitutes a central matter of discussion before MMW and MIMO technology is disseminated all over the planet.

1.3 Overview of the policy action internationally and in Europe

1.3.1 International organisations

The International Agency for Research on Cancer (Baan et al., 2011; IARC, 2013) classified RF-EMF as "*possibly carcinogenic to humans*" (Group 2B).

The World Health Organization (WHO) recently relaunched a call for expressions of interest for systematic reviews (2020). The WHO is undertaking a health risk assessment of RF-EMF, to be published as a monograph in the Environmental Health Criteria Series. This publication will complement the monographs on static fields (2006) and extremely low frequency fields (2007), and will update the monograph on RF fields published in 1993 (WHO, 1993).

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) in March 2020 published new guidelines covering several new technologies, including 5G (ICNIRP, 2020a). The new guidelines introduce new and revised restrictions concerning 5G. On the ICNIRP website there is extensive information on the new guidelines and differences between the 1998 and 2020 guidelines. The guidelines refer only to thermal effects caused by 6 minutes and 30 minutes of exposure to RF-EMF, so the guidelines concern only short-term exposure. Safety guidelines for the currently deployed of 5G technology have been established though insufficient scientific research has yet been performed, while peer-reviewed science on non-thermal effects of RF already in use has not been evaluated in all ICNIRP guidelines (ICNIRP, 2020c).

1.3.2 European organisations and governments (by year)

The Council of Europe Resolution 1815 highlights that: "*The independence and credibility of the scientific expertise employed is crucial for a transparent and balanced assessment of possible negative effects on human health and environment. The resolution recommends: taking all reasonable measures to reduce exposure to EMF (especially from mobile phones) and particularly to protect children and young people who seem to be most at risk of developing head tumours; reconsidering the scientific basis for the present standards on exposure to electromagnetic fields set by the International Commission on Non-Ionising Radiation Protection, which have serious limitations; distributing information and awareness-raising campaigns on the risks of potentially harmful long-term biological effects on the environment and on human health, especially targeting children, teenagers and young people of reproductive age; giving preference to wired internet connections (for children in general and particularly in schools), and strictly regulating the use of mobile phones by schoolchildren on school premises; increasing public funding of independent research to evaluate health risks.*" (European Parliament Assembly, 2011)

The French Agency For Food, Environmental And Occupational Health and Safety (ANSES) in 2013, "(...) *issues recommendations for limiting exposure to radio frequencies limited levels of evidence do point to different biological effects in humans or animals. In addition, some publications suggest a possible increased risk of brain tumour, over the long term, for heavy users of mobile phones. Given this information, and against a background of rapid development of technologies and practices, ANSES recommends limiting the population's exposure to radiofrequencies – in particular from mobile phones – especially for children and intensive users, and controlling the overall exposure that results from relay antennas. It will also be further developing its work on electro-sensitive individuals, specifically by examining all the available French and international data on this topic that merits closer attention. Therefore, to limit exposure to radiofrequencies, especially in the most vulnerable population groups, the Agency recommends: - for intensive adult mobile phone users (in talk mode): use of hands-free kits and more generally, for all users, favouring the purchase of phones with the lowest SAR [values;- reducing the exposure of children by encouraging only moderate use of mobile phones; continuing to improve characterisation of population exposure in outdoor and indoor environments through the use of measurement campaigns; that the development of new mobile phone network infrastructures be subject to prior studies concerning the characterisation of exposures, and an in-depth study be conducted of the consequences of possibly multiplying the number of relay antennas in order to reduce levels of environmental exposure; - documenting the conditions pertaining at those existing installations causing the highest exposure of the public and investigating in what measure these exposures can be reduced by technical means; - that all common devices emitting electromagnetic fields intended for use near the body (DECT telephones, tablet computers, baby monitors, etc.) display the maximum level of exposure generated (SAR, for example), as is already the case for mobile phones; finally, in order to resolve the various uncertainties it identified when conducting this work, and in addition to the research projects already undertaken under the National Plan for Research on Environmental and Occupational Health, the Agency is also making a series of research recommendations"* (ANSES, 2013).

The European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) had a mandate to evaluate the risks of EMF and periodically reviews the scientific evidence available to assess whether it still supports the exposure limits proposed in Council Recommendation 1999/519/EC. In its latest opinion of January 2015, SCENIHR suggested that there is a lack of evidence that EMF radiation affects cognitive functions in humans or contributes to an increase of the cases of cancer in adults and children (SCENIHR, 2015). However, the International EMF Alliance (IEMFA) suggested that many members of SCENIHR could have a conflict of interests, as they had professional relationships with or received funding from various telecom companies.

Consequently, the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), replacing the former SCENIHR, indicated a preliminary estimate of the importance of 5G as high, in a statement in December 2018. Furthermore, it evaluates the scale, urgency and interactions (with ecosystems and species) of possible hazard as high. It suggested that there could be biological consequences from a 5G environment, due to the fact that there is a lack of "*(...) evidence to inform the development of exposure guidelines to 5G technology*" (SCHEER, 2018).

In a briefing of June 2017, the European Parliamentary Research Service stated: *"Finally, little research has been performed on the health impacts of 5G, as most of the studies to date relate to previous generation of mobile technology. According to one recent study, this could prove a further bottleneck should 5G pose health risks owing to, 'its urban concentration and dense cellular structure, its use of much higher microwave frequencies and its highly directional concentration'. In the USA a 2016 government-funded study raised concern, as in its preliminary results it found significantly greater rates of rare tumours of the brain and heart in rats exposed to wireless radiation. Other 2017 research and publications also suggest that long-term mobile phone use could increase brain cancer risk. However the latest opinion published by the Commission's expert group in 2015 and research by the World Health Organization do not recognise a direct link. In France, meanwhile, a review of wireless radiation has concluded that there is a need to evaluate all wireless devices for their impact on children's health and recommends only moderate and supervised use by children. This complex issue therefore remains controversial while further research is ongoing"* (EPRS, 2017).

A more recent EPRS document stated that: *"The recent academic literature illustrates that continuous wireless radiation seems to have biological effects especially considering the particular characteristics of 5G: the combination of MMW, a higher frequency, the quantity of transmitters and the quantity of connections. Various studies suggest that 5G would affect the health of humans, plants, animals, insects, and microbes – and as 5G is an untested technology, a cautious approach would be prudent" (EPRS, 2020).*

The Federal Office for Radiation Protection of Germany published a report, where is stated that: *"In a few years, 5G will lead to higher frequencies. However, the effects of these have not yet been well researched. The Federal Office for Radiation Protection advises a prudent expansion of 5G and will further explore the effects of the new frequency bands"* (FORPG, 2019).

In 2020, the EMF scientific council of the Radiation Safety Authority in Sweden (SSM), published its 14th report. This is a consensus report, which means that all members of the Scientific Council agree with the report in toto. Despite the fact that no health risks with weak EMF have been established to date, the Authority considers that: "*Further research is important, in particular regarding long-term effects as the entire population is exposed. One key issue here is to further investigate the relationship between radio wave exposure and oxidative stress observed in animal studies and to establish whether and to what extent it may affect human health. There is also a need to further investigate the observed decreased sperm counts, sperm viability and decreased serum testosterone due to radio wave exposure of testes in animal studies before any conclusions concerning the possible implications for human health can be drawn*" (SSM, 2020).

The Austrian Institute of Technology (AIT) states: "*1) Electromagnetic fields have already been considered a potential health risk with previous generations of mobile radio communication. In 2011, the International Agency for Research on Cancer (IARC) classified mobile phone radiation as "possibly carcinogenic". To this day, experts continue to discuss this topic with much controversy. 2) 5G, the latest generation of mobile phone networks, promises to transmit larger amounts of data with lower latency. Industry 4.0, augmented reality games or the Internet of things rely on such higher performance. 3) The assessment of risks and gaps of knowledge enables precautionary regulation and a prudent approach to 5G*" (Kastenhofer, 2020).

The Health Council of the Netherlands published its opinion on 5G and health in September 2020. A selection of quotes from the report are as follow: *"The rollout of 5G networks has only just begun. Therefore, there are no studies as yet into the health effects of (long-term) exposure to electromagnetic fields with the frequencies that are reserved for 5G"; "According to the committee, it cannot be excluded that the incidence of cancer, reduced male fertility, poor pregnancy outcomes and birth defects could be associated with exposure to RF electromagnetic fields. However, the committee deems the relationship between exposure and these and other diseases or conditions neither proven nor probable"; "There has been almost no research into the effects of exposure to frequencies around 26 GHz" ; "The committee recommends not using the 26 GHz frequency band for 5G for as long as the potential health risks have not been investigated"; "The committee recommends using the latest guidelines from the International Commission on Non-Ionising Radiation Protection (ICNIRP) as the basis for exposure policy in the Netherlands. Because it cannot be excluded that exposure under the latest ICNIRP standards also has the potential to affect health, the committee recommends taking a cautious approach and keeping exposures as low as reasonably achievable".* In this report, common adverse effects from RF exposure are reported, but as a conclusion the committee only recommends taking a cautious approach (Health Council of the Netherlands, 2020).

In Switzerland, the Federal Office for the Environment (FOEN) is the government body responsible for monitoring and assessing research on health effects of NIR from stationary sources in the environment. This includes informing and updating the public about the current state of research, which is the basis for the ambient regulatory limits stated in the Swiss "ordinance relating to protection from non-ionising radiation (NIR)". In the case of reliable new scientific knowledge and experiences, the FOEN would advise the Federal Council of Switzerland to adapt these ambient regulatory limits. The FOEN has therefore nominated a consultative group of Swiss experts from various disciplines with scientific competence regarding EMF and NIR, which commenced its work in July 2014. The group is called BERENIS, based on an acronym of the respective German term. The BERENIS experts regularly screen the scientific literature, and assess the publications which they consider relevant for the protection of humans from potentially adverse effects. As part of the work of BERENIS, non-ionising radiation (NIR) at frequencies below 10 GHz is addressed.

In the special issue of the BERENIS newsletter (BERENIS, 2021), an up-to-date assessment of a possible correlation between oxidative stress and exposure to EMF and their putative effects on health are presented. For this purpose, relevant animal and cell studies published between 2010 and 2020 were identified and summarised. An extended report presenting these recent studies in more detail will be published soon by FOEN 1 (not yet available at the time of this report). The newsletter contains a short version of the report, writing that: "*The majority of the animal and more than half of the cell studies provided evidence of increased oxidative stress caused by RF-EMF (...). This notion is based on observations in a large number of cell types, applying different exposure times and dosages (SAR [Specific Absorption Rate] or field strengths), also in the range of the regulatory limits.*". This review of the literature evidences that one of the mechanisms underlying adverse effects from RF-EMF is oxidative stress, forming free radicals that impair a number of different functions (Yakymenko, 2016).

1.4 Biologically effects other than the ones analysed in this review (both FR1 and FR2)

The present review examines only carcinogenicity and reproductive/developmental adverse effects related to RF exposure observed in epidemiological and laboratory animal studies, published since 1945. However, in order to better understand the impact of RF on human health, we cannot ignore the fact that other biological non thermal effects have been reported. For instance, we need only cite the preponderance of research published from 1990 through 2020, which has found various significant effects from exposure to radio frequency radiation. Overall, 75% (n=711) of 944 analysed radio frequency radiation studies have reported biological effects (Moskowitz, 2018).

The National Toxicology Program (NTP) found that RF-EMF exposure was associated with an increase in DNA damage. Specifically, they found RF-EMF exposure was linked with significant increases in DNA damage in the frontal cortex of the brain in male mice; the blood cells of female mice, and the hippocampus of male rats. There are many factors that influence whether damaged DNA will lead to tumours. NTP plans to conduct additional studies to learn more about how RF-EMF might cause DNA damage (Smith-Roe et al., 2019). Other adverse effects were observed in the NTP studies, including reduced birth weights, DNA strand breaks in brain cells, which is supportive of the cancer findings (Yakymenko, 2015), increased incidences of proliferative lesions (hyperplasia), and exposure-related increases in the incidence of cardiomyopathy of the right ventricle in male and female rats (NTP, 2018).

MMWs rarely included in the above mentioned studies have specific characteristics. MMWs are mostly absorbed within 1 to 2 millimetres of human skin and in the surface layers of the cornea. Thus, the skin or near-surface zones of tissues are the primary targets of such radiation. Since the skin contains capillaries and nerve endings, MMW bio-effects may be transmitted through molecular mechanisms by the skin or through the nervous system. Thermal (or heating) effects occur when the power density of the waves is above 5–10 mW/cm2 (Foster, 1998).

Such high-intensity MMWs act on human skin and the cornea in a dose-dependent manner—beginning with heat sensation followed by pain and physical damage at higher exposures. Temperature elevation affects the growth, morphology and metabolism of cells, induces production of free radicals, and damages DNA. Few studies have examined prolonged exposure to low-intensity MMWs, and no research has focused on exposure to MMWs combined with other RF radiation. Some studies reported that the radiation inhibits cell cycle progression, and some studies reported no biological effects (Le Drean et al., 2013).

(Ramundo-Orlando, 2010) noted that: "*A large number of cellular studies have indicated that MMW may alter structural and functional properties of membranes*". Exposure to MMWs may affect the plasma membrane either by modifying ion channel activity or by modifying the phospholipid bilayer. Water molecules also seem to play a role in these effects. Skin nerve endings are a likely target of MMWs and the possible starting point of numerous biological effects. MMWs may activate the immune system through stimulation of the peripheral neural system (Ramundo-Orlando, 2010).

In 1998, scientists employed by U.S. Army research institutes published a seminal review of the research on MMWs. They reported: "*Increased sensitivity and even hypersensitivity of individual specimens to MMW may be real. Depending on the exposure characteristics, especially wavelength, a low-intensity MMW radiation was perceived by 8 to 30% of healthy examinees (Lebedeva, 1993, 1995). Some clinical studies reported MMW hypersensitivity, which was or was not limited to a certain wavelength (Golovacheva, 1995). It should also be realized that biological effects of a prolonged or chronic MMW exposure of the whole body or a large body area have never been investigated. Safety limits for these types of exposures are based solely on predictions of energy deposition and MMW heating, but in view of recent studies this approach is not necessarily adequate*" (Pakhomov et al., 1998).

In 1977, Zalyubovskaya published a study which examined the effects of exposing mice to millimetre radiation (37-60 GHz; 1 milliwatt per square centimetre) for 15 minutes daily for 60 days. The animal results were compared to a sample of people working with millimetre generators. The summary of the paper reports: "*Morphological, functional, and biochemical studies conducted in humans and animals revealed that millimeter waves caused changes in body manifested in structural alteration in the skin and internal organs, qualitative and quantitative changes in the blood and bone marrow composition and changes of the conditioned reflex activitiy, tissue respiration, activity of enzymes participating in the processes of tissue respiration and nucleic metabolism. The degree of unfavorable effect of millimeter waves depends on the duration of the radiation and individual characteristics of the organism*" (Zalyubovskaya, 1977).

Microbes are also affected by MMW radiations. In 2014 a review on the effects of MMWs on bacteria was published. The authors summarised their findings as follows: "(…) *bacteria and other cells might communicate with each other by electromagnetic field of sub-extremely high frequency range. These MMW affected Escherichia coli and many other bacteria, mainly depressing their growth and changing properties and activity. These effects were non-thermal and depended on different factors. The consequences of MMW interaction with bacteria are the changes in their sensitivity to different biologically active chemicals, including antibiotics. These effects are of significance for understanding changed metabolic pathways and distinguish the role of bacteria in the environment; they might be leading to antibiotic resistance in bacteria.These effects are of significance for understanding changed metabolic pathways and distinguish the role of bacteria in the environment; they might be leading to antibiotic resistance in bacteria"* (Adebayo et al., 2014).

"Changing the sensitivity of bacteria to antibiotics by MMW irradiation can be important for the understanding of antibiotic resistance in the environment. In this respect, it is interesting that bacteria [that] survived near telecommunication-based stations like Bacillus and Clostridium spp. have been found to be multidrug resistant" (Soghomonyan et al., 2016).

In a recently published paper,it was) found that: "*Taken together, MW-irradiated water [pulsed 3.5GHz high power] microwaves irradiation can alter cellular physiology noticeably, whereas irradiated media and buffered saline solutions induce negligible or irrelevant changes that do not affect cellular health"* (Bhartiya et al., 2021).

Yet we know that athermal bio-responses exist. Indeed, some frequencies are already being used for therapeutic purposes in a number of branches of medicine. These include nerve regeneration, wound healing, graft behaviour, diabetes, and myocardial and cerebral ischaemia (heart attack and stroke), among other conditions. Some studies even suggest possible benefits in controlling malignancy. Low-intensity, intermediate-frequency, alternating electric fields (tumour-treating fields) that target dividing cells in glioblastoma multiforme (brain malignant tumour) while generally not harming normal cells, are used for therapy purposes (Guo et al., 2011; Zimmerman et al., 2013; Alphandéry, 2018).

Since any drug, may also entail some adverse effects, non-thermal adverse effects of RF-EMF should also be considered for risk assessment. In sum, the peer-reviewed research shows that short-term exposure MMW radiation not only affects human cells, it may also result in changes in sensitivity of bacteria harmful to humans, and to various biologically active chemicals, including antibiotics.

Since little research has been conducted on the health consequences from long-term exposure to MMWs, widespread deployment of 5G infrastructure constitutes a massive experiment that may have adverse impacts on public health. Unfortunately, few studies have examined prolonged (long-term) exposure to low-intensity MMWs, and no research that we are aware of has focused on exposure to MMWs combined with other RF radiation.

1.5 Social conflict related to 5G

Another aspect of the 5G discussion is social polarisation. Currently, both activists for the 'Stop 5G' movements and 5G promoters claim there are thousands of studies on the health effects of RF used in wireless communication and their related EMF. Activists claim that studies show a lot of different harmful health effects, 5G promoters claim that studies do not show any adverse health effects. Both sides refer to the EMF Portal, a specialized database in Germany: "*The internet information platform EMF-Portal of the RWTH Aachen University summarizes systematically scientific research data on the effects of electromagnetic fields (EMF). All information is made available in both English and German. The core of the EMF-Portal is an extensive scoping database with an inventory of 32,119 publications and 6,805 summaries of individual scientific studies on the effects of EMF*" (EMF Portal homepage). The number of 32.119 publications (October 20, 2020) includes the studies of all types of biological and technical end points on all EMF originating from RF. However, the collection of 5G MMW frequencies-related studies is scanty (around 100) and, for the most part, regards technical/dosimetric studies. As a consequence, both claims, presence or lack of harms, about 5G MMW safety are based on assumption, not on scientific evidence.

The issue of social conflict is well developed by Leszczynski (2020). It is evident that the scenario in which 5G should be exploited is full of uncertainty on one side, denial on the other, and exaggerated alarmism in yet another.

2. Aims of the study and methodology

This review aims to evaluate the current state of knowledge on non-thermal effects regarding both the carcinogenic and the reproductive/developmental hazards of RF-EMF exploited by 5G as they emerge from in vivo experimental studies and epidemiological studies, considering separately the frequencies 700-3600 MHz and 26,000 MHz.

2.1 Rationale

This review of the currently available scientific evidence focuses on both the carcinogenic and the reproductive/developmental effects of RF from mobile phone telecommunications systems using 2-5G networks, based on both in vivo animal studies and human epidemiological studies.

The studies evaluated have been divided into 2 groups:

1) Studies evaluating health effects due to RF at the lower frequency range (FR) (FR1: 450 to 6000 MHz), which also includes the frequencies used in existing 2-4 generations of the broadband cellular network. The current evidence from 1G-4G studies is the best evidence currently available. The studies were evaluated using narrative methods.

2) Studies evaluating health effects due to RF at the higher frequency range (FR2: 24 to 100 GHz - MMW). The higher frequencies are new, previously not used for mobile communication and specific for the new 5G technology, which have particular physical characteristics and interactions with biological matter (lower penetration, higher energy, etc.): they were considered separately with a scoping review method.

Scoping reviews have great utility for evaluating research evidence and are often used to categorize or group existing scientific evidence in a given field in terms of its nature, quality, other features, and volume. This scoping review was performed assuming the principles of transparency, reproducibility and rigour. This was achieved by adopting the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) as the methodological framework of this work. At least two reviewers worked independently on every stage of this review: uniformity and standardisation in decision making was obtained through discussion and consensus-reaching among the reviewers. A distinction is made between the narrative review (FR1) and the scoping review (FR2), but the selection and assessment criteria indicated for scoping reviews were adopted for both searches and for including/excluding studies on the cancer and reproductive/developmental biological end-points.

2.1.1 Cancer

Epidemiological studies are potentially susceptible to several different sources of error. Study quality was assessed as part of the review process and all informative studies were considered. The informativeness of a study is its ability to show a true association, if there is one, between the agent and cancer, and the lack of an association, if no association exists. Key determinants of informativeness include: having a study population of sufficient size to obtain precise estimates of effect; sufficient time elapsing from exposure to measurement of outcome for the effect, if present, to be observable; presence of an adequate exposure contrast (intensity, frequency, and/or duration); biologically relevant definitions of exposure; and relevant and well-defined time windows for exposure and outcome (IARC Preamble, 2019).

As explained in the IARC Preamble, most human carcinogens that have been studied adequately for carcinogenicity in experimental animals have produced positive results in one or more animal species. For some agents, carcinogenicity in experimental animals was demonstrated before epidemiological studies identified their carcinogenicity in humans. Although such observation cannot establish that all agents that cause cancer in experimental animals also cause cancer in humans, it is biologically plausible that agents for which there is sufficient evidence of carcinogenicity in experimental animals should present a carcinogenic hazard to humans (IARC Preamble, 2019).

All available long-term studies of cancer in experimental animals on RF-EMF were considered in the review, after a thorough evaluation of the study features. Those studies that we judged to be irrelevant to the evaluation or judged to be inadequate (e.g. too short a duration, too few animals, poor survival; exposure assessment, etc) were omitted. Guidelines for conducting long-term carcinogenicity experiments have been published (e.g. OECD, 2018a) and their criteria were considered as a reference for assessing the adequacy of studies.

As concerns cancer-related studies on RF, both epidemiological and experimental, comprehensive reviews of the literature had already been performed in the last decades; in particular, we refer to the IARC Monograph 102, which dealt with the RF range 30 kHz-300 Ghz. In May 2011, 30 scientists from 14 countries met at IARC in Lyon, France, to assess the carcinogenicity of RF-EMF. These assessments were published as Volume 102 of the IARC Monographs. A summary of the conclusions of the Working Group and the rationale for the evaluation together with the studies supporting the conclusions was published in May 2011 (Baan et al., 2011), the full Monograph was published in April 2013 (IARC, 2013).

Preparation of the IARC Monograph on RF was scheduled so as to include the results of the large international case-control study INTERPHONE on mobile phone use (performed in 2003-2004; published in 2010). We thus decided to adopt the IARC publication Monograph 102 (IARC, 2013) as a 'key reference' upon which to update the 2011 data to the year 2020 and hence produce the present report. After collecting and examining the original works related to the IARC 2011 analyis, published in 2013, and cited throughout as (IARC, 2013) considering their assessment criteria so as to conform to them in later assessments, we collected all relevant works dating from 2011 on, following the same criteria.

Once we had selected and examined the literature available according to the criteria described below, consistent with a scoping review, we updated the IARC (2013) tables to 2020. The studies selected, in abstract form, are included in the text, and tables in the "Assessment of individual studies" chapter, divided by end-point studied and by study characteristics. Each study is numbered in the same sequence in both abstract and corresponding table. In the summary tables, the studies are classified without specific comments, but only as adequate/inadequate for sample size, study design, exposure assessment and, when adequate, positive/negative/equivocal results:

- *Adequate*: no major qualitative or quantitative limitations.
- *Inadequate*: major qualitative or quantitative limitations affect the study, not valid for showing either the presence or absence of specific adverse effects.

When adequate:

- *Positive*: statistically significant increase of the specific pathology in association with RF-EMF exposure.
- *Equivocal:* adverse effect is demostrated showing a marginal increase (not statistically significant increase) of the specific pathology that may be associated with RF-EMF.
- *Negative*: no RF-EMF-related increases in specific pathologies.

2.1.2 Reproduction/development

Since no adequate, major review of studies on the reproduction/development effects exists to this date, such a review of all studies published between 1945 and 2020 was performed. Once we had selected and examined the literature according to the criteria described below, we summarized data up to 2020 in specific tables.

Regarding animal studies, in order to select informative studies only, another selection of studies was based on the guidelines NTP Modified One Generation Study and OECD 443, assessed in 2014 (Foster et al., 2014), planned in order to study experimental animals (rodents) for evidence of developmental pathology, endocrine disrupters, female reproduction, male reproduction, the reproductive system. The guideline study design envisages at least 10 animals/sex/group in order to produce statistically robust results.

The abstracts of the selected studies are included in the text and tables in the 'Assessment of individual studies' chapter, divided according to end-point studied and the study characteristics. Each study is numbered and presented in the same sequence of the corresponding table. In the summarising tables, the studies are classified without specific comments, but only as adequate/ inadequate for sample size, study design, exposure assessment and, when adequate, positive/negative/equivocal results:

- *Adequate*: no major qualitative or quantitative limitations.
- *Inadequate*: major qualitative or quantitative limitations affect the study, not valid for showing either the presence or absence of specific adverse effects.

When adequate:

- *Positive*: statistically significant increase of the specific pathology in association with RF-EMF exposure.
- *Equivocal:* adverse effect is demostrated showing a marginal increase (not statistically significant increase) of the specific pathology that may be associated with RF-EMF.
- *Negative*: no RF-EMF-related increases in specific pathologies.

2.2 Search strategy

First a selection of the most appropriate keywords was performed:

Exposure: EMF; RF; 5G; radiofrequency radiation; radiofrequency; electromagnetic field; electromagnetic radiation.

Population (animal): in vivo; experimental; animal; rodent(s); rat(s); mouse; mice.

Population (human): epidemiological; observational; cross-sectional; case-control; worker(s); military; population.

Outcome (carcinogenic effects): cancer; tumour.

Outcome (reproductive effects): reproductive; development; fertility; sperm; ovary; pregnancy; ano-genital; estrus.

Based on the keywords, the following search strings were prepared to collect any studies of interest from PubMed, a major database that comprises more than 30 million citations for biomedical literature from MEDLINE, life science journals, and online books. Citations may include links to full-text content from PubMed Central and publisher web sites.

Studies on Humans, Carcinogenic effects

((epidemiologic* OR observation* OR "cross sectional" OR "case control" OR worker OR military OR population OR child OR employ*) AND (EMF OR RF OR 5G OR "radiofrequency radiation" OR radiofrequency OR "electromagnetic field" OR "electromagnetic radiation") AND (cancer OR tumour)) NOT (therapy OR ablation).

In vivo studies (rodents), Carcinogenic effects

(("in vivo" OR experimental OR animal OR rodent* OR rat OR mouse OR mice OR hamster* OR rabbit*) AND (EMF OR RF OR 5G OR "radiofrequency radiation" OR radiofrequency OR "electromagnetic field" OR "electromagnetic radiation") AND (cancer OR tumour)) NOT (therapy OR ablation)

Studies on Humans, Reproductive- developmental effects

((epidemiologic* OR observation* OR "cross sectional" OR "case control" OR worker OR military OR population OR child OR employ*) AND (EMF OR RF OR 5G OR "radiofrequency radiation" OR radiofrequency OR "electromagnetic field" OR "electromagnetic radiation") AND (reproductive OR development OR fertility OR sperm OR ovary OR pregnancy OR "ano genital" OR estrus)) NOT (therapy OR ablation)

In vivo (rodents) and Reproductive- developmental effects

(("in vivo" OR experimental OR animal OR rodent* OR rat OR mouse OR mice OR hamster* OR rabbit*) AND (EMF OR RF OR 5G OR "radiofrequency radiation" OR radiofrequency OR "electromagnetic field" OR "electromagnetic radiation") AND (reproductive OR development OR fertility OR sperm OR ovary OR pregnancy OR "ano genital" OR estrus)) NOT (therapy OR ablation).

We systematically searched the electronic academic database PubMed and the EMF Portal for potentially eligible records. The PubMed search occurred on 24 February 2020 for epidemiological and experimental carcinogenicity studies, and on the 20 July 2020 for epidemiological and experimental studies on reproductive outcomes - all searches being updated on the EMF Portal in January 2021. The first 100 results obtained from Google and Google Scholar were evaluated to check for any relevant, non-duplicate results. We also checked the bibliographies of the studies selected for the same purpose. Finally, we asked experts in the field to revise our lists and suggest any additional relevant studies.

2.3 Selection of the relevant literature

The "Population, Exposure, Comparator and Outcome" criteria (PECO Statement, Morgan et al. 2018) was adopted to clearly define the scope of this work and consequently the criteria for the selection of literature according to:

Population: RF-exposed population from in vivo studies, in particular experimental bioassays on rodents, as they represent the most predictive models for human health, and workers and the general population included in epidemiological studies;

Exposure: exposure to RF used in 5G networks, in particular the frequencies that were established as standard for use by the European Union: 450 MHz to6 GHz, and 24 to 100 GHz.

Comparator: untreated population (controls) from experimental bioassays on rodents, and, where this was available, groups of healthy or not exposed controls from epidemiological studies;

Type of outcome: health effects of particular concern that have been associated with the exposure to RF, namely reproductive effects, and carcinogenicity effects (Vornoli et al., 2019).

We considered all types of study design for the review; non-original studies, letters, and comments were not considered. Peer-reviewed articles in English, published from 1945 to January 2021 were considered. English is the most widely used language for scientific publications, and papers in other languages usually have an abstract available in English.

2.4 Screening process

The screening process was performed using the online systematic review app Rayyan QCRI. Selection of the literature was performed by two reviewers independently examining all references in two steps: in the first, the decision on exclusion/inclusion was based on title and abstract; in the second, the full texts of the potentially relevant articles were examined thoroughly to verify conformity with the aforementioned PECO criteria. At the second stage of selection, all inclusion/exclusion decisions and all doubts were discussed, solved and agreed upon by the two reviewers. Results of the selection process are illustrated in the following sections using PRISMA flow diagrams (Moher et al., 2009).

2.5 Extraction of information from the relevant literature

It was decided to use two different data-charting forms to extract information from the selected literature, since epidemiological and experimental studies have very different characteristics and peculiarities that need to be accounted for. The tools were chosen to achieve a complete and standardized collection of all information relevant to evaluating the conduct of the study, the exposure assessment and the health effects. The data chart for epidemiological studies was based on the one used for the series of reviews performed to elaborate, perfect and test the *WHO/ILO joint methodology for estimating the work-related burden of disease and injury* (Mandrioli et al, 2018; Sgargi et al., 2020). The data chart for experimental studies was based on the format used in IARC Monographs to evaluate carcinogenicity.

Both forms are validated tools, proven providers of exhaustive data on relevant literature. Calibration and uniformity was obtained through several rounds of independent blind trial extraction, discussion, and reaching of consensus among reviewers.

For epidemiological studies, a wide set of information was extracted, namely:
Ref ID; Type of study; Mode of data collection; Country; Year; N; Sex; Age; Occupation; Source of exposure; Duration of exposure; Frequency of exposure; Intensity of exposure; Any other co-exposure/adjustments; Method for exposure assessment; Observed health effects; Measure of observed health effects; Results; Conclusions; Authors; Affiliations; Conflict of interest; Funding.

For experimental studies, the extracted items from the literature were the following:
Reference ID; Type of study; Strain, Species (Sex); Exposure duration; Frequency; Intensity; Any other co-exposure; Exposure time - No of animals; Increased tumour incidence

The information was extracted by reviewers independently, and then double-checked by all reviewers and a senior expert.

2.6 Evidence synthesis

In finally assessing the results of the review for both epidemiological and experimental study, and for cancer and reproductive/developmental outcomes, we took into account the parameters indicated in (IARC Preamble, 2019), tailored to the needs of the present report, and valid for both end points (i.e. cancer and reproductive/developmental effects):

Sufficient evidence: A causal association between exposure to RF-EMF and the specific adverse effect has been established. That is, a positive association has been observed in the body of evidence on exposure to the agent and the specific adverse effect in studies in which chance, bias, and confounding factors were ruled out with reasonable confidence.

Limited evidence: A causal interpretation of the positive association observed in the body of evidence on exposure to RF-EMF and the specific adverse effect is credible, but chance, bias, or confounding factors cannot be ruled out with reasonable confidence.

No evidence: There are no data available or evidence suggesting lack of adverse effects (to be specified).

2.7 Overall evaluation of the present review

The results of the review for both cancer and reproductive/developmental outcomes, were finally assessed according to the criteria indicated in (IARC Preamble, 2019), tailored to the needs of the present report. Figure 8 presents the streams of evidence used for reaching the overall classification by IARC. The reasoning that the IARC used to reach its evaluation is summarised, so the basis for the evaluation offered is transparent. The IARC Monograph Preamble integrates the major findings from studies of cancer in humans, cancer in experimental animals, and mechanistic evidence (IARC Preamble, 2019).

The IARC criteria regard cancer, but equally apply to assessment of effects on reproductive /developmental parameters. Mechanistic evidence was not considered in the present review, so we integrated the results for cancer and reproductive/developmental effects in humans solely with the results for cancer and reproductive/developmental effects in experimental animals, using the criteria indicated in Figure 9.

Figure 7 – IARC criteria for overall classifications (the evidence in bold italic represents the basis of the overall evaluation) (Source: IARC Preamble, 2019)

Stream of evidence			Classification based on strength of evidence
Evidence of cancer in humans[a]	**Evidence of cancer in experimental animals**	**Mechanistic evidence**	
Sufficient	Not necessary	Not necessary	Carcinogenic to humans (Group 1)
Limited or Inadequate	Sufficient	Strong (b) (1) (exposed humans)	
Limited	Sufficient	Strong (b) (2-3), Limited or Inadequate	Probably carcinogenic to humans (Group 2A)
Inadequate	Sufficient	Strong (b) (2) (human cells or tissues)	
Limited	Less than Sufficient	Strong (b) (1-3)	
Limited or Inadequate	Not necessary	Strong (a) (mechanistic class)	
Limited	Less than Sufficient	Limited or Inadequate	Possibly carcinogenic to humans (Group 2B)
Inadequate	Sufficient	Strong (b) (3), Limited or Inadequate	
Inadequate	Less than Sufficient	Strong (b) (1-3)	
Limited	Sufficient	Strong (c) (does not operate in humans)[b]	
Inadequate	Sufficient	Strong (c) (does not operate in humans)[b]	Not classifiable as to its carcinogenicity to humans (Group 3)
All other situations not listed above			

[a] Human cancer(s) with highest evaluation.
[b] The *strong evidence that the mechanism of carcinogenicity in experimental animals does not operate in humans* must specifically be for the tumour sites supporting the classification of *sufficient evidence in experimental animals*.

Figure 8 – Criteria for overall evaluation in the present review (FR1 and FR2)

Evidence in humans	Evidence in experimentalanimals	Evaluation based on strengh of evidence
Sufficient	Not necessary	Clear association between exposure and the adverse effect
Limited	Sufficient	Probable association between exposure and the adverse effect
Limited	Less than sufficient	Possible association between exposure and the adverse effect
Inadequate	Inadequate or limited	Not classificable

3. Limitations of the present review

3.1 Assessment of individual studies

Experimental studies adopt a standardised methodology, following specific guidelines, making it much easier to assess the individual outcomes and evaluate the quality of the study and of the results. Blinded assessment of outcomes, adequacy of the sample size, and appropriateness of statistical analysis were also evaluated and reported for each study, when available. We selected and analysed animal studies considering their compliance with the pertinent guidelines.

As regards epidemiological studies, errors of recall are a systematic danger with epidemiology affecting retrospective studies when participants are interviewed or compile questionnaires about exposure that occurred in the past. Usually the problem is that people's memories may be inaccurate or incomplete; this becomes a serious problem in case-control studies, where cases, whose health was affected, are likely to be more conscious and clear about past exposure, whereas controls are often less aware and remember less precisely. This may increase or diminish the cause-effect relation observed.

3.2 Exposure assessment

Exposure assessment is a critical issue in epidemiological studies of RF from mobile communication, as it can be very demanding and, when not up to the highest standards, can render the findings uninformative. We excluded studies which do not contribute any useful information due to shortcomings in their conduct and analysis.

Recall bias, as mentioned in the previous section, may be a major issue in all case-control studies with self-reported exposures. Furthermore, substantial misclassification is often a concern in studies where exposure assessment is based on job titles alone or mobile phone subscriptions alone; in such cases, this was merely an estimate of the exposure. For a meaningful interpretation, we tried to evaluate all original reports objectively, comprehensively and consistently, following a standardised method, but without presuming that our review could compete with any systematic review by a specific working group.

For experimental studies, the comparability of the procedures for dealing with the exposed and control groups, including sham exposure, quality of the exposure system and dosimetry, possibility of thermal effects due to tissue heating, were considered for achieving a correct analysis.

As described in the report, the frequencies are (amongst other things) related to depth of penetration into tissues, but other dimensions of exposure may also affect health outcomes. Given certain new features of 5G (MIMO, beamforming) and the related and acknowledged uncertainties regarding exposure and exposure assessment, it is questionable wether the studies on 1G-4G can be directly generalized to 5G (even when using the same frequencies, here FR1). These uncertainties in exposure characterisation will impact on exposure assessment for new studies (particularly for epidemiological studies on 5G, here FR2), and, in terms of risk assessment, some metrics of exposure to RF-EMF and associated adverse health outcomes (suggested or established) could be different. These considerations should not detract from the fact that the current evidence from 1G-4G studies is the best evidence available.

Experimental investigations also include studies that used a mobile phone in GSM mode with an active call at small distances from the animal's body. Active call mode is usually maintained throughout the experiment; the control group (sham exposed group) is treated with the mobile phone switched off. The exposure depends on the quality of the connection with the base station and exposure is measured throughout the study; we considered this kind of study adequate in terms of exposure assessment as they simulate the human counterpart situation.

3.3 Limits for a systematic review on 5G frequencies

STOA asked the author to collect the information available on the impact of 5G frequencies on health. The original aim was to follow the criteria of a systematic review, but we soon realized there are no adequate studies on millimetric waves for the relevant end points. We thus agreed to perform a narrative review of the lowest frequencies (FR1) already assessed by authoritative working groups at least for carcinogenic effects down to 2011, and a scoping review on millimetric waves (FR2) which, as expected, produced no adequate results. However, the review methodology (the scoping review) was kept same for both FR1 and FR2 outcomes.

3.4 Overall evaluation

A scoping review (SR) requires strong subject matter expertise in several disciplines. The assessment of individual studies represented a great challenge for the scientists involved in the review. A systematic assessment would require a full and in-depth review of the underlying studies. This is beyond the scope of this document, which is prepared for, and addressed to, the Members and staff of the European Parliament as background material to assist them in their parliamentary work.

The evaluation criteria adopted by the IARC as described in its Preamble (IARC Preamble, 2019) were tailored to and used for both cancer and reproductive /developmental effects. We used these consolidated criteria in order to work in complete transparency and allow reviewers to check our work.

This report was written by Dr Fiorella Belpoggi, an expert on RF-EMF, experimental carcinogenesis and experimental studies on reproductive and developmental health outcomes. The author was supported by experts with expertise in systematic/scoping review methodology (DM), biostatistics (DS), cancer research (AV), exposure assessment (FaB) and human reproduction and development (CF, AG). Together, the team fields strong expertise in most domains required for this review, perhaps with some room for improvement in cancer epidemiology.

4. Assessment of individual studies

4.1 Carcinogenicity by frequency range

4.1.1 Cancer in epidemiological studies: Studies evaluating health effects due to RF at a lower frequency range (FR1: 450 to 6000 MHz), which also includes the frequencies used in previous generations' broadband cellular networks (1G-4G)

The articles identified through database searching and other sources were 950. After removal of duplicates (20) and excluding non-pertinent articles (685) based on title and abstracts, 245 articles remained. Based on full-text screening, 90 papers were further excluded, so that the articles with appropriate frequencies to be included in this qualitative synthesis were 155.

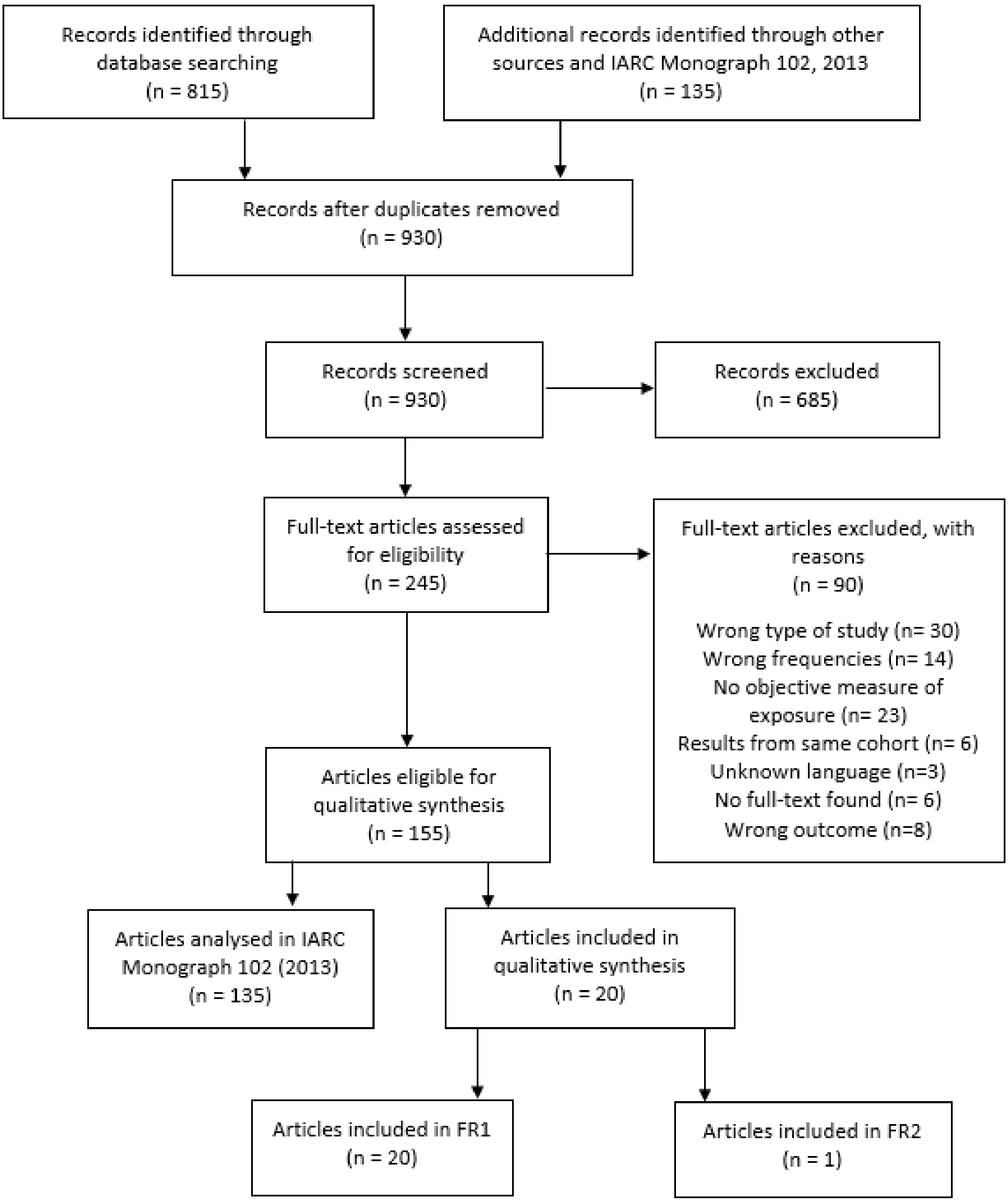
As further explained in the methodology section, we considered IARC (2013) as our key reference for all studies published until 2011: all original papers (135) that were included in the IARC monograph were analysed and referenced in this report as well; of course, for this report we considered only the final IARC classification. The remaining 20 articles published after 2011 were included in this scoping review.

At this stage, a separation based on frequency range was also performed: of the 20 papers included, all 20 reported exposures belonging to the band considered in FR1, and one also reported exposures regarding FR2, in particular MMW from occupational exposure to radar.

For each article, the abstract is presented, together with a table summarising the most important information; furthermore, a senior expert evaluated their adequacy for assessing carcinogenic effects (adequate/inadequate), and expressed an overall synthesis of the results (positive/negative/equivocal) following criteria described in the Methodology section.

The flow chart regarding the selection of papers on cancer epidemiological studies for FR1 is presented in Fig. 9.

Figure 9 – Flow diagram. Epidemiological studies on cancer (FR1)



KEY REFERENCE: IARC 2013

The IARC Monograph 102 (IARC, 2013) is the key reference for the present evaluation. In May 2011, after 1 year of preparing and reviewing drafts, 30 scientists from 14 countries met at the International Agency for Research on Cancer (IARC) in Lyon, France, to assess the carcinogenicity of radiofrequency electromagnetic fields (RF-EMF). This assessment was published as Volume 102 of the IARC Monographs (IARC, 2013). Epidemiological evidence for an association between RF-EMF and cancer comes from cohort, case-control, and time-trend studies. The populations in these studies were exposed to RF-EMF in occupational settings, from sources in the general environment, and from use of wireless (mobile and cordless) telephones, which is the most extensively studied exposure source.

One cohort study (Schüz et al., 2006) and five case-control studies (Muscat et al., 2000; Inskip et al., 2001; Auvinen et al., 2002; INTERPHONE Study Group, 2010; Hardell et al., 2011) were judged by the Working Group to offer potentially useful information regarding associations between use of wireless phones and glioma.

Although both the INTERPHONE study and the Swedish pooled analysis are susceptible to bias—due to recall error and selection for participation— the Working Group concluded that the findings could not be dismissed as reflecting bias alone, and that a causal interpretation between mobile phone RF-EMF exposure and glioma is possible. A similar conclusion was drawn for acoustic neuroma, although the case numbers were substantially smaller than for glioma. Additionally, a study from Japan (Sato et al., 2011) found some evidence of an increased risk of acoustic neuroma associated with ipsilateral mobile phone use.

For meningioma, parotid-gland tumours, leukaemia, lymphoma, and other tumour types, the Working Group found the available evidence insufficient to reach a conclusion on the potential association with mobile phone use. Epidemiological studies of individuals with potential occupational exposure to RF-EMF have investigated brain tumours, leukaemia, lymphoma, and other types of malignancy including uveal melanoma, and cancers of the testis, breast, lung, and skin. The Working Group noted that the studies had methodological limitations and the results were inconsistent. In reviewing studies that addressed the possible association between environmental exposure to RF-EMF and cancer, the Working Group found the available evidence insufficient for any conclusion.The Working Group concluded that there is "*limited evidence in humans*" for the carcinogenicity of RFEMF, based on positive associations between glioma and acoustic neuroma and exposure to RF-EMF from wireless phones.

At that time, a few members of the Working Group considered the current evidence in humans "inadequate". In their opinion there was inconsistency between the two case-control studies and a lack of an exposure-response relationship in the INTERPHONE study results; no increase in rates of glioma or acoustic neuroma was seen in the Danish cohort study (Shuz et al., 2006) and up to that time, reported time trends in incidence rates of glioma had not shown a parallel with time trends in mobile phone use (Baan et al., 2011).

REVIEW OF EPIDEMIOLOGICAL STUDIES 2011-2020

Starting from 2011, the present review evaluates by type of study and by year of publication (2011-2020) the epidemiological studies also summarized in Tables 1-4. The author adds to short abstracts her own brief comments on the results of the different studies.

CASE-CONTROL STUDIES (Tables 1, a-m)

1. Aydin et al., 2011.

Denmark, Sweden, Norway, and Switzerland. 2004-2008.CEFALO multicenter case-control study.

Mobile phone use association with brain tumour risk among children and adolescents is studied. CEFALO is a multicenter case-control study conducted in Denmark, Sweden, Norway, and Switzerland that includes all children and adolescents aged 7-19 years who were diagnosed with a brain tumour between 2004 and 2008. Interviews, in person, with 352 case patients (participation rate: 83%) and 646 control subjects (participation rate: 71%) and their parents. Control subjects were randomly selected from population registries and matched by age, sex, and geographical region. We asked about mobile phone use and included mobile phone operator records when available. Odds ratios (ORs) for brain tumour risk and 95% confidence intervals (CIs) were calculated using conditional logistic regression models. Regular users of mobile phones were not statistically significantly more likely to have been diagnosed with brain tumours compared with nonusers (OR = 1.36; 95% CI = 0.92 to 2.02). Children who started to use mobile phones at least 5 years ago were not at increased risk compared with those who had never regularly used mobile phones (OR = 1.26, 95% CI = 0.70 to 2.28). In a subset of study participants for whom operator recorded data were available, brain tumour risk was related to the time elapsed since the mobile phone subscription was started but not to amount of use. No increased risk of brain tumours was observed for brain areas receiving the highest amount of exposure. The absence of an exposure-response relationship either in terms of the amount of mobile phone use or by localisation of the brain tumour argues against a causal association.

Comment: Extent of exposure not assessed. The study was not statistically powered to detect small risk increases. Several RR increased in highest exposure category, albeit not statistically significant.

2. Atzmon et al., 2012.

Israel, diagnosis between 1989 and 2007. Population-based case control study.

The study was initiated to examine the claims of the residents of the Druze Isifya Village in Northern Israel that their high cancer rates were associated with past exposures to radiation from radio and cellular transmitters.To investigate the association between past exposure to RF/MW transmitters and cancer risks, familial cancer history and occupational exposures and indicators of life-style were taken into account; a population-based case-control study involved 307 residents, of whom 47 were diagnosed between 1989 and 2007 with different types of cancer and 260 controls. Cancer diagnoses were obtained from medical records. Exposure status of individual houses was determined from a map, based on the distances between each house and RF/MW antennas, and calculated using geographic information systems (GIS). Data on additional risk factors for cancer, like smoking and occupation, were obtained from individual questionnaires. The analysis was adjusted for measures of life style and occupational exposure, and Binary multiple logistic regressions was used, for all cancer sites and for individual cancer types for those cancers with at least 5 documented cases. Past occupational exposures to chemicals (e.g., pesticides) and electronics, were found to be strongly associated with increased cancer risks (all sites: OR=2.79; CI=1.14-6.82; P<0.05), but no discernible trend in overall cancer risk was associated with proximity to sources of past RF/MW radiation exposure (n=47 OR=1.00; CI=0.99-1.02; P>0.4). Colorectal cancer showed a negligible elevated adjusted risk associated with radiation intensity (n=11 OR=1.03; CI=1.01-1.05; P<0.01). There was evidence for an increased risk of cancers which were associated with chemicals in manufacturing and agriculture and electronics, where there may have been exposure to EMF, but the study did not confirm the suspicion of increased cancer risks associated with radiation for most cancer types in this village. Misclassification of past exposures could explain the negative finding.

Comment: No appropriate measurement of RF radiation was provided. Results inconclusive.

3. Li et al., 2012.

Taiwan, 1998-2007. Population-based case–control study (childhood neoplasms).

This population-based case-control study in Taiwan considered incident cases aged 15 years or less and admitted from 2003 to 2007 for all neoplasms (ICD-9-CM: 140-239) (n=2606), including 939 leukemia and 394 brain neoplasm cases. Controls were randomly selected, with a case/control ratio of 1:30 and matched by year of birth, from all non-neoplasm children insured in the same year when the index case was admitted. Annual summarized power (ASP, watt-year) was calculated for each of the 71,185 mobile phone base stations (MPBS) in service between 1998 and 2007. Then, the annual power density (APD, watt-year/km(2)) of each township (n=367) was computed as a ratio of the total ASP of all MPBS in a township to the area of that particular township. Exposure of each study subject to radio frequency (RF) was indicated by the averaged APD within 5 years prior to the neoplasm diagnosis (cases) or July 1st of the year when the index case was admitted (controls) in the township where the subject lived. An unconditional logistic regression model with a generalized estimation equation was employed to calculate the covariate-adjusted odds ratio [AOR] of childhood neoplasm in relation to RF exposure. A higher than median averaged APD (approximately 168 WYs/km(2)) was significantly associated with an increased AOR for all neoplasms (1.13; 1.01 to 1.28), but not for leukaemia (1.23; 0.99 to 1.52) or brain neoplasm (1.14, 0.83 to 1.55). This study noted a significantly increased risk of all neoplasms in children with higher-than-median RF exposure to MPBS. The slightly elevated risk was seen for leukaemia and brain neoplasm, but was not statistically significant. These results may occur due to several methodological limitations.

Comment: The authors admit several methodological limitation. Inconclusive study.

4. Soderqvist et al., 2012.

Sweden, 2000-2003. Case–control study.

The objective of this case-control study was to assess whether the use of wireless phones is associated with an increased risk of tumour at this site. Sixty-nine patients with salivary gland tumours (63 with a parotid gland tumour) and 262 randomly recruited controls were included. Unconditional logistic regression - adjusted for age at diagnosis, sex, year of diagnosis and socioeconomic index - was used to produce odds ratios and 95% confidence intervals. The use of wireless phones was not associated with an overall increased risk of salivary gland tumours, odds ratio 0.8, 95% confidence interval 0.4-1.5. Neither was there an increased risk for the different phone types when calculated separately nor was there an increased risk for different latencies or when cumulative use was divided into three groups (1-1000, 1001-2000 and >2000 h). The overall results were similar for the risk of parotid gland tumours. In conclusion, our data add to the evidence against there being an increased risk for parotid gland tumours associated with light-to-moderate use of wireless phones and for less than 10 years of use but offers little information on risk related to more prolonged and/or heavy use.

Comment: Self-reported exposure from postal questionnaire. Any association for parotid gland tumours and light-to-moderate use of mobile phone.

5. Carlberg et al., 2013.

Sweden, 2007-2009. Case-control study.

The association between use of wireless phones and meningioma is studied. A case–control study on brain tumour cases of both genders aged 18–75 years and diagnosed during 2007–2009 is performed. One population-based control matched on gender and age was used to each case. Here we report on meningioma cases including all available controls. Exposures were assessed by a questionnaire. Unconditional logistic regression analysis was performed. In total 709 meningioma cases and 1,368 control subjects answered the questionnaire. Mobile phone use in total produced odds ratio (OR) = 1.0, 95% confidence interval (CI) = 0.7-1.4 and cordless phone use gave OR = 1.1, 95% CI = 0.8-1.5. The risk increased statistically significant per 100 h of cumulative use and highest OR was found in the fourth quartile (>2,376 hours) of cumulative use for all studied phone types. There was no statistically significant increased risk for ipsilateral mobile or cordless phone use, for meningioma in the temporal lobe or per year of latency. Tumour volume was not related to latency or cumulative use in hours of wireless phones. No conclusive evidence of an association between use of mobile and cordless phones and meningioma was found. An indication of increased risk was seen in the group with highest cumulative use but was not supported by statistically significant increasing risk with latency. Results for even longer latency periods of wireless phone use than in this study are desirable.

Comment*: *Self-reported exposure. No conclusive association for meningioma and use of mobile phone was found.

6. Hardell et al., 2013a.

Sweden, 2007-2009. Case-control study.

Previous studies have shown a consistent association between long-term use of mobile and cordless phones and glioma and acoustic neuroma, but not for meningioma. The aim of this study was to further explore the relationship between especially long-term (>10 years) use of wireless phones and the development of malignant brain tumours. A new case-control study of brain tumour cases of both genders aged 18-75 years and diagnosed during 2007-2009 was conducted. One population-based control matched on gender and age (within 5 years) was used in each case. Malignant cases including all available controls are reported. Exposures on e.g. use of mobile phones and cordless phones were assessed by a self-administered questionnaire. An unconditional logistic regression analysis was performed, adjusting for age, gender, year of diagnosis and socio-economic index using the whole control sample. Of the cases with a malignant brain tumour, 87% (n=593) participated, and 85% (n=1,368) of controls in the whole study answered the questionnaire. The odds ratio (OR) for mobile phone use of the analogue type was 1.8, 95% confidence interval (CI)=1.04-3.3, increasing with >25 years of latency (time since first exposure) to an OR=3.3, 95% CI=1.6-6.9. Digital 2G mobile phone use rendered an OR=1.6, 95% CI=0.996-2.7, increasing with latency >15-20 years to an OR=2.1, 95% CI=1.2-3.6. The results for cordless phone use were OR=1.7, 95% CI=1.1-2.9, and, for latency of 15-20 years, the OR=2.1, 95% CI=1.2-3.8. Few participants had used a cordless phone for >20-25 years. Digital type of wireless phones (2G and 3G mobile phones, cordless phones) gave increased risk with latency >1-5 years, then a lower risk in the following latency groups, but again increasing risk with latency >15-20 years. Ipsilateral use resulted in a higher risk than contralateral mobile and cordless phone use. Higher ORs were calculated for tumours in the temporal and overlapping lobes. Using the meningioma cases in the same study as the reference entity gave somewhat higher ORs indicating that the results were unlikely to be explained by recall or observational bias. These findings provide support for the hypothesis that RF-EMFs play a role in both the initiation and promotion stages of carcinogenesis.

Comment*: *Self-reported exposure. This study confirms previous results of an association between heavy mobile and cordless phone use and malignant brain tumours.

7. Hardell et al., 2013b, Hardell and Carlberg, 2015.

Sweden, 1997-2003 and 2007-2009. Case-control study.

A case-control study of acoustic neuroma was previously conducted by the authors. Subjects of both genders aged 20-80 years, diagnosed during 1997-2003 in parts of Sweden, were included, and the results were published. A further study for the time period 2007-2009 including both men and women aged 18-75 years selected from throughout the country was performed. Similar methods were used for both study periods. In each, one population-based control, matched on gender and age (within five years), was identified from the Swedish Population Registry. Exposures were assessed by a self-administered questionnaire supplemented by a phone interview. Since the number of acoustic neuroma cases in the new study was low, pooled results from both study periods based on 316 participating cases and 3,530 controls were presented. An unconditional logistic regression analysis was performed, adjusting for age, gender, year of diagnosis and socio-economic index (SEI). Use of mobile phones of the analogue type gave odds ratio (OR) = 2.9, 95% confidence interval (CI) = 2.0-4.3, increasing with >20 years latency (time since first exposure) to OR = 7.7, 95% CI = 2.8-21. Digital 2G mobile phone use gave OR = 1.5, 95% CI = 1.1-2.1, increasing with latency >15 years to an OR = 1.8, 95% CI = 0.8-4.2. The results for cordless phone use were OR = 1.5, 95% CI = 1.1-2.1, and, for latency of >20 years, OR = 6.5, 95% CI = 1.7-26. Digital type wireless phones (2G and 3G mobile phones and cordless phones) gave OR = 1.5, 95% CI = 1.1-2.0 increasing to OR = 8.1, 95% CI = 2.0-32 with latency >20 years. For total wireless phone use, the highest risk was calculated for the longest latency time >20 years: OR = 4.4, 95% CI = 2.2-9.0. Several of the calculations in the long latency category were based on low numbers of exposed cases. Ipsilateral use resulted in a higher risk than contralateral for both mobile and cordless phones. OR increased per 100 h cumulative use and per year of latency for mobile phones and cordless phones, though the increase was not statistically significant for cordless phones. The percentage tumour volume increased per year of latency and per 100 h of cumulative use, statistically significant for analogue phones. This study confirmed previous results demonstrating an association between mobile and cordless phone use and acoustic neuroma.

A pooled analysis was performed of two case-control studies on malignant brain tumours with patients diagnosed during 1997–2003 and2007–2009. They were aged 20–80 years and 18–75 years, respectively, at the time of diagnosis. Only cases with histopathological verificationof the tumour were included. Population-based controls, matched on age and gender, were used. Exposures were assessed by questionnaire.The whole reference group was used in the unconditional regression analysis adjusted for gender, age, year of diagnosis, and socio-economicindex. In total, 1498 (89%) cases and 3530 (87%) controls participated. Mobile phone use increased the risk of glioma, OR = 1.3, 95%CI = 1.1–1.6 overall, increasing to OR = 3.0, 95% CI = 1.7–5.2 in the >25 year latency group. Use of cordless phones increased the risk toOR = 1.4, 95% CI = 1.1–1.7, with highest risk in the >15–20 years latency group yielding OR = 1.7, 95% CI = 1.1–2.5. The OR increasedstatistically significant both per 100 h of cumulative use, and per year of latency for mobile and cordless phone use. Highest ORs overall werefound for ipsilateral mobile or cordless phone use, OR = 1.8, 95% CI = 1.4–2.2 and OR = 1.7, 95% CI = 1.3–2.1, respectively. The highest riskwas found for glioma in the temporal lobe. First use of mobile or cordless phone before the age of 20 gave higher OR for glioma than in laterage groups.

Comment*: *Self-reported exposure.These studies confirm previous results demonstrating an association between heavy mobile and cordless phone use, with acoustic neuroma and glioma.

8. Coureau et al., 2014.

France. 2004-2006. CERENAT. Case-control study.

The objective was to analyse the association between mobile phone exposure and primary central nervous system tumours (gliomas and meningiomas) in adults. CERENAT is a multicenter case-control study carried out in four areas in France in 2004-2006. Data about mobile phone use were collected through a detailed questionnaire delivered in a face-to-face manner. Conditional logistic regression for matched sets was used to estimate adjusted ORs and 95% CIs. A total of 253 gliomas, 194 meningiomas and 892 matched controls selected from the local electoral rolls were analysed. No association with brain tumours was observed when comparing regular mobile phone users with non-users (OR=1.24; 95% CI 0.86 to 1.77 for gliomas, OR=0.90; 95% CI 0.61 to 1.34 for meningiomas). However, the positive association was statistically significant in the heaviest users when considering life-long cumulative duration (≥896 h, OR=2.89; 95% CI 1.41 to 5.93 for gliomas; OR=2.57; 95% CI 1.02 to 6.44 for meningiomas) and number of calls for gliomas (≥18,360 calls, OR=2.10, 95% CI 1.03 to 4.31). Risks were higher for gliomas, temporal tumours, occupational and urban mobile phone use. These additional data support previous findings concerning a possible association between heavy mobile phone use and brain tumours.

Comment*: *Self reported exposure with face to face interview by trained personel.This study confirms previous results of a possible association between heavy mobile phone use and malignant brain tumours.

9. Pettersson et al., 2014.

Sweden, 2002-2007. Population-based case-control study.

A population-based, nation-wide, case-control study of acoustic neuroma in Sweden was conducted. Eligible cases were persons aged 20 to 69 years, who were diagnosed between 2002 and 2007. Controls were randomly selected from the population registry, matched on age, sex, and residential area. Postal questionnaires were completed by 451 cases (83%) and 710 controls (65%). Ever having used mobile phones regularly (defined as weekly use for at least 6 months) was associated with an odds ratio (OR) of

1.18 (95% confidence interval = 0.88 to 1.59). The association was weaker for the longest induction time (≥10 years) (1.11 [0.76 to 1.61]) and for regular use on the tumour side (0.98 [0.68 to 1.43]). The OR for the highest quartile of cumulative calling time (≥680 hours) was 1.46 (0.98 to 2.17). Restricting analyses to histologically confirmed cases reduced all ORs; the OR for ≥680 hours was 1.14 (0.63 to 2.07). A similar pattern was seen for cordless land-line phones, although with slightly higher ORs. Analyses of the complete history of laterality of mobile phone revealed considerable bias in laterality analyses. The findings do not support the hypothesis that long-term mobile phone use increases the risk of acoustic neuroma. The study suggests that phone use might increase the likelihood that an acoustic neuroma case is detected and that there could be bias in the laterality analyses performed in previous studies

Comment: Self-reported exposure. Weak evidence of association between heavy mobile phone use and acoustic neuroma.

10. Yoon et al., 2015.

Korea; 2002- 2007; case- control study.

Study methods were based on the International Interphone study that aimed to evaluate possible adverse effects of mobile phone use. This study included 285 histologically-confirmed Korean patients 15 to 69 years of age, with gliomas diagnosed between 2002 and 2007 in 9 hospitals. The 285 individually matched controls were healthy individuals that had their medical check-up in the same hospitals. Unconditional logistic regression was used to calculate the adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for use of mobile phones. For the entire group, no significant relationship was investigated between gliomas and regular use of mobile phones, types of mobile phones, lifetime years of use, monthly service fee, and the other exposure indices. Analyses restricted to self-respondents showed similar results. For ipsilateral users, whose body side for usual mobile phone use matched the location of glioma, the aORs (95% CIs) for lifetime years of use and cumulative hours of use were 1.25 (0.55 to 2.88) and 1.77 (0.32 to 1.84), respectively. However, contralateral users showed a slightly lower risk than ipsilateral users. Results do not support the hypothesis that the use of mobile phones increases the risk of glioma; however, we found a non-significant increase in risk among ipsilateral users. These findings suggest further evaluation for glioma risk among long-term mobile phone users.

Comment: Self reported exposure. Weak evidence of association between mobile phone use and brain tumour is found among ipsilateral users.

11. Al-Qahtani, 2016.

Saudi Arabia; 1996-2013; Retrospective case-control study.

A total of 26 patients diagnosed with parotid gland tumours and 61 healthy controls were enrolled through a hospital-based retrospective case-control study. The patients were referred and admitted to a tertiary hospital from January 1996 to March 2013. The Odds of exposure were 3.47 times higher among patients compared to their controls. 95% CI suggested that the true Odds Ratio (OR) at the population level could be somewhere between 1.3 and 9.23 and so the observed OR was statistically significant at 5% level of significance. Overall, an association between the exposure of cellular phone use for more than 1 hour daily and parotid tumour was observed. This association should be interpreted with caution because of the relatively small sample size.

Comment: Small sample size; poor methodology. Inconclusive study.

12. Satta et al., 2018.

Italy; 1998–2004; Population-based case-control study as part of the European multicenter study EPILYMPH.

A case-control study comprised of 322 patients and 444 individuals serving as controls in Sardinia, Italy in 1998-2004. Questionnaire information included the self-reported distance of the three longest held residential addresses from fixed radio-television transmitters and mobile phone base stations. For each address within a 500-meter radius from a mobile phone base station, RF-EMF intensity using predictions from spatial models was estimated, and RF-EMF measurements performed at the door in the subset of the longest held addresses within a 250-meter radius. Risk of lymphoma and its major subtypes associated with the RF-EMF exposure metrics with unconditional logistic regression, adjusting by age, gender and years of education. Risk associated with residence in proximity (within 50 meters) to fixed radio-television transmitters was likewise elevated for lymphoma overall [odds ratio = 2.7, 95% confidence interval = 1.5-4.6], and for the major lymphoma subtypes. With reference to mobile phone base stations, the authors did not observe an association with either the self-reported, or the geocoded distance from mobile phone base stations. RF-EMF measurements did not vary by case-control status. By comparing the self-reports to the geocoded data, cases tended to underestimate the distance from mobile phone base stations differentially from the controls (P = 0.073). The interpretation of findings is compromised by the limited study size, particularly in the analysis of the individual lymphoma subtypes, and the unavailability of the spatial coordinates of radio-television transmitters. Nonetheless, our results do not support the hypothesis of a link between environmental exposure to RF-EMF from mobile phone base stations and risk of lymphoma subtypes.

Comment*: *Limited study size, exposure assessment unclear (far field, radiobase-stations). The study does not support the hypothesis of a link between environmental exposure to RF-EMF from mobile phone base stations and risk of lymphoma subtypes.

13. Balekouzou et al., 2017.

Central Africa. Case- control study.

Breast cancer is recognized as a major public health problem in developing countries; however, there is very little evidence of behavioral factors associated with breast cancer risk. This study was conducted to identify lifestyles as risk factors for breast cancer among Central African women. A case-control study was conducted with 174 cases confirmed histologically by the pathology unit of the National Laboratory and 348 age-matched controls. Data collection tools included a questionnaire with interviews and medical records of patients. Data were analyzed using SPSS software version 20. Odd ratio (OR) and 95% confidence intervals (95% CI) were obtained by unconditional logistic regression. In total, 522 women were studied with a mean age of 45.8 (SD = 13.4) years. By unconditional logistic regression model, women with breast cancer were more likely to have attained illiterate and elementary education level [11.23 (95% CI, 4.65±27.14) and 2.40 (95% CI, 1.15±4.99)], married [2.09 (95% CI, 1.18±3.71)], positive family history [2.31 (95% CI, 1.36±3.91)], radiation exposure [8.21 (95% CI, 5.04±13.38)], consumption charcuterie [10.82 (95% CI, 2.39±48.90)], fresh fish consumption [4.26 (95% CI, 1.56±11.65)], groundnut consumption [6.46 (95% CI, 2.57± 16.27)], soybean consumption [16.74 (95% CI, 8.03±39.84)], alcohol [2.53 (95% CI, 1.39± 4.60)], habit of keeping money in bras[3.57 (95% CI, 2.24±5.69)], overweight [5.36 (95% CI, 4.46±24.57)] and obesity [3.11(95% CI, 2.39±20.42)]. However, decreased risk of breast cancer was associated with being employed [0.32 (95% CI, 0.19±0.56)], urban residence [0.16 (95% CI, 0.07±0.37)], groundnut oil consumption [0.05 (95% CI, 0.02±0.14)], wine consumption [0.16 (95% CI, 0.09±0.26)], non habit of keeping cell phone in bras [0.56 (95% CI, 0.35±0.89)] and physical activity [0.71(95% CI, 0.14±0.84)]. The study showed that little or no education, marriage, positive family history of cancer, radiation exposure, charcuterie, fresh fish, groundnut, soybean, alcohol, habit of keeping money in bras, overweight and obesity were associated with breast cancer risk among Central African women living in Bangui. Women living in Bangui should be more cautious on the behavioral risk associated with breast cancer.

Comment*: *Limitations in self reporting of data. Many confounders. Any conclusive finding for an association beetween keeping cell phone in bras and mammary cancer.

14. Vila et al., 2018.

Australia, Canada, France, Germany, Israel, New Zealand and the United Kingdom; 2000-2004; INTEROCC study: international case-control study on mobilephone use and brain cancer risk in seven countries.

This study examines the relation between occupational RF and intermediate frequency (IF) EMF exposure and brain tumour (glioma and meningioma) risk in the INTEROCC multinational population-based case-control study (with nearly 4000 cases and over 5000 controls), using a novel exposure assessment approach. Individual indices of cumulative exposure to RF and IF-EMF (overall and in specific exposure time windows) were assigned to study participants using a source-exposure matrix and detailed interview data on work with or nearby EMF sources. Conditional logistic regression was used to investigate associations with glioma and meningioma risk. Overall, around 10% of study participants were exposed to RF while only 1% were exposed to IF-EMF. There was no clear evidence for a positive association between RF or IF-EMF and the brain tumours studied, with most results showing either no association or odds ratios (ORs) below 1.0. The largest adjusted ORs were obtained for cumulative exposure to RF magnetic fields (as A/m-years) in the highest exposed category (≥90th percentile) for the most recent exposure time window (1-4 years before the diagnosis or reference date) for both glioma, OR = 1.62 (95% confidence interval (CI): 0.86, 3.01) and meningioma (OR = 1.52, 95% CI: 0.65, 3.55). Despite the improved exposure assessment approach used in this study, no clear associations were identified. However, the results obtained for recent exposure to RF electric and magnetic fields are suggestive of a potential role in brain tumour promotion/progression and should be further investigated.

Comment*: *Study suggestive of a potential role in brain tumour promotion/progression.

15. Luo et al., 2019.

USA. 2010-2011. Population-based case-control study.

This study aims to investigate the association between cell phone use and thyroid cancer. A population-based case-control study was conducted in Connecticut between 2010 and 2011 including 462 histologically confirmed thyroid cancer cases and 498 population-based controls. Multivariate unconditional logistic regression was used to estimate odds ratios (OR) and 95% confidence intervals (95% CI) for associations between cell phone use and thyroid cancer. Cell phone use was not associated with thyroid cancer (OR: 1.05, 95% CI: 0.74–1.48). A suggestive increase in risk of thyroid microcarcinoma (tumour size ≤10mm) was observed for long-term and more frequent users. Compared to cell phone non-users, several groups had nonstatistically significantly increased risk of thyroid microcarcinoma: individuals who had used a cell phone >15 years (OR: 1.29, 95% CI: 0.83–2.00), who had used a cell phone >2 hours per day (OR: 1.40, 95% CI: 0.83–2.35), who had the most cumulative use hours (OR: 1.58, 95% CI: 0.98–2.54), and who had the most cumulative calls (OR: 1.20, 95% CI: 0.78–1.84) Cumulative cell phone use was estimated by multiplying cell phone use hours or calls per day with the duration of use. Each variable was categorized into tertiles based on its distribution among controls.. This study found no significant association between cell phone use and thyroid cancer. A suggestive elevated risk of thyroid microcarcinoma associated with long-term and more frequent uses warrants further investigation.

Comment*: *Self reported exposure. No significant association was found, but a suggestive elevated risk of thyroid microcarcinoma associated with long-term and more frequent users.

ECOLOGICAL STUDIES (Table 2, a)

16. Gonzalez Rubio et al., 2017.

Spain. 2012-2015. Case-control ecological study.

This paper presents the results of a preliminary epidemiological study, combining Epidemiology, Statistics and Geographical Information Systems (GIS), in which the correlation between exposure to RF-EMF in the city of Albacete (166,000 inhabitants, southeast Spain) and the incidence of several cancers with unspecific causes (lymphomas, and brain tumours) are analysed. Statistical tools to analyze the spatial point patterns and aggregate data so as to study the spatial randomness and to determine the zones with the highest incidence from 95 tumours studied (65 lymphomas, 12 gliomas and 18 meningiomas) were used. A correlation (Spearman) study between the personal exposure to RF-EMF in 14 frequency bands, recorded by an EME Spy 140 (Satimo) exposimeter in the city's administrative regions, and the incidence of the tumours registered from January 2012 to May 2015. The cancer cases studied have a random spatial distribution inside the city. On the other hand, and by means of an ecological study, the exposure to RF-EMF registered in the city of Albacete shows little correlation with the incidence of the tumours studied (gliomas (ρ=0.15), meningiomas (ρ=0.19) and lymphomas (ρ=-0.03)). The proposed methodology inaugurates an unexplored analysis path in this field.

***Comment*: *Little correlation between environmental exposure to RF-EMF and glioma, meningioma and lymphomas. Exposure assessment not clear*.**

COHORT STUDIES (Tables 3, a-d)

17. Frei et al., 2011.

Denmark. Subscribers and non-subscribers of mobile phones before 1995.

All Danes aged ≥30 and born in Denmark after 1925, subdivided into subscribers and non-subscribers of mobile phones before 1995. Main outcome measures Risk of tumours of the central nervous system, identified from the complete Danish Cancer Register. Sex specific incidence rate ratios estimated with log linear Poisson regression models adjusted for age, calendar period, education, and disposable income. Results 358,403 subscription holders accrued 3.8 million person years. In the follow-up period 1990-2007, there were 10,729 cases of tumours of the central nervous system. The risk of such tumours was close to unity for both men and women. When restricted to individuals with the longest mobile phone use—that is, ≥13 years of subscription—the incidence rate ratio was 1.03 (95% confidence interval 0.83 to 1.27) in men and 0.91 (0.41 to 2.04) in women. Among those with subscriptions of ≥10 years, ratios were 1.04 (0.85 to 1.26) in men and 1.04 (0.56 to 1.95) in women for glioma and 0.90 (0.57 to 1.42) in men and 0.93 (0.46 to 1.87) in women for meningioma. There was no indication of dose-response relation either by years since first subscription for a mobile phone or by anatomical location of the tumour—that is, in regions of the brain closest to where the handset is usually held to the head. Conclusions In this update of a large nationwide cohort study of mobile phone use, there were no increased risks of tumours of the central nervous system, providing little evidence for a causal association.

Comment*: *Limits in exposure assessment. No increased risks of tumours of the central nervous system.

18. Benson et al., 2013.

UK. Million Women Study. 1999-2005 and 2005-2009. Prospective cohort study.

The relation between mobile phone use and incidence of intracranial central nervous system (CNS) tumours and other cancers was examined in 791,710 middle-aged women in a UK prospective cohort, the Million Women Study. Cox regression models were used to estimate adjusted relative risks (RRs) and 95% confidence intervals (CIs). Women reported mobile phone use in 1999 to 2005 and again in 2009. Results During 7 years' follow-up, 51 680 incident invasive cancers and 1 261 incident intracranial CNS tumours occurred. Risk among ever vs never users of mobile phones was not increased for all intracranial CNS tumours (RR=1.01, 95% CI=0.90–1.14, P=0.82), for specified CNS tumour types nor for cancer at 18 other specified sites. For longterm users compared with never users, there was no appreciable association for glioma (10þ years: RR¼0.78, 95% CI¼0.55–1.10, P¼0.16) or meningioma (10+ years: RR=1.10, 95% CI=0.66–1.84, P=0.71). For acoustic neuroma, there was an increase in risk with long term use vs never use (10+ years: RR=2.46, 95% CI=1.07– 5.64, P=0.03), the risk increasing with duration of use (trend among users, P=0.03). Conclusions In this large prospective study, mobile phone use was not associated with increased incidence of glioma, meningioma or non-CNS cancers.

Comment*: *Self reported exposure. For acoustic neuroma, there was an increase in risk with long term use vs never use; the risk increasing with duration of use.

19. Poulsen et al., 2013.

Denmark, 1982-1995, follow up until 2007. Cohort study: CANULI study of social inequality and cancer incidence and survival.

In a nationwide cohort study, 355,701 private mobile phone subscribers in Denmark from 1987 to 1995 were followed up through 2007. We calculated incidence rate ratios (IRRs) for melanoma, basal cell carcinoma, and squamous cell carcinoma by using Poisson regression models adjusted for age, calendar period, educational level, and income. Separate IRRs for head/neck tumours and torso/leg tumours were compared (IRR ratios) to further address potential confounders. We observed no overall increased risk for basal cell carcinoma, squamous cell carcinoma, or melanoma of the head and neck. After a follow-up period of at least 13 years, the IRRs for basal cell carcinoma and squamous cell carcinoma remained near unity. Among men, the IRR for melanoma of the head and neck was 1.20 (95% confidence interval: 0.65, 2.22) after a minimum 13-year follow-up, whereas the corresponding IRR for the torso and legs was 1.16 (95% confidence interval: 0.91, 1.47), yielding an IRR ratio of 1.04 (95% confidence interval: 0.54, 2.00). A similar risk pattern was seen among women, though it was based on smaller numbers. In this large, population-based cohort study, little evidence of an increased skin cancer risk was observed among mobile phone users.

Comment*: *Extent of exposure not assessed. Little evidence of an increased skin cancer risk was observed among mobile phone users.

20. Hauri et al., 2014.

Switzerland. 2000-2008. Census-based cohort study (far field, radiobase stations).

The association between exposure to radio-frequency electromagnetic fields (RF-EMFs) from broadcasting transmitters and childhood cancer was investigated. Time-to-event analysis including children under age 16 years living in Switzerland on December 5, 2000 was performed. Follow-up lasted until December 31, 2008. All children living in Switzerland for some time between 1985 and 2008 were included in an incidence density cohort. RF-EMF exposure from broadcasting transmitters was modeled. Based on 997 cancer cases, adjusted hazard ratios in the time-to-event analysis for the highest exposure category (>0.2 V/m) as compared with the reference category (<0.05 V/m) were 1.03 (95% confidence interval (CI): 0.74, 1.43) for all cancers, 0.55 (95% CI: 0.26, 1.19) for childhood leukemia, and 1.68 (95% CI: 0.98, 2.91) for childhood central nervous system (CNS) tumours. Results of the incidence density analysis, based on 4,246 cancer cases, were similar for all types of cancer and leukemia but did not indicate a CNS tumour risk (incidence rate ratio = 1.03, 95% CI: 0.73, 1.46). This large census-based cohort study did not suggest an association between predicted RF-EMF exposure from broadcasting and childhood leukemia. Results for CNS tumours were less consistent, but the most comprehensive analysis did not suggest an association.

Comment: Limits in the assessment of residential exposure. No association between RF-EMF and cancer in children is suggested.

Table 1 – Cancer in epidemiological case-control studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
1. Aydin et al. 2011. Denmark, Sweden, Norway, and Switzerland; 2004-2008; CEFALO-Multicenter case-control study.	352 cases; 646 population-based matched controls (M and F). Age 7-19 years. Data from reports from pediatric, oncology, and neurosurgery departments and from national population-based registries.	Use of mobile phones, assessed by face-to-face interviews with the subjects and their parents.	Mobile phone use.	Intracranial central nervous system tumours..	**Odds ratio (OR) and 95% confidence intervals (95% CI) from conditional logistic regression. Trend from two-sided Wald testOR (95% CI) for brain tumours**	**p-value for trend**	Education, family history of cancer, past medical radiation exposure to the head, maternal smoking during pregnancy, past head injuries, use of baby monitors near the head, use of cordless phones, contact with animals, location where the child lived before age, having siblings, birth weight, born premature, ever doctor-diagnosed asthma, ever doctor-diagnosed atopic eczema, and ever doctor-diagnosed hay fever.	Adequate/ Equivocal (brain tumour) Children and adolescent
			Regular use (at least once per week, > 6 months)					
			No		1.0 (ref.)			
			Yes		1.36 (0.92 -2.02)			
			Time since first use (years)					
			Never regular user		1.0 (ref.)	0.37		
			≤3.3		1.35 (0.89 to 2.04)			
			3.3–5.0		1.47 (0.87 to 2.49)			
			>5.0		1.26 (0.70 to 2.28)			
			Cumulative duration of calls (hours)					
			Never regular user		1.0 (ref.)	0.42		
			≤35		1.33 (0.89 to 2.01)			
			36-144		1.44 (0.85 to 2.44)			
			>144		1.55 (0.86 to 2.82)			

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjustments	Comments
2. Atzmon et al 2012. Israel, diagnosis between 1989 and 2007. Population-based case-control study/ The present analysis is a retrospective follow up study at diagnosis.	307 subjects, of whom 47 cases (M and F), median age 48. Cases from medical documents with confirmed diagnosis of cancer. Face-to-face interviews in the participant's home.	Exposure to radio and cellular transmitters located in the village prior to 2000. Individual exposure (E) was estimated using the following formula: E=1/D2, where D is distance (in meters) between a house and the closest transmitter.	Individual exposure and years of residence.	Cancer: colorectal (11), breast cancer (10), lymphoma (6), leukemia (3), lungs (2), uterine (2), liver (2), stomach (2), ovarian (2), pancreas (2), prostate (2), cervix (1), brain (1), and bladder (1). Odds ratios and confidence intervals (OR, 95% CI) from binary logistic regression model.	**OR (95% CI), Colorectal**	**OR (95% CI), Lymphoma**	**OR (95% CI), Uterine**	**OR (95% CI), Prostate**	**OR (95% CI), Brain**	Duration of residence in the same house; alcohol consumption; nutritional habits; frequency of physical exercise; use of cellular phones; exposure to wireless equipment in the house; use of oral contraceptives or hormones replacement therapy and income	**Inadequate**
			Radiation intensity		1.03 (1.01-1.05)	0.95 (0.86-1.06)	0.99 (0.91-1.07)	1.67 (0.04-61.04)	12.45 (0.34–453.54)	**No appropriate measurement of RF exposure**	
			Years of exposure to radiation		0.97 (0.877-1.082)	0.95 (0.82-1.11)	1.12 (0.88-1.42)	0.97 (0.86-1.10)	0.96 (0.84–1.11)		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued c)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
3. Li et al. 2012. Taiwan; 2003-2007; Population-based case-control study.	2606 childhood neoplasm cases (M and F), 78180 matched controls (939-28170 for leukemia; 394- 11820 for brain neoplasms). Age < 15 years. Clinical data from the National Health Insurance Research Database (NHIRD).	RF exposure metric was estimated from the averaged Annual Power Density for the five-year period prior to the neoplasm diagnosis in the township where the subject lived at the time of neoplasm diagnosis. Information on MPBS from the Taiwan National Communication Council (NCC).	Exposure to mobile phone base stations (MPBS): 800-900 MHz; 1800-2200 Mhz. Estimate APD	All neoplasms; Leukemia; Brain neoplasms. Odds ratio (OR) and 95% confidence intervals (95% CI) from multiple unconditional logistic regression models	**OR (95% CI) for all neplasms**	**OR (95% CI) for leukemia**	**OR (95% CI) for brain neplasms**	age, gender, calendar year of neoplasm diagnosis, urbanisation level of township, and high-voltage (69/161/345 kV) transmission line (HVTL) density of the township. Limits in exposure assessment	Inadequate
			Level of exposure (compared to median= 167.02 WYs/km2						
			<Median		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			≥Median		1.13 (1.01–1.28)	1.23 (0.99-1.52)	1.14 (0.83-1.55)		
			p-value		0.048	0.052	0.426		
4. Soderqvist et al. 2012. Sweden, 2000-2003. Case–control study.	78 cases; 312 controls (M and F), age 22–80, median 69. Patients were recruited as reported by the Regional Oncology Centre of Uppsala/Orebro and Linkoping, including nine of 21 Swedish counties. Controls were drawn from the population registry at random.	Use of wireless phones, i.e. both mobile and cordless phones. Self-reported exposure from postal questionnaire.	The cumulative number of hours of use was calculated using the number of years and average time used per day. Cumulative hours of use was also divided into three groups, 1–1000, 1001–2000 and more than 2000 h. Use of wireless phones within 1 year before diagnoses were treated as unexposed.	Salivary gland tumour. Odds ratios and 95% confidence intervals from unconditional logistic regression.	**OR (95% CI) for Mobile phones**	**OR (95% CI) for cordless phones**	**OR (95% CI) for wireless phones, total**	No information available Limits in exposure assessment	Inadequate
			Cumulative use (h)						
			Unexposed		1 (Ref.)	1 (Ref.)	1 (Ref.)		
			1–1000		0.9 (0.4–1.7)	0.6 (0.3–1.3)	0.8 (0.5-1.6)		
			1001–2000		0.7 (0.1–3.6)	1.2 (0.2–7.8)	0.7 (0.2–2.7)		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued d)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)				Any Other Co-Exposure/adjustments	Comments
5. Carlberg et al. 2013. Sweden; 2007-2009; Case-control study.	709 cases; 1368 population-based matched controls (M and F). Age 18-75 years. Data from a cancer register.	Use of wireless phones (mobile and cordless phones), assessed by a self-administered structured phone questionnaire.	Mobile phone use (UMTS, 4G); cordless phone use (1900 MHz).	Meningioma. Odds ratio (OR) and 95% confidence intervals (95% CI) from unconditional logistic regression.	**OR (95% CI) for meningioma, Digital (2G)**	**OR (95% CI) for meningioma, Digital (UMTS, 3G)**	**OR (95% CI) for meningioma, Cordless phone**	**OR (95% CI) for meningioma, Digital type**	Gender, age, year of diagnosis, socio-economic index (SEI).	Adequate/ Positive (meningioma)
			Cumulative use of wireless phones (h)							
			<39-405		1.0 (0.7-1.4)	0.7 (0.3-1.3)	1.0 (0.7-1.4)	1.1 (0.8-1.6)		
			406–1091		1.0(0.7-1.5)	0.4 (0.1-1.2)	0.9 (0.6-1.3)	0.9 (0.6-1.3)		
			1092-2376		0.9 (0.6-1.4)	0.6 (0.2-1.8)	1.2 (0.8-1.8)	0.9 (0.6-1.3)		
			>2376		1.5 (0.9-2.3)	7.3 (1.2-46)	1.8 (1.2-2.8)	1.4 (0.96-2.6)		
			P for trend		0.06	0.04	0.0003	0.002		
6. Hardell et al. 2013a. Sweden, 2007-2009. Case-control study.	593 cases, 1368 controls (M and F), age 18-75. Newly diagnosed brain tumour cases from the regional and national Swedish cancer registers. The Swedish Population Registry was used for identification of controls.	Use of wireless phones, i.e. both mobile and cordless phones. Self-reported exposure from self-administered questionnaire supplemented by a phone interview.	Frequency of use; Duration of exposure.	Malignant brain tumours. Odds ratio (OR) and 95% confidence interval (CI) from unconditional logistic regression analysis.	**OR (95% CI) for Mobile phone use (Analogue, 2G, 3G)**	**OR (95% CI) for digital phone use (2G, 3G, cordless)**	**OR (95% CI) for all wireless phones**		Occupational history, exposure to different agents, smoking habits, medical history including hereditary risk factors, and exposure to ionising radiation.	Adequate/ Positive (Malignant brain tumours)
			Frequency of use							
			Non users (<1 years)		1 (Ref.)	1 (Ref.)	1 (Ref.)			
			Users (>1 years)		1.6 (0.99 - 2.7)	1.7 (1.04 - 2.8)	1.7 (1.04 - 2.8)			
			Duration of use (years)							
			1-5		1.8 (1.002 - 3.4)	2.6 (1.4 - 4.9)	2.6 (1.4 - 5.0)			
			5-10		1.7 (0.98 - 2.8)	1.6 (0.9 - 2.7)	1.6 (0.98 - 2.8)			
			10-15		1.3 (0.8 - 2.2)	1.4 (0.8 - 2.3)	1.3 (0.8 - 2.2)			
			15-20		1.5 (0.8 - 2.6)	2.2 (1.3 - 3.6)	1.7 (1.02 - 3.0)			
			20-25		1.9 (1.1 - 3.5)	1.5 (0.5 - 4.6)	1.9 (1.04 - 3.4)			
			>25		2.9 (1.4 - 5.8)	-	3.0 (1.5 - 6.0)			

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued e)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
7. Hardell et al. 2013b and Hardell and Carlberg 2015. Sweden, 1997-2003 and 2007-2009. Pooled case-control study.	316 cases of acoustic neuroma, 3530 controls (M and F), aged 20–80 years (1997–2003) and18–75 years (2007–2009) at the time of diagnosis. Cases reported from cancer registries.	Use of wireless phones, i.e. both mobile and cordless phones. Self-reported exposure from self-administered questionnaire supplemented by a phone interview.		Acoustic neuroma. Odds ratio (OR) and 95% confidence intervals (CI) from unconditional logistic regression analysis.	**OR (95% CI) for Mobile phone use (Analogue, 2G, 3G)**	**OR (95% CI) for digital phone use (2G, 3G, cordless)**	**OR (95% CI) for all wireless phones**	Occupational history, exposure to different agents, smoking habits, medical history including hereditary risk factors, and exposure to ionising radiation.	Adequate/ Positive (acoustic neuroma and glioma)
			Frequency of use						
			Non users (<1 years)		1 (Ref.)	1 (Ref.)	1 (Ref.)		
			Users (>1 years)		1.6 (1.2 - 2.2)	1.5 (1.1 - 2.0)	1.5 (1.1 - 2.0)		
			Duration of use (years)					Positive association in heavy users	
			1-5		1.3 (0.9 - 1.8)	1.4 (1.01 - 1.9)	1.2 (0.8 - 1.6)		
			5-10		2.3 (1.6 - 3.3)	1.6 (1.1 - 2.3)	1.9 (1.3 - 2.7)		
			10-15		2.1 (1.3 - 3.5)	1.6 (0.97 - 2.8)	2.0 (1.3 - 3.2)		
			15-20		2.1 (1.02 - 4.2)	1.1 (0.5 - 2.5)	1.7 (0.9 - 3.3)		
			>20		4.5 (2.1 - 9.5)	8.1 (2.0 - 32)	4.4 (2.2 - 9.0)		
	1380 cases of glioma, 3530 controls (M and F), aged 20–80 years (1997–2003) and18–75 years (2007–2009) at the time of diagnosis. Cases reported from cancer registries.	Use of wireless phones, i.e. both mobile and cordless phones. Self-reported exposure from self-administered mailed questionnaire.		Glioma. Odds ratio (OR) and 95% confidence intervals (CI) from unconditional logistic regression analysis.	**OR (95% CI) for Mobile phone use (Analogue, 2G, 3G)**	**OR (95% CI) for digital phone use (2G, 3G, cordless)**	**OR (95% CI) for all wireless phones**	Occupational history, exposure to different agents, smoking habits, medical history including hereditary risk factors, and exposure to ionising radiation.	)
			Frequency of use						
			Non users (<1 years)		1 (Ref.)	1 (Ref.)	1 (Ref.)		
			Users (>1 years)		1.6 (1.2 - 2.0)	1.3 (1.1- 1.6)	1.3 (1.1- 1.6)		
			Duration of use (years)						
			1-5		1.1 (0.7- 1.7)	1.2 (0.9- 1.4)	1.1 (0.9- 1.4)		
			5-10		1.1 (0.8- 1.6)	1.6 (1.3 - 2.0)	1.5 (1.2- 1.9)		
			10-15		2.2 (1.5 - 3.7)	1.4 (1.1- 1.9)	1.4 (1.1- 1.8)		
			15-20		2.4 (1.5- 3.7)	2.0 (1.5- 2.8)	1.7 (1.2- 2.3)		
			20- 25		3.2 (1.9- 5.5)	1.6 (0.6- 4.4)	1.9 (1.3- 2.9)		
			> 25		4.8 (2.5- 9.1)	-	3.0 (1.7- 5.2)		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued f)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
8. Coureau et al.2014. France. 2004-2006. CERENAT. Case-control study.	596 cases and 1192 controls (M and F) over 16 years of age. Cases identified from populationbased cancer registries. Two controls with no history of CNS tumour were randomly selected from the local electoral rolls matched on age (±2 years), sex and department of residence.	Exposure from mobile phone use. Self-reported exposure from standardised questionnaires delivered as face-to-face non-blinded structured interviews by trained interviewers.	Time since first use (years), Cumulative duration of calls (hours)	Gliomas, meningiomas. Conditional logistic regression for matched sets was used to estimate ORs and 95%Cis	**OR (95% CI) for glioma**	**OR (95% CI) for meningioma**	Level of education, smoking, alcohol consumption. Potential occupational confounders were identified from detailed job calendars, and from specific questions about exposure to pesticides, extremely low-frequency electromagnetic fields (ELF-EMF), RF-EMF, and ionising radiation	Adequate/ Positive (glioma, meningioma)
			Regular mobile phone use					
			Not regular user		1 (Ref.)	1 (Ref.)	Positive association in heavy users	
			Regular user		1.24 (0.86 - 1.77)	0.90 (0.61 - 1.34)		
			Time since first use (years)					
			1-4		0.88 (0.56 - 1.39)	0.79 (0.49 - 1.27)		
			5-10		1.34 (0.87 - 2.06)	0.97 (0.58 - 1.61)		
			>10		1.61 (0.85 - 3.09)	1.57 (0.64 - 3.86)		
			Cumulative duration of calls (hours)					
			<43		0.83 (0.48 - 1.44)	1.12 (0.61 - 2.04)		
			43-112		0.77 (0.42 - 1.41)	0.85 (0.45 - 1.61)		
			113-338		1.07 (0.60 - 1.90)	0.52 (0.25 - 1.07)		
			339-895		1.78 (0.98 - 3.24)	0.52 (0.18 - 1.45)		
			>896		2.89 (1.41 - 5.93)	2.57 (1.02 - 6.44)		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued g)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
9. Pettersson et al. 2014. Sweden, 2002-2007. Population-based case-control study.	422 cases with acoustic neuroma, 643 controls for analyses of mobile phone use. 417 cases with acoustic neuroma, 635 controls for analyses of cordless phone use (M and F), age 20-69 years. Cases identified in clinics, the Swedish Regional Cancer Registers and local acoustic neuroma registries. Two matched controls per case randomly selected from the Swedish population register.	Use of mobile phone and cordless phone . Self-reported exposure from mail questionnaire.	Frequency of use; Duration of exposure; Cumulative hours of use	Acoustic Neuroma. Odds Ratios (OR) with 95% CIs from conditional logistic regression	**OR (95% CI) for Mobile phone users**	**OR (95% CI) for Cordless phone users**	Smoking, education, marital status, and parity; for cordless phone analyses: hands-free use. Limits in exposure assessment. Positive association in heavy users.	Adequate/ Equivocal (Acoustic neuroma)
			Frequency of use					
			Never or rarely		1 (Ref.)	1 (Ref.)		
			Regular use		1.18 (0.88 - 1.59)	1.41 (1.07 - 1.86)		
			Duration of use (years)					
			<5		1.06 (0.73 - 1.54)	1.35 (0.97 - 1.89)		
			5 to 9		1.39 (0.97 - 1.97)	1.74 (1.22 - 2.46)		
			=>10		1.09 (0.75 - 1.59)	1.10 (0.73 - 1.64)		
			Cumulative use (hours)					
			<38		1.09 (0.73 - 1.62)	1.22 (0.82 - 1.82)		
			39-189		1.12 (0.74 - 1.69)	1.27 (0.85 - 1.89)		
			190-679		1.13 (0.75 - 1.70)	1.42 (0.96 - 2.09)		
			=>680		1.46 (0.98 - 2.17)	1.67 (1.13 - 2.49)		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued h)

Study information	Population	Type of Exposure and assessment method		Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)	Any Other Co-Exposure/adjustments	Comments
10 Yoon et al. 2015. Korea; 2002- 2007; case-control study.	285 cases, 285 controls (M and F), mean age 42.3 (±14.1) cases; 42.5 (±14.0) controls. Patients recruited from five areas including Seoul and checked at department of neurosurgery in nine hospitals. The control group persons who received health screenings at the same hospitals.	Exposure from mobile phone use. Self-reported exposure from questionnaires.		Cumulative hours and lifetime years of use; average daily receiving call and the average daily sending call; average call duration time	Glioma; adjusted odds ratios (aORs) and 95% CIs were calculated using logistic regression	**OR (95% CI) for glioma**	adjusted for sex, age, type of respondent, five residential regions, educational achievement, the use of dye, alcohol drinking, the use of computer, and the use of electric blanket	Adequate/ Equivocal (Glioma)
				Use of mobile phone				
				Non users		1 (Ref.)		
				Users		1.17 (0.63 - 2.14)		
				Lifetime years of use (months)				
				< 48		1.28 (0.62 - 2.64)		
				48-84		1.27 (0.63 - 2.56)		
				>48		1.04 (0.52 - 2.09)		
				Cumulative hours of use (h)				
				< 300		1.25 (0.64 - 2.45)		
				300-900		1.59 (0.72 - 3.21)		
				>900		0.64 (0.30 - 1.34)		
				Average duration time (min)				
				<2		1.18 (0.62 - 2.24)		
				3-4		1.31 (0.65 - 2.63)		
				>5		1.00 (0.45 - 2.24)		
11. Al-Qahtani 2016. Saudi Arabia; 1996-2013; Retrospective case-control study.	26 cases, 61 controls (M and F). <30 years: 28; 30-39 years: 23; 40-49 years: 15; >50 years: 21. Hospital records.	Exposure from mobile phone use. Self-reported exposure from telephone and in-person interviews using standardized questionnaire.		Everyday use: <=1 h/day: unexposed; >1 h/day: exposed. Latency: <10 years of use; =>10 years of use	Parotid gland tumour. OR and 95% confidence interval	**OR (95% CI) for parotid gland tumour**	Smoking Other confounding not considered. Small sample.	Inadequate
				Everyday use				
				Non exposed		1 (Ref.)		
				Exposed		3.47 (1.30 - 9.23)		
				Duration of exposure				
				< 10 years		3.6 (0.97 - 13.36)		
				10 years or more		3.46 (0.77 - 15.56)		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued i)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)				Any Other Co-Exposure/adjustments	Comments
12. Satta et al. 2018. Sardinia, Italy; 1998–2004; Population-based case-control study as part of the European multicenter study EPILYMPH.	322 lymphoma cases; 444 matched controls (M and F). Cases aged 25 to 74 years. In person interviews using a standardized questionnaire.	Exposure from radio-television transmitter or mobile phone base station near the three most prolonged residential addresses at any time of the life. Distance used as proxy for intensity of exposure; RF-EMF measurements at the door of the longest residential addresses available for the subset of subjects residing within 250 m of the closest transmitter base station, using a Microrade broadband detector.	Radiofrequency field estimates (V/m):	Lymphoma subtypes: B-cell; T-cell; Hodgkin; not otherwise specified NHL; OR and 95% confidence interval from logistic regression.	**OR for all lymphomas**	**OR for B-cell lymphoma**	**OR for Chronic lymphocytic leukemia**		Age, gender, years of education (categorized as 8 years, 9–13 years, 14 years), level of education and quartiles of vehicular traffic in proximity to the residential addresses of study subjects.	Inadequate
			RF field estimates (V/m):							
			<0.01		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		Uncertain exposure assessment	
			0.01- 1.23		0.7 (0.4 - 1.5)	0.8 (0.4 - 2.0)	1.5 (0.5 - 4.4)			
			1.24- 1.50		0.7 (0.3 - 1.5)	0.9 (0.4 - 2.1)	-			
			1.51- 1.7401		1.0 (0.5 - 2.1)	1.1 (0.5 - 2.7)	0.6 (0.1 - 3.1)			
			>1.7401		1.2 (0.6 - 2.6)	1.4 (0.6 - 3.4)	0.9 (0.2 - 4.6)			
13. Balekouzou et al. 2017. Central African Republic; 2003-2015; Case-control study.	174 cases; 348 age-matched controls (F). Age >15 years. Data from a cancer register.	Use of mobile phones,radiation exposure. Trained interviewers administered a standardized in person interview.	Exposure to radiation; habit to keep mobile phone in the bra.	Breast cancer. Odds ratio (OR) and 95% confidence intervals (95% CI) from unconditional logistic regression.	**OR (95% CI) for Breast cancer, univariate analysis**	**p-value**	**OR (95% CI) for Breast cancer, multivariate analysis**	**p-value**	Age, occupation, economic status, education, residence, ethnic group and marital status, family history, radiation exposure, food consumption, physical activity, alcohol, tobacco, use of bra, habit to keep money or cell phones in bras, height, weight and BMI.	Inadequate
			Daily use (h/day)						Self reported habit to keep mobilphone in the bra	
			No		1.00 (ref.)		1.00 (ref.)			
			Yes		8.02 (5.16-12.47)	0.000	8.21 (5.04 – 13.38)	0.000		
			Habit of keeping cell phone in bras							
			Yes		1.00 (ref.)		1.00 (ref.)			
			No		0.45 (0.31-0.65)	0.000	0.56 (0.35-0.89)	0.01		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued j)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
14. Vila et al. 2018. Australia, Canada, France, Germany, Israel, New Zealand and the United Kingdom; 2000-2004; INTEROCC study: international case-control study on mobilephone use and brain cancer risk in seven countries. "	2054 glioma cases; 1924 meningioma cases; 5601 controls (M and F). Cases aged 30 to 59 years of age; up to 69 years in Germany; 18 years and above in Israel; 18 to 69 years in the United Kingdom. In person computer-assisted personal interview.	Self-reported occupational exposure or proximity to radars, telecommunication antennas, transmitters, equipment for semiconductors manufacturing, medical diagnosis and treatment, industrial heating or food heating. A source-exposure matrix (SEM) was used to assign average exposure levels to each RF and IF source reported. Field intensities for each EMF source were weighted using the frequency-dependent reference levels (RLs) by the International Commission on Non-Ionising Radiation Protection (ICNIRP) for occupational exposure. Frequency of exposure: 10 MHz- 300 GHz.	E-field (V/m, Arithmetic mean exposure levels from the SEM. RF sources organized by E-field exposure level)	Glioma and meningioma risk; adjusted OR and 95% confidence intervals.	**OR (95% CI) for Gliomas**	**OR for Meningiomas**	No information available Study suggestive of a potential role in brain tumour promotion/progression	Adequate/ negative (Glioma and meningioma)
			Duration of exposure: 1-4 years					
			Non exposed		1.00 (ref.)	1.00 (ref.)		
			<0.42		0.69 (0.49 - 0.98)	0.60 (0.38 - 0.96)		
			0.42–4.47		0.85 (0.54 - 1.35)	1.13 (0.60 - 2.14)		
			4.48–18.8		0.77 (0.44 - 1.37)	0.86 (0.35 - 2.13)		
			≥18.9		1.38 (0.75 - 2.54)	1.30 (0.58 - 2.91)		
			Duration of exposure: 5-9 years					
			Non exposed		1.00 (ref.)	1.00 (ref.)		
			<0.42		0.84 (0.61 - 1.17)	0.60 (0.38 - 0.97)		
			0.42–4.47		0.93 (0.60 - 1.44)	1.48 (0.84 - 2.61)		
			4.48–18.8		0.82 (0.46 - 1.47)	1.08 (0.66 - 2.39)		
			≥18.9		0.90 (0.44 - 1.83)	1.03 (0.45 - 2.63)		

Table 1 - Cancer in epidemiological Case-Control studies (450-6000 MHz) (Continued I)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
15. Luo et al. 2019. Connecticut, USA, 2010-2011; population-based case-control study.	462 cases and 498 population-based controls (M and F), 21-84 years of age.	Use of mobile phones,radiation exposure. Trained interviewers administered a standardized and structured questionnaire.	Use of mobile phones; Duration of exposure.	Thyroid cancer (papillary, follicular, medullary, anaplastic). Multivariate unconditional logistic regression to estimate odds ratios (OR) and 95% confidence intervals (95% CI).	**OR (95% CI) for Thyroid cancer, Overall**	**OR (95% CI) for Thyroid cancer, MM**	**OR (95% CI) for Thyroid cancer, FF**	age, sex, education, family history of thyroid cancer, alcohol consumption, body mass index, previous benign thyroid diseases, occupational radiation exposure, and radiation treatment.	Adequate/ Equivocal (Thyroid cancers)
			Use of mobile phone						
			Non users (< 6 months use)		1 (Ref.)	1 (Ref.)	1 (Ref.)		
			Users (< 6 months use)		1.05 (0.74, 1.48)	1.27 (0.62, 2.61)	0.99 (0.66, 1.47)		
			Daily use (h/day)						
			≤1		1.10 (0.72, 1.66)	1.76 (0.72, 4.32)	0.97 (0.60, 1.56)		
			1-2		1.51 (0.90, 2.53)	1.66 (0.57, 4.82)	1.45 (0.79, 2.65)		
			>2		1.40 (0.83, 2.35)	1.05 (0.35, 3.14)	1.52 (0.83, 2.80)		
			Age at first use (years)						
			≤20		1.08 (0.53, 2.20)	1.49 (0.34, 6.01)	0.95 (0.42, 2.18)		
			21-50		1.06 (0.72, 1.55)	1.44 (0.65, 3.17)	0.96 (0.62, 1.49)		
			>50		1.03 (0.62, 1.70)	0.99 (0.36, 2.70)	1.05 (0.58, 1.90)		
			Duration of use (years)						
			≤12		0.99 (0.66, 1.49)	0.99 (0.39, 2.48)	0.97 (0.61, 1.53)		
			12-15		0.94 (0.63, 1.42)	0.82 (0.34, 1.97)	0.97 (0.61, 1.55)		
			>15		1.29 (0.83, 2.00)	2.11 (0.91, 4.89)	1.03 (0.62, 1.73)	Some evidence in long term users	

Table 2 – Cancer in epidemiological ecological case-control studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjust ments	Comments
16. Gonzalez Rubio et al. 2017. Spain. 2012-2015. Case-control ecological study.	95 cases: 65 lymphomas, 12 gliomas, 18 meningiomas (30 brain tumours); 390 anonymous controls (M and F). Resident population data in the 110 administrative districts from the Spain's National Statistics Institute (INE). Addresses for all cancer cases of gliomas, meningiomas and lymphomas from Oncology Service of the University Hospital of Albacete. Representative random sample of 390 anonymous addresses for the control group from the Statistics Service of the Town Council of Albacete.	Residential exposure to any RF. 14 frequency bands (FM, TV3, TETRA, TV4and5, GSMTx, GSM Rx, DCS Tx, DCS Rx, DECT, UMTS Tx, UMTS Rx,WiFi 2G,WiMAX y WiFI 5G), ranging from 88MHz up to 6 GHz. Personal exposure assessed using an EME Spy 140 (Satimo)exposimeter, conveying the exposimeter in a bicycle. 168266 total measurement, 12019 measurements per frequency, 1540 average measurement records per administrative region.	Average total exposure to RF-EMF (V/m) per administrative region: Min 0.07, max 1.03	Gliomas, meningiomas and lymphomas; Spearman correlation test between exposure and incidence of tumours. Effect estimate not appropriate	**ρ of Spearman for Meningioma, (p-value)**	**ρ of Spearman for Glioma, (p-value)**	**ρ of Spearman for all brain, (p-value)**	**ρ of Spearman for Lymphoma, (p-value)**	**ρ of Spearman for all tumours, (p-value)**	Smoking Other counfounders not analysed Design not clear, particularly given that there seems to be personal exposure assessment	inadequate
	Design not clear, particularly given that there seems to be personal exposure assessment	Not clear exposure assessment			0,19 (0,04)	0,15 (0,13)	0,28 (0,003)	-0,03 (0,72)	0,13 (0,19)		

Table 3 – Cancer in epidemiological cohort studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
17. Frei et al. 2011. Denmark; 1990-2007. Nationwide cohort study.	All Danes aged ≥30 and born in Denmark after 1925, subdivided into subscribers and non-subscribers of mobile phones before 1995.	Use of mobile phones as mobile phone subscription; records for 1982-95 were obtained from the Danish network operators.	Mobile phone use, duration of subscription.	Tumours in the central nervous system. Sex-specific incidence rate ratios (IRR) and 95% confidence intervals from log-linear Poisson regression models.	**IRR (95% CI) for Central nervous system tumours, MM**	**IRR (95% CI) for Central nervous system tumours, FF**	**IRR (95% CI) for Central nervous system tumours, MM with >12 years of education**	Age, calendar period, education, and disposable income.	Inadequate
			Use of mobile phones						
			Non-subscribers		1.0 (ref.)	1.0 (ref.)	1.0 (ref.)		
			Subscribers		1.02 (0.94 to 1.10)	1.02 (0.86 to 1.22)	1.00 (0.83 to 1.22)	Exposure assessment only by subscriptions	
			Years of subscription						
			Non-subscribers		1.0 (ref.)	1.0 (ref.)	1.0 (ref.)		
			1-4		1.07 (0.92 to 1.24)	0.97 (0.69 to 1.36)	1.29 (0.92 to 1.79)		
			5-9		0.95 (0.83 to 1.08)	1.05 (0.81 to 1.37)	0.95 (0.70 to 1.29)		
			10-12		1.08 (0.93 to 1.25)	1.05 (0.75 to 1.47)	0.82 (0.55 to 1.24)		
			≥13		1.03 (0.83 to 1.27)	0.91 (0.41 to 2.04)	0.94 (0.55 to 1.60)		

Table 3 – Cancer in epidemiological cohort studies (450-6000 MHz) (Continued b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjustments	Comments
18. Benson et al. 2013. United Kingdom,; prospective Cohort study , the Million Women Study.	1.3 million middle-aged women recruited for Breast Screening Programme	Use of mobile phone. Postal questionnaire; questions on mobile phone use were asked in 1999–2005, and again in 2009	Use of mobile phone.	Intracranial central nervous system tumours. Cox regression models to estimate adjusted relative risks (RRs) and 95% confidence intervals (CIs)	**RR (95% CI) for all intracranial CNS tumours**	**RR (95% CI) for glioma**	**RR (95% CI) for meningioma**	**RR (95% CI) for pituitary**	**RR (95% CI) for acoustic neuroma**	Socioeconomic status, region, age at baseline, height, BMI, smoking, alcohol intake, exercise, use of menopausal hormone therapy.	Adequate/ Positive (acoustic neuroma, pituitary gland)
			Ever used a mobile phone							Overadjusted for several outcomes.	
			No		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			Yes		1.01 (0.90-1.14)	0.91 (0.76-1.08)	1.05 (0.81-1.38)	1.52 (0.99-2.33)	1.44 (0.91-2.28)		
			Frequency of use								
			Never user		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			<Daily use		1.02 (0.90-1.15)	0.92 (0.77-1.10)	1.05 (0.80-1.37)	1.53 (0.99-2.36)	1.45 (0.91-2.31)		
			Daily use		1.00 (0.80-1.26)	0.80 (0.56-1.14)	1.11 (0.67-1.85)	1.45 (0.68-3.10)	1.37 (0.61-3.07)		
			Duration of exposure (years)					*p-value for trend = 0.23*	*p-value for trend = 0.03*		
			Never user		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			<5		1.00 (0.84-1.20)	0.93 (0.71-1.21)	0.88 (0.60-1.31)	2.31 (1.31-4.06)	1.00 (0.54-1.82)		
			5-9		1.02 (0.89-1.17)	0.92 (0.75-1.13)	1.21 (0.89-1.65)	1.08 (0.64-1.82)	1.80 (1.08-3.03)		
			10+		1.02 (0.81-1.27)	0.78 (0.55-1.10)	1.10 (0.66-1.84)	1.61 (0.78-3.35)	2.46 (1.07-5.64)		

Table 3 – Cancer in epidemiological cohort studies (450-6000 MHz) (Continued c)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)				Any Other Co-Exposure/adjustments	Comments
19. Poulsen et al. 2013. Denmark, 1982-1995, follow up until 2007. Cohort study: CANULI study of social inequality and cancer incidence and survival	355701 (M and F), 30 years to date of the first cancer diagnosis, death, emigration.	Use of mobile phones. Mobile phone subscriptions in Denmark during the period from 1982 until the end of 1995. Person-time within the first year of subscription was defined as unexposed.	Use of mobile phones; Duration of exposure.	Basal Cell Carcinoma of the head and neck, Squamous Cell Carcinoma and Melanoma on the head and neck. Incidence rate ratios (IRRs) and 95% confidence intervals from log-linear Poisson regression models.	**IRR (95% CI) for Basal Cell Carcinoma of the head and neck, FF**	**IRR (95% CI) for Basal Cell Carcinoma of the head and neck, MM**	**IRR (95% CI) for Squamous Cell Carcinoma and Melanoma of the head and neck, FF**	**IRR (95% CI) for Squamous Cell Carcinoma and Melanoma of the head and neck, MM**	Age, calendar year, educational level, and income. Exposure assessment by mobile phone subscription only	Inadequate
			Use of mobile phone							
			Non users (< 1 year subscription)		1 (Ref.)	1 (Ref.)	1 (Ref.)	1 (Ref.)		
			Users (>1 year subscription)		0.93 (0.82 - 1.05)	0.98 (0.93 - 1.03)	1.01 (0.88 - 1.16)	1.05 (0.80 - 1.37)		
			Duration of use (years)							
			1–4		1.02 (0.80 - 1.30)	1.01 (0.91 - 1.13)	0.86 (0.61 - 1.21)	1.16 (0.69 - 1.94)		
			5-9		0.78 (0.64 - 0.95)	0.96 (0.89 - 1.04)	1.01 (0.81 - 1.26)	1.01 (0.65 - 1.57)		
			10-12		1.02 (0.83 - 1.26)	0.96 (0.87 - 1.05)	1.17 (0.93 - 1.48)	0.92 (0.55 - 1.54)		
			>=13		1.20 (0.79 - 1.82)	1.02 (0.90 - 1.15)	0.91 (0.66 - 1.27)	1.20 (0.65 - 2.22)		

Table 3 – Cancer in epidemiological cohort studies (450-6000 MHz) (Continued d)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
20. Hauri et al. 2014. Switzerland. 2000-2008. Census-based cohort study.	997 cancer cases from Swiss National Cohort: 283 leukemia, 258 CNS tumours, 456 other cancers; 117 cases from Swiss Childhood Cancer Registry, not linked with SNC: 27 leukemia, 26 CNS tumours, 64 other cancers (M and F); ≤15 years.	Residential exposure to broadcast transmitters emitting medium-wave (0.5–1.6 MHz), short-wave (6–22 MHz), very high frequency (VHF; 174–230 MHz), and ultra-high frequency (UHF; 470–862 MHz) EMFs. RF-EMF levels from VHF and UHF transmitters ... were modeled by the Federal Office of Communications for an area with a radius of 10 km around each transmitter for the years 1990 and 2000.	A priori chosen cutpoints to differentiate between low, medium, and high exposure. V/m	Leukemia, acute lymphoblastic leukemia, and Central Nervous System tumours, including benign tumours. Hazard Ratio from time-to-event analysis (Cox Regression), 2000–2008. Incidence Rate Ratio from Poisson regression analysis, 1985–2008.	**HR (95% CI), IRR (95% CI), All cancers**	**HR (95% CI), IRR (95% CI), All leukemias**	**HR (95% CI), IRR (95% CI), CNS tumours**	Sex, benzene, natural background ionising γ radiation, distance to the nearest high-voltage power line, and degree of urbanisation.	Adequate/ Negative (Childood cancers)
			Residential exposure						
			Low		1 (Ref.)	1 (Ref.)	1 (Ref.)		
			Medium		1.14 (0.94 - 1.38) 1.09 (1.00 - 1.20)	0.70 (0.46 - 1.07) 0.92 (0.77 - 1.10)	1.35 (0.94 - 1.95) 1.16 (0.95 - 1.42)		
			High		1.03 (0.74 - 1.43) 0.90 (0.76 - 1.06)	0.55 (0.26 - 1.19) 0.76 (0.55 - 1.05)	1.68 (0.98 - 2.91) 1.03 (0.73 - 1.46)		

Table 4 (summary 1-3) – Collected data on cancer in epidemiological studies (450-6000 MHz)

Total studies FR1*	20			
Adequate studies	11			
Observed Tumour	Total adequate studies	Positive results	Equivocal results	Negative results
Glioma	8	3	2	3
Acoustic neuroma	3	2	1	
Meningioma	4	2		2
Lymphoma	1			1
Thyroid gland	1		1	
Pituitary gland	1	1		

*Some of the studies include more than one tumour site.

1. SUMMARY OF THE RESULTS OF EPIDEMIOLOGICAL STUDIES (FR1: 450 to 6000 MHz) (Table 4)

The epidemiological evidence on possible associations of exposure to RF-EMF with cancer comes from studies of diverse design that assessed a range of exposure sources: the populations included people exposed in occupational settings, people exposed through sources in the general environment, e.g. radio-base stations, and people exposed through use of wireless (mobile and cordless) telephones.

In chapter 4 (Limitations) general methodological concerns related to the assessment of individual studies are covered. The total number of epidemiological studies published after the IARC 2011 evaluation (IARC, 2013) and up to 2020, as selected for the present review for FR1, was 20.

After further deep analyses of the 20 original papers, 11 studies proved to be adequate on the basis of exposure assessment, sample size and appropriateness of confounding analyses.

Gliomas, acoustic neuromas, meningiomas, lymphomas, thyroid and pituitary gland tumours were analysed in the 11 adequate studies for a possible association with exposure to RF-EMF, related to the use of mobile phone, or for environmental/occupational exposure to emissions from radiobase stations. The association of the different neoplasias to RF-EMF exposure is reported below. Between brackets numbers assigned to the various studies are reported.

Glioma: out of 7 adequate studies regarding this outcome, 3 showed a positive association with RF-EMF exposure (Ref: 6, 7, 8), 2 were equivocal (1,10) and 3 negative (Ref: 14,18, 20).

Acoustic neuroma: out of 3 adequate studies regarding this outcome, 2 showed a positive association with the RF-EMF exposure (Ref: 7, 18), 1 was equivocal (Ref:9).

Meningioma: out of 4 adequate studies regarding this outcome, 2 showed a positive association with the RF-EMF exposure (Ref: 5,8), and 2 were negative (Ref: 14, 18).

Lymphoma/leukaemia: the only adequate study (childhood) regarding this outcome was negative (Ref: 20).

Thyroid tumour: the only adequate study regarding this outcome showed equivocal results (Ref: 15).

Pituitary gland tumour: the only adequate study regarding this outcome was positive (Ref: 18).

The results of the different studies for the same outcome are mixed (showing conflicting findings) , as summarized in Table 4. The tumours with more robust evidence of association are glioma and acoustic neuroma. The association of glioma and acoustic neuroma is stronger among long-term heavy users of mobile phones, which is also the most extensively investigated exposure source, and in some cases the onset of tumours was related to the side on which the device was handled.

The IARC evaluation of *limited evidence* of cancerogenicity of RF-EMF in epidemiological studies as regards FR1 is confirmed.

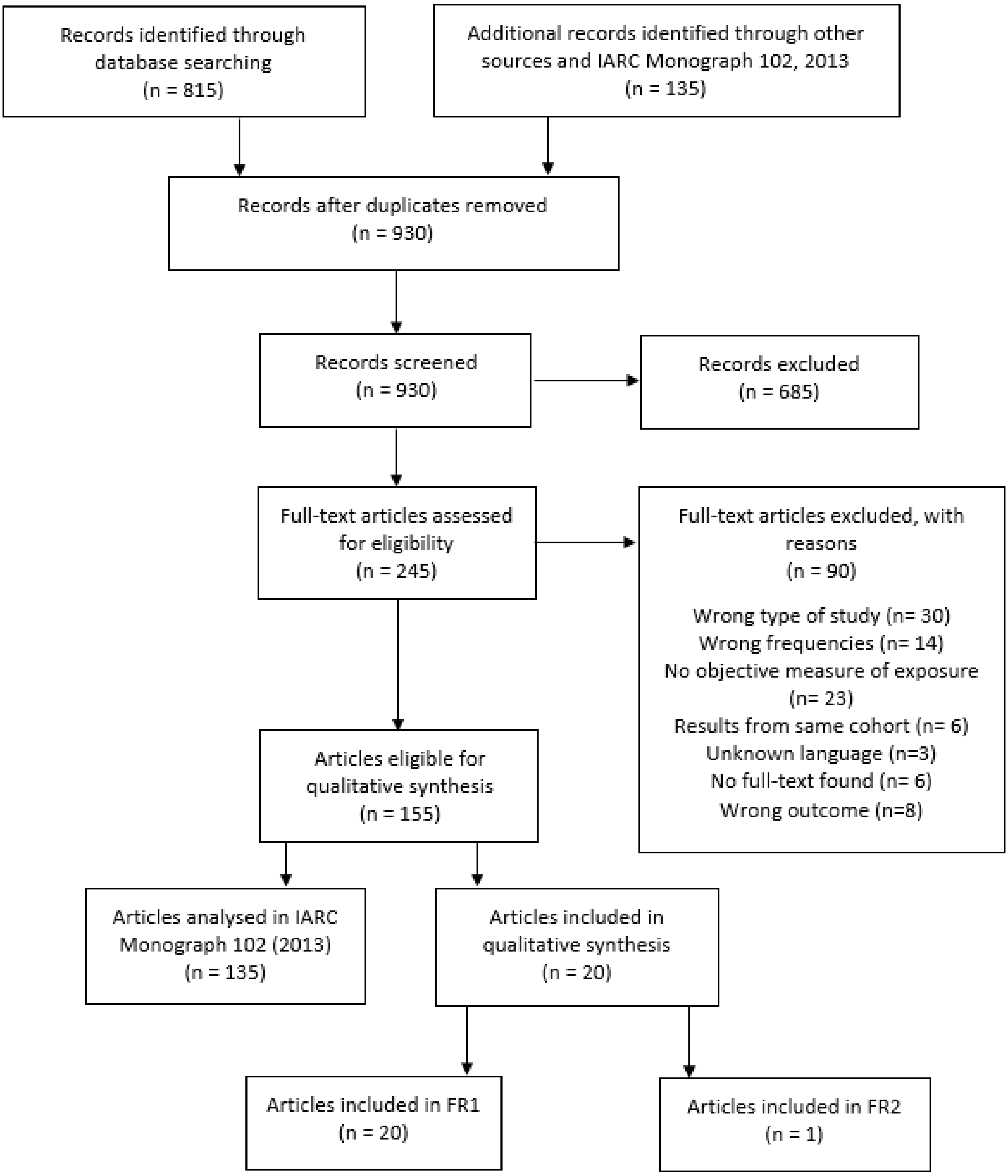
4.1.2 Cancer in epidemiological studies: Studies evaluating health effects due to RF at a higher frequency range (FR2: 24 to 100 GHz, MMW).

The stream of selection of the relevant literature is the same as for FR1, as highlighted in the PRISMA flowchart, 930 articles were screened based on title and abstract and 685 were excluded at this stage; 245 were screened based on full-texts and 90 were excluded at this stage, and after a more thorough assessment, only one published article was eligible for inclusion in the scoping review for the highest range of frequencies (this article reported occupational exposures for both FR1 and FR2, so this doesn't add up to the overall number of included studies) (Fig. 10).

Two articles that were included in IARC Monograph 102 (IARC, 2013) (and are therefore not described here) presented exposures related to FR2 range: it was decided to provide the most important information in the summary tables, since these novel frequencies are the real focal point of this scoping review.

Again, for each article, the abstract is presented, together with a table summarising the most important information; furthermore, a senior expert evaluated their adequacy for assessing carcinogenic effects (adequate/inadequate), and an overall synthesis of the results (positive/negative/equivocal), following the criteria used to assess the adequacy described in the methodology section.

Figure 10 – Flow diagram. Epidemiological studies on cancer for FR2



In conclusion, search on PubMed e EMFPortal databases for epidemiological studies considering exposures from 24GHz to 100 GHz (FR2) included 3 studies. Two were already described in the IARC Monograph 102 (Stang et al., 2001 (1); Baumgardt-Elms et al., 2002 (2)) , one was published after 2011 (Vila et al, 2018 (3)); the latter was also studied in the lower frequencies analysis included in the review.The 3 studies regard occupational exposures of radar operators or workers nearby radar stations. The range of frequencies used by radar telecommunications are represented in Table 5 (IEEE 521-2002). Exposure of workers is not well assessed, as the RF-EMF exposure is self reported, usually quantified by distance from the radar or simply job title:

Table 5 – Range of frequencies used by radar communication.

Range name	Frequency
L	1 - 2 GHz
S	2 – 4 GHz
C	4 – 8 GHz
[3]	8 – 12 GHz
Ku	12 – 18 GHz
K	18 – 27 GHz
Ka	27 – 40 GHz
V	40 – 75 GHz
W	75 – 110 GHz

Summaries of the analysed studies for these frequencies are presented in Tables 6a,b. The epidemiological study not included in the 2011 IARC Working group evaluation is the following:

3. Vila et al., 2018.

Australia, Canada, France, Germany, Israel, New Zealand and the United Kingdom; 2000-2004; INTEROCC study: international case-control study on mobilephone use and brain cancer risk in seven countries.

In 2011, the International Agency for Research on Cancer classified radiofrequency (RF) electromagnetic fields (EMF) as possibly carcinogenic to humans (group 2B), although the epidemiological evidence for the association between occupational exposure to RF-EMF and cancer was judged to be inadequate, due in part to limitations in exposure assessment. This study examines the relation between occupational RF and intermediate frequency (IF) EMF exposure and brain tumour (glioma and meningioma) risk in the INTEROCC multinational population-based case-control study (with nearly 4000 cases and over 5000 controls), using a novel exposure assessment approach. Methods: Individual indices of cumulative exposure to RF and IF-EMF (overall and in specific exposure time windows) were assigned to study participants using a source-exposure matrix and detailed interview data on work with or nearby EMF sources. Conditional logistic regression was used to investigate associations with glioma and meningioma risk. Overall, around 10% of study participants were exposed to RF while only 1% were exposed to IF-EMF. There was no clear evidence for a positive association between RF or IF-EMF and the brain tumours studied, with most results showing either no association or odds ratios (ORs) below 1.0. The largest adjusted ORs were obtained for cumulative exposure to RF magnetic fields (as A/m-years) in the highest exposed category (≥90th percentile) for the most recent exposure time window (1–4 years before the diagnosis or reference date) for both glioma, OR=1.62 (95% confidence interval (CI): 0.86, 3.01) and meningioma (OR=1.52, 95% CI: 0.65, 3.55). Despite the improved exposure assessment approach used in this study, no clear associations were identified. However, the results obtained for recent exposure to RF electric and magnetic fields are suggestive of a potential role in brain tumour promotion/progression and should be further investigated.

Comment*: *Improved exposure assessment. No clear associations were identified for glioma and meningioma, potential role in brain tumour promotion/progression.

Table 6 – Cancer in epidemiological case-control studies (24 to 100 GHz, MMW) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
1.Stang et al. 2001. Germany. 1994-1997. Hospital-based and population-based case-control study.	118 cases, 475 controls (M and F). 35-74 years. Hospital-based case-control study at the Division of Ophthalmology, University of Essen; Controls in the population-based study were selected randomly from mandatory lists of residence.	Occupational sources of electromagnetic radiation. Self-reported exposure from face-to-face interview.	Lifetime exposure: source of exposure, duration, beginning of exposure.	Uveal Melanoma. Odds ratios (ORs) and 95% CI from conditional logistic regression models.	**OR (95% CI), Uveal Melanoma**		Medical history, phenotypic characteristics, life-style factors, Few participants reported exposure to radar	Adequate/negative (Uveal melanoma)
			EMF Source					
			Radar units		0.4 (0.0-2.6)			
2. Baumgardt-Elms et al. 2002. Germany. 1995-1997. Population-based case–control study.	269 cases, 797 controls (M). 15-69 years. Cases were ascertained through an active reporting system of clinical and pathology departments in the study regions. Controls were selected at random from the mandatory registries of residents.	Occupational exposure to EMF. Self-reported exposure from face-to-face interview.	At least 6 months of exposure. Exposures grouped according to the electromagnetic spectrum and assumptions on the strength of the electric and magnetic fields measured in specific workplaces.	Testicular cancer; Odds ratio and 95% confidence intervals (OR, 95% CI) from conditional logistic regression.	**OR (95% CI), testicular cancer**		Matching factors age (ten 5-year age groups since there were no cases in the highest age group) and region of residence (five strata) through stratification; subgroup analysis for blue- and white-collar workers.	Adequate/negative (Tumours of the testis)
			EMF Source					
			Working near radar units		1.0 (0.60-1.75)			

Table 6 – Cancer in epidemiological case control studies (24 to 100 GHz, MMW) (continued b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
3. Vila et al. 2018. Australia, Canada, France, Germany, Israel, New Zealand and the United Kingdom; 2000-2004; INTEROCC study: international case-control study on mobilephone use and brain cancer risk in seven countries.	2054 glioma cases; 1924 meningioma cases; 5601 controls (M and F). Cases aged 30 to 59 years of age; up to 69 years in Germany; 18 years and above in Israel; 18 to 69 years in the United Kingdom. In person computer-assisted personal interview.	Self-reported occupational exposure or proximity to radars, telecommunication antennas, transmitters, equipment for semiconductors manufacturing, medical diagnosis and treatment, industrial heating or food heating. A source-exposure matrix (SEM) was used to assign average exposure levels to each RF and IF source reported. Field intensities for each EMF source were weighted using the frequency-dependent reference levels (RLs) by the International Commission on Non-Ionising Radiation Protection (ICNIRP) for occupational exposure. Frequency of exposure: 10 MHz-300 GHz.	E-field (V/m, Arithmetic mean exposure levels from the SEM. RF sources organized by E-field exposure level)	Glioma and meningioma risk; adjusted OR and 95% confidence intervals.	**OR (95% CI) for Gliomas**	**OR for Meningiomas**	No information available Improved exposure assessment. No clear associations were identified for glioma and meningioma, potential role in brain tumour promotion/progression.	Adequate/negative (glioma and meningioma)
			Duration of exposure: 1-4 years					
			Non exposed		1.00 (ref.)	1.00 (ref.)		
			<0.42		0.69 (0.49-0.98)	0.60 (0.38-0.96)		
			0.42–4.47		0.85 (0.54-1.35)	1.13 (0.60-2.14)		
			4.48–18.8		0.77 (0.44-1.37)	0.86 (0.35-2.13)		
			≥18.9		1.38 (0.75-2.54)	1.30 (0.58-2.91)		
			Duration of exposure: 5-9 years					
			Non exposed		1.00 (ref.)	1.00 (ref.)		
			<0.42		0.84 (0.61-1.17)	0.60 (0.38-0.97)		
			0.42–4.47		0.93 (0.60-1.44)	1.48 (0.84-2.61)		
			4.48–18.8		0.82 (0.46-1.47)	1.08 (0.66-2.39)		
			≥18.9		0.90 (0.44-1.83)	1.03 (0.45-2.63)		

Table 7 (Summary 6 a, b) – Summary table for epidemiological studies on Cancer, FR2: 24-100 GHz

Total studies*	3			
Adequate studies	3			
Observed Tumour	Total adequate studies	Positive results	Equivocal results	Negative results
Glioma	1			1
Meningioma	1			1
Uveal melanoma	1			1
Testicular cancer	1			1

*one of the studies includes more than one tumour site.

- **SUMMARY OF THE RESULTS EPIDEMIOLOGICAL STUDIES ON CANCER (FR2: 24 to 100 GHz, MMW) (Table 6a, b)**

All 3 adequate studies reviewed did not show any clear association between exposure to higher frequencies (FR2) and the selected cancer (table 7).

The IARC Working group in the summary of data reported for occupational exposure regarding also FR2, concluded:

"Tumours of the brain*: "…exposure misclassification and insufficient attention to possible confounding limit the interpretation of findings. Thus, there is no clear indication of an association of occupational exposure to RF radiation with risk of cancer of the brain. "*

*"*Leukaemia/Lymphoma*: In summary, while there were weak suggestions of a possible increase in risk of leukaemia or lymphoma associated with occupational exposure to RF radiation, the limited exposure assessment and possible confounding make these results difficult to interpret".*

Other kinds of tumour emerged as potentially associated with exposure to high frequencies (uveal melanoma, cancer of the testis, breast, lung, and skin), but many of the studies showed methodological limitations and the results were inconsistent (IARC 2013). Afterwards, any other adequate study was performed regarding the association of these types of tumours with the exposure to RF-EMF (FR2).

The present review bears out these remarks, so we must confirm that, where the highest 5G (FR2) frequency is concerned, the only 3 epidemiological studies examined for FR2 exposure are *not adequate* to assess the impact on health.

4.1.3 Cancer in experimental animals: Studies evaluating health effects due to RF at a lower frequency range (FR1: 450 to 6000 MHZ), which also includes the frequencies used in previous generations' broadband cellular networks (1G, 2G, 3G and 4G).

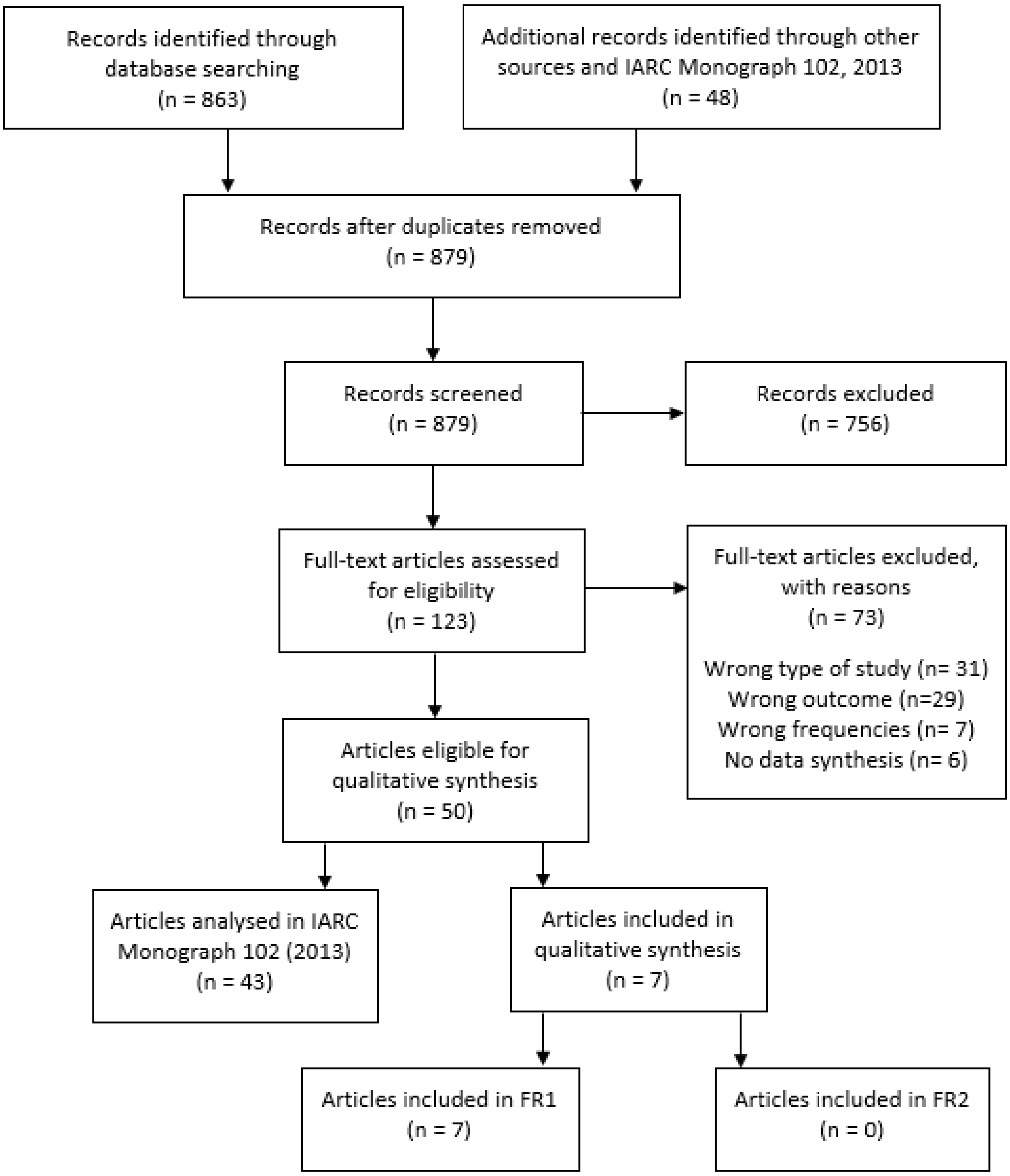
The articles identified through database searching and other sources were 911. After removing duplicates (32) and excluding non-pertinent articles (756) based on title and abstracts, 123 articles remained. Based on full-text screening, 73 papers were further excluded, so that the articles with frequencies appropriate for inclusion in this qualitative synthesis were 50.

As further explained in the methodology section, we considered IARC Monograph 102 (IARC, 2013) as our key reference for all studies on cancer in experimental animals published until 2011: all original papers (43) that were included in the IARC monograph were analysed and referenced in this report as well; of course, we considered for this report only the final IARC classification. Seven adequate studies were published after 2011.

At this stage, a separation based on frequency range was also performed: of the 7 papers included, all reported exposures belonging to the band considered in FR1, and none reported exposures regarding FR2 (Fig. 11).

For each article selected, the abstract is presented, together with the tables summarising the most important information; furthermore, a senior expert evaluated their adequacy for assessing carcinogenic effects adequate/inadequate), and expressed an overall synthesis of the results (positive/negative/equivocal), following the criteria described in the methodology chapter.

Figure 11 – Flow diagram. Cancer in experimental animal studies FR1



KEY REFERENCE: IARC 2013 (43 studies)

The IARC Monograph 102 is the key reference for the present review. The evaluation of the adequate available studies at that time is reported below (IARC, 2013).

In May, 2011, 30 scientists from 14 countries met at the International Agency for Research on Cancer(IARC) in Lyon, France, to assess the carcinogenicity of radiofrequency electromagnetic fields (RF-EMF). These assessments was published as Volume 102 of the IARC Monographs (IARC, 2013).

Four classes of cancer bioassays in animals were reviewed and assessed by the Working Group. These studies involved a variety of animal models, exposure metrics, duration of exposure, and other criteria on which the evaluation of carcinogenicity was based.

The Working Group evaluated:

- 7 two-year cancer bioassays of RF radiation, two in mice and five in rats; six studies were performed to examine the effects of exposure to mobile-phone RF metrics, and one study involved exposure to pulsed RF radiation. When compared with sham controls, no statistically significant increases in the incidence of benign or malignant neoplasms at any organ site were identified in animals exposed to mobilephone RF radiation in any study. In the study with exposure to pulsed RF radiation, an increased incidence of total malignant tumours (all sites combined) was observed in rats; however, the Working Group considered this finding to be of limited biological significance since it resulted from pooling of non-significant changes in tumour incidence at several sites. Exposure to RF radiation did not increase total tumour incidence in any of the other six studies that were evaluated. The Working Group concluded that the results of the 2-year cancer bioassays provided no evidence that long-term exposure to RF radiation increases the incidence of any benign or malignant neoplasm in standard-bred mice or rats.

- 12 studies that used four different tumour-prone animal models; two of these studies demonstrated an increased incidence of tumours in animals exposed to RF radiation. The first study with positive results demonstrated an increased incidence of lymphoma in *Eμ-Piml-transgenic* mice exposed to GSM mobile-phone RF radiation at 900 MHz; however, two subsequent studies by other investigators using the same model system failed to confirm this finding. In the second study with positive results, an increased incidence of tumours of the mammary gland was observed in C3H/HeA mice exposed to RF radiation at 2450 MHz; although two later studies using the same exposure metric did not confirm this finding, these follow-on studies were performed at lower levels of exposure. The Working Group concluded that the results of studies in three tumour-prone animal models (the *Eμ-Piml* mouse model of lymphoma, the *AKR* mouse model of lymphoma, and the *Patchedr -1* mouse model of brain cancer) do not support the hypothesis that the incidence of tumours in the brain or lymphoid tissue would increase as a result of exposure to RF radiation.

- 16 studies of initiation and promotion that were performed with animal models of tumourigenesis in skin, mammary gland, brain, and lymphoid tissue. None of the five studies in models of skin cancer and none of the six studies in models of brain cancer showed an association with exposure to RF radiation. One of four studies with the model of mammary-gland tumour in Sprague-Dawley rats gave positive results; the other three studies - one with a nearly identical protocol - did not show an association, although they used the same experimental model and the same conditions of exposure to RF radiation. Likewise, the study with the model of lymphoma was negative. The Working Group concluded that the evidence from these studies of initiation and promotion failed to demonstrate a consistent pattern of enhancement of carcinogenesis by exposure to RF radiation in any of the tissues studied.

- 6 co-carcinogenesis studies involving five different animal models. Four positive responses were reported. Two studies giving positive results, one in Wistar rats continuously exposed to drinking-water containing MX - a by-product of water disinfection - and another study in pregnant B6C3F1 mice given a single dose of ethyl-nitrosourea, involved exposures to mobile-phone RF radiation at 900 and 1966 MHz, respectively. The other two studies with positive results involved coexposure of BALB/c mice to RF radiation at 2450 MHz and benzo[a]pyrene. Although the value of two of these studies was weakened by their unknown relevance to cancer in humans, the Working Group concluded that they did provide some additional evidence supporting the carcinogenicity of RF radiation in experimental animals.

The conclusion for the animal studies evaluation was: "*There is limited evidence in experimental animals for the carcinogenicity of radiofrequency radiation*" (IARC, 2013).

- REVIEW OF THE ANIMAL STUDIES 2011-2020

Starting from 2011, the present review evaluates by type of study and by year of publication (2011-2020) the animal studies also summarized in Table 3 (a, b, c, d). The author adds to short abstracts her own brief comments on the results of the different studies.

TWO YEAR CANCER BIOASSAY IN MICE (Table 8a)

1. NTP TR 596, 2018.

GSM-modulated RFR, B6C3F1/N mice (M, F), for 24 months, Carcinogenicity study.

Groups of 105 male and 105 female mice were housed in reverberation chambers and received whole-body exposures to GSM-modulated cell phone RFR at power levels of 0 (sham control), 2.5, 5, or 10 W/kg, 9 hours and 10 minutes per day, 7 days per week for 106 (males) or 108 (females) weeks with continuous cycling of 10 minutes on and 10 minutes off during a period of 18 hours and 20 minutes each day. The sham control animals were housed in reverberation chambers identical to those used for the exposed groups, but were not exposed to RFR; shared groups of unexposed mice of each sex served as sham controls for both RFR modulations. Fifteen mice per group were randomly selected from the core group after 10 weeks of study; 10 of those 15 mice per group were used for interim evaluation at 14 weeks, and five mice per group were used for genetic toxicity testing at 14 weeks. The remaining 90 animals per group were exposed up to 2 years. In the 2-year study, percent survival was significantly higher for the 5 W/kg males than the sham control group. Survival of the other exposed groups of males and females was generally similar to that of the sham controls. Mean body weights of exposed groups of males and females were similar to those of the sham controls throughout the study. The combined incidences of fibrosarcoma, sarcoma, or malignant fibrous histiocytoma of the skin were increased in 5 and 10 W/kg males, although not significantly or in a SAR-related manner; however, the incidences exceeded the overall historical control ranges for malignant fibrous histiocytoma. In the lung, there was a significant positive trend in the incidences of alveolar/ bronchiolar adenoma or carcinoma (combined) in males. Compared to the sham controls, all exposed groups of females had increased incidences of malignant lymphoma and the incidences in the 2.5 and 5 W/kg groups were significantly increased. The sham control group had a low incidence of malignant lymphoma compared to the range seen in historical controls. There were no nonneoplastic lesions that were considered related to exposure to GSM-modulated cell phone RFR.

2. NTP TR 596, 2018.

CDMA-modulated RFR, B6C3F1/N mice (M, F), for 24 months, Carcinogenicity study.

Groups of 105 male and 105 female mice were housed in reverberation chambers and received whole-body exposures to CDMA-modulated cell phone RFR at power levels of 0 (sham control), 2.5, 5, or 10 W/kg, 9 hours and 10 minutes per day, 7 days per week for 106 (males) or 108 (females) weeks with continuous cycling of 10 minutes on and 10 minutes off during a period of 18 hours and 20 minutes each day. The sham control animals were housed in reverberation chambers identical to those used for the exposed groups, but were not exposed to RFR; shared groups of unexposed mice of each sex served as sham controls for both RFR modulations. Fifteen mice per group were randomly selected from the core group after 10 weeks of study; 10 of those 15 mice per group were used for interim evaluation at 14 weeks, and five mice per group were used for genetic toxicity testing at 14 weeks. The remaining 90 animals per group were exposed up to 2 years. Percent survival was significantly higher in 2.5 W/kg males compared to that in the sham controls in the 2-year study. Survival of males and females in all other exposed groups was generally similar to that of the sham controls. Mean body weights of exposed groups of males and females were similar to those of the sham controls throughout the study. There was a significantly increased incidence of hepatoblastoma in 5 W/kg males. Compared to the sham controls, the incidences of malignant lymphoma were increased in all exposed groups of females, and the increase was significant in the 2.5 W/kg group. As noted for the GSM study, the shared sham control group had a low incidence of malignant lymphoma compared to the range observed in historical controls.There were no nonneoplastic lesions that were considered related to exposure to CDMA-modulated cell phone RFR.

Comprehensive summary: Under the conditions of these 2-year studies, there was equivocal evidence of carcinogenic activity of GSM-modulated cell phone RFR at 1,900 MHz in male B6C3F1/N mice based on the combined incidences of fibrosarcoma, sarcoma, or malignant fibrous histiocytoma in the skin, and the incidences of alveolar/ bronchiolar adenoma or carcinoma (combined) in the lung. There was equivocal evidence of carcinogenic activity of GSM-modulated cell phone RFR at 1,900 MHz in female B6C3F1/N mice based on the incidences of malignant lymphoma (all organs). There was equivocal evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 1,900 MHz in male B6C3F1/N mice based on the incidences of hepatoblastoma of the liver. There was equivocal evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 1,900 MHz in female B6C3F1/N mice based on the incidences of malignant lymphoma (all organs).

Comprehensive comment*: *Equivocal evidence of carcinogenicity in mice for GSM and CDMA-modulated RFR.

TWO YEAR CANCER BIOASSAY IN RATS (Table 9 a)

3. NTP TR 595, 2018.

GSM-modulated RFR, Harlan SD rats (M, F), prenatal exposure for 24 months, carcinogenicity study.

Beginning on GD 5, groups of 56 time-matched F0 female rats were housed in specially designed reverberation chambers and received whole-body exposures to GSM-modulated cell phone RFR at power levels of 0 (sham control), 1.5, 3, or 6 W/kg for 7 days per week, continuing throughout gestation and lactation. Exposure was up to 18 hours and 20 minutes per day with continuous cycling of 10 minutes on and 10 minutes off during the exposure periods. There were seven exposure groups per sex, including a shared sham control and three exposure groups for each modulation. At weaning, three males and three females per litter from 35 litters were randomly selected per exposure group for continuation. Weaning occurred on the day the last litter reached PND 21, marking the beginning of the 2-year studies. Groups of 105 male and 105 female F1 offspring continued to receive whole-body exposures to GSM-modulated cell phone RFR at the same power levels and under the same exposure paradigm, 7 days per week for up to 104 weeks. After 14 weeks of exposure, 10 rats per group were randomly selected for interim histopathologic evaluation and five were designated for genetic toxicity evaluation. In the heart at the end of the 2-year studies, malignant schwannoma (synonymous neurinoma) was observed in all exposed male groups and the 3 W/kg female group, but none occurred in the sham controls. Endocardial Schwann cell hyperplasia also occurred in a single 1.5 W/kg male and two 6 W/kg males. There were also significantly increased incidences of right ventricle cardiomyopathy in 3 and 6 W/kg males and females. In the brain of males, there were increased incidences of malignant glioma and glial cell hyperplasia in all exposed groups, but none in the sham controls. There was also increased incidences of benign or malignant granular cell tumours in all exposed groups. There were significantly increased incidences of benign pheochromocytoma and benign, malignant, or complex pheochromocytoma (combined) of the adrenal medulla in males exposed to 1.5 or 3 W/kg. In the adrenal medulla of females exposed to 6 W/kg, there were significantly increased incidences of hyperplasia. In the prostate gland of male rats, there were increased incidences of adenoma or adenoma or carcinoma (combined) in 3 W/kg males and epithelium hyperplasia in all exposed male groups. In the pituitary gland (pars distalis), there were increased incidences of adenoma in all exposed male groups. There were also increased incidences of adenoma or carcinoma (combined) of the pancreatic islets in all exposed groups of male rats, but only the incidence in the 1.5 W/kg group was significant. In female rats, there were significantly increased incidences of C-cell hyperplasia of the thyroid gland in all exposed groups, and significantly increased incidences of hyperplasia of the adrenal cortex in the 3 and 6 W/kg groups.

GSM-modulated RFR: Under the conditions of this 2-year whole-body exposure study, there was clear evidence of carcinogenic activity of GSM-modulated cell phone RFR at 900 MHz in male Hsd:Sprague Dawley SD rats based on the incidences of malignant schwannoma of the heart. The incidences of malignant glioma of the brain and benign, malignant, or complex pheochromocytoma (combined) of the adrenal medulla were also related to RFR exposure. The incidences of benign or malignant granular cell tumours of the brain, adenoma or carcinoma (combined) of the prostate gland, adenoma of the pars distalis of the pituitary gland, and pancreatic islet cell adenoma or carcinoma (combined) may have been related to RFR exposure. There was equivocal evidence of carcinogenic activity of GSM-modulated cell phone RFR at 900 MHz in female Hsd:Sprague Dawley SD rats based on the incidences of schwannomas of the heart. Increases in nonneoplastic lesions of the heart, brain, and prostate gland in male rats, and of the heart, thyroid gland, and adrenal gland in female rats occurred with exposures to GSM-modulated RFR at 900 MHz.

***Comment**: Positive evidence of carcinogenicity for malignant Schwannoma (neurinoma) of the heart associated to RF-EMF exposure in the near field (GSM-modulated RFR); the incidences of malignant glioma of the brain and benign, malignant, or complex pheochromocytoma (combined) of the adrenal medulla were also related to RFR exposure. Note: brain tumours and neurinomas are also increased in epidemiological studies.*

4. Falcioni et al., 2018.

SD rats (M, F), prenatal exposure until spontaneous death, Carcinogenicity study.

Male and female Sprague-Dawley rats were exposed from prenatal life until natural death to a 1.8 GHz GSM far field of 0, 5, 25, 50 V/m with a whole-body exposure for 19 h/day. A statistically significant increase in the incidence of heart Schwannomas was observed in treated male rats at the highest dose (50 V/m). Furthermore, an increase in the incidence of heart Schwann cells hyperplasia was observed in treated male and female rats at the highest dose (50 V/m), although this was not statistically significant. An increase in the incidence of malignant glial tumours was observed in treated female rats at the highest dose (50 V/m), although not statistically significant. The RI findings on far field exposure to RFR are consistent with and reinforce the results of the NTP study on near field exposure, as both reported an increase in the incidence of tumours of the brain and heart in RFR-exposed Sprague-Dawley rats. These tumours are of the same histotype as those observed in some epidemiological studies on cell phone users. These experimental studies provide sufficient evidence to call for re-evaluation of the IARC conclusions regarding the carcinogenic potential of RFR in humans.

***Comment**: Positive evidence for an association of RF-EMF in the far field (environmental) exposure with an increase in heart Schwannoma (neurinoma is a synonymous) [pubblication of the whole study is ongoing]. Note: brain tumours and neurinomas are also increased in epidemiological studies.*

TUMOUR-PRONE MICE (Table 10 a)

5. Lee et al., 2011

AKR/J mice (M, F), 42 weeks (~10 months), Lymphoma-prone.

Carcinogenic effects of combined signal RF-EMFs on AKR/J mice, which were used for the lymphoma animal model, were investigated. Six-week-old AKR/J mice were simultaneously exposed to two types of RF signals: single code division multiple access (CDMA) and wideband code division multiple access (WCDMA). AKR/J mice were exposed to combined RF-EMFs for 45 min/day, 5 days/week, for a total of 42 weeks. The whole-body average specific absorption rate (SAR) of CDMA and WCDMA fields was 2.0 W/kg each, 4.0 W/kg in total. When we examined final survival, lymphoma incidence, and splenomegaly incidence, no differences were found between sham- and RF-exposed mice. However, occurrence of metastasis infiltration to the brain in lymphoma-bearing mice was significantly different in RF-exposed mice when compared to sham-exposed mice, even though no consistent correlation (increase or decrease) was observed between male and female mice. However, infiltration occurrence to liver, lung, and spleen was not different between the groups. From the results, we suggested that simultaneous exposure to CDMA and WCDMA RF-EMFs did not affect lymphoma development in AKR/J mice.

Comment: Short period of exposure. Exposure did not affect lymphoma development in AKR/J mice.

PROMOTION STUDIES IN MICE (Table 11a)

6. Lerchl et al., 2015, B6C3F1 mice (F), 24 months, Promotion study.

(Tillmann et al., 2010) suggested tumour-promoting effects of RF-EMF. A replication study using higher numbers of animals per group and including two additional exposure levels (0 (sham), 0.04, 0.4 and 2 W/kg SAR) was performed. Numbers of tumours of the lungs and livers in exposed animals were significantly higher than in sham-exposed controls. In addition, lymphomas were also found to be significantly elevated by exposure. A clear dose-response effect was absent. We hypothesize that these tumour-promoting effects may be caused by metabolic changes due to exposure. Since many of the tumour-promoting effects in our study were seen at low to moderate exposure levels (0.04 and 0.4 W/kg SAR), thus well below exposure limits for the users of mobile phones, further studies are warranted to investigate the underlying mechanisms. Our findings may help to understand the repeatedly reported increased incidences of brain tumours in heavy users of mobile phones.

Comment: The study does not exactly replicate the Tillmann et al., (2010) study. It shows positive evidence of association between lung, liver tumours, and lymphomas with exposure to RF-EMF.

Table 8 – Cancer in experimental animals: two years cancer bioassays in mice (450-6000 MHz) (a)

Reference, Strain, Species (sex), Duration, Type of study	RF Exposure Level Frequencies, Intensities; Any Other Co-Exposure	Exposure time, No. of Animals	Increased Tumour Incidence (Significance)	Comments
1. NTP TR 596, B6C3F1/N mice (M, F), prenatal exposure for 24 months, carcinogenicity study, 2018	GSM, (1900 MHz), 2.5, 5, and 10 W/Kg	9 h/day, 7 days/week, 105/sex/group	Combined incidences of fibrosarcoma, sarcoma, or malignant fibrous histiocytoma in the skin and the incidences of alveolar/ bronchiolar adenoma or carcinoma (combined) in the lung. In females increased incidences of malignant lymphoma (all organs).	Adequate, equivocal
2. NTP TR 596, B6C3F1/N mice (M, F), prenatal exposure for 24 months, carcinogenicity study, 2018	CDMA (1900 MHz), 2.5, 5, and 10 W/Kg	9 h/day, 7 days/week, 105/sex/group	Hepatoblastoma of the liver. in female increased incidences of malignant lymphoma (all organs).	Adequate, equivocal

Table 9 – Cancer in experimental animals: two years cancer bioassays in rats (450-6000 MHz) (a)

Reference, Strain, Species (sex), Duration, Type of study	RF Exposure Level Frequencies, Intensities; Any Other Co-Exposure	Exposure time, No. of Animals	Increased Tumour Incidence (Significance)	Comments
3. NTP TR 595, SD rats (M, F), prenatal exposure for 24 months, carcinogenicity study, 2018	GSM, CDMA (900 MHz), 1.5, 3, 5 W/kg	9 h/day, 7 days/week, 105/sex/group	Male brain glioma, heart Schwannoma, and combined adrenal pheochromocytoma ($p < 0.05$)	Adequate, positive for heart Schwannomas and brain tumours; positive for adrenal tumours
4. NTP TR 595, SD rats (M, F),), prenatal exposure for 24 months, carcinogenicity study, 2018	GSM, CDMA (900 MHz), 1.5, 3, 5 W/kg	9 h/day, 7 days/week, 105/sex/group	Male brain glioma, heart Schwannoma, and combined adrenal pheochromocytoma ($p < 0.05$)	Adequate, positive for heart Schwannomas and brain tumours; positive for adrenal tumours
5. Falcioni et al., 2018, SD rats (M, F), prenatal exposure until spontaneous death, carcinogenicity study	GSM (1800 MHz), 0.1, 0.03, 0.001 W/Kg	19 h/day, 7 days/week, 200,400 /sex/group	Male heart Schwannoma ($p < 0.05$) and female brain glioma	Adequate, positive for heart Schwannomas; borderline for brain tumours

Table 10a - Cancer in experimental animals: tumour-prone mice (450-6000 MHz) (a)

Reference, Strain, Species (sex), Duration, Type of study	RF Exposure Level Frequencies, Intensities; Any Other Co-Exposure	Exposure time, No. of Animals	Increased Tumour Incidence (Significance)	Comments
6. Lee et al., 2011, AKR/J mice (M, F), 42 weeks (~10 months), Lymphoma-prone	CDMA (849 MHz) and WCDMA (1950 MHz), 4 W/kg (combined)	45 min/day, 5 days/week, 40/sex/group	No statistically significant increase in tumour incidence	Inadequate (Short daily exposure)

Table 10b - Cancer in experimental animals: promotion studies in mice (450-6000 MHz) (a)

Reference, Strain, Species (sex), Duration, Type of study	RF Exposure Level Frequencies, Intensities; Any Other Co-Exposure	Exposure time, No. of Animals	Increased Tumour Incidence (Significance)	Comments
7. Lerchl et al., 2015, B6C3F1 mice (F), 24 months, Promotion study	UMTS fields, 0.04, 0.4 and 2.0 W/kg; prenatal ENU 40mg/kg b.w.	23.5 h/day, 7 days/week, 96/group	Female lymphoma, lung adenoma and carcinoma, liver carcinoma (tumour promotion) ($p < 0.05$)	Adequate, positive

Table 11 (summary tables 8-10) - Collected data for experimental studies on Cancer (FR1: 450-6000 MHz)

Total studies FR1*	7							
Adequate studies	7							
	Rat				Mouse			
Observed Tumour	Total adequate studies[a]	Positive results	Equivocal results	Negative results	Total adequate studies[b]	Positive results	Equivocal results	Negative results
Glioma	3	2	1					
Heart Schwannoma	3	3						
Alveolar-bronchiolar adenoma, carcinoma					3	1	2	
Liver tumours	2		1		3	1	2	
Adrenal pheochromocytoma	2	2						
Pancreatic islet adenoma+carcinoma	2		2					
Prostate adenoma+carcinoma	2		2					
Pituitary gland adenoma	2		2					
Lymphoma					4	1	2	1
Fibrosarcoma, fibro-histiocitic sarcoma of the skin					3		2	

*Some of the studies include more than one tumour site. [a] 1 study published only partial results on brain and heart.[b]1 study on lymphoma prone mice

SUMMARY OF THE RESULTS OF CANCER IN EXPERIMENTAL ANIMALS STUDIES (FR1: 450 to 6000 MHZ)(Table 11)

Based on full-text screening, the articles with frequencies appropriate for inclusion in this qualitative synthesis were 50. As further explained in the methodology section, we considered IARC Monograph 102 (IARC, 2013) as our key reference for all studies on cancer in experimental animals published until 2011: all original papers (43) that were included in the IARC monograph were analysed and referenced in this report as well; of course, we considered for this report only the final IARC classification. Seven adequate studies were published after 2011. From the present review, 7 studies on carcinogenicity in experimental animals were selected. 4 studies were performed on mice, 3 were performed on rats. Summaries of the results are presented in Table 27.

Out of the 7 adequate studies, the results were:

- Carcinogenicity in mice:

Two adequate carcinogenicity studies were performed to investigate possible non-thermal adverse effects on carcinogenicity related to RF-EMF exposure in mice. The studies were performed by the NTP laboratory in the USA .

Ref: 1: GSM-modulated cell phone RFR at 1,900 MHz in male B6C3F1/N mice showed: *positive* association of RF-EMF exposure with combined incidences of fibrosarcoma, sarcoma, or malignant fibrous histiocytoma in the skin, and the incidences of alveolar/ bronchiolar adenoma or carcinoma (combined) in the lung. There was *equivocal* evidence of carcinogenic activity in female B6C3F1/N mice based on the incidences of malignant lymphoma (all organs).

Ref: 2: There was *equivocal* evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 1,900 MHz in male B6C3F1/N mice based on the incidences of hepatoblastoma of the liver. There was equivocal evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 1,900 MHz in female B6C3F1/N mice based on the incidences of malignant lymphoma (all organs).

Two studies with different animal model and design were also performed on mice:

Ref: 6: one study on lymphoma-prone mice did not show any increase in lymphoma (*no* evidence).

Ref: 7: one two-years promotion study showed a statistically significant increase of tumours of the lung and liver in exposed animals. In addition, lymphomas were also found to be significantly increased (*positive* ass0ciation)

- Carcinogenicity in rats

Three adequate carcinogenicity studies were performed to investigate possible non-thermal adverse effects on carcinogenicity related to RF-EMF exposure in rats. Two studies were performed by the NTP laboratory in the USA (Ref:3,4) , one study (partially published) by the Ramazzini Institute in Italy (Ref: 5).

The most convincing evidence for the 3 studies regards the statistically significant increase (positive association) of brain tumours (Ref: 3, 4) supported by the *equivocal* association of the same tumour in the third study (Ref: 5) and the statistically significant increase of a very rare tumour of the heart, malignant Schwannoma, in all 3 studies (*positive* association). The increase of adrenal pheochromocytoma was statistically significant (positive association), and pancreatic islet adenoma+carcinoma, prostate adenoma+carcinoma, pituitary gland adenoma were also increased in treated groups (Ref: 3, 4) (*equivocal* association).

FR1: Our review on experimental studies on rats and mice shows a sufficient evidence of carcinogenicity of RF-EMF at lower frequencies (FR1). The observation of tumours of the nervous system (central and peripheral) in male rats is of particular significance, because supporting findings of epidemiological studies.

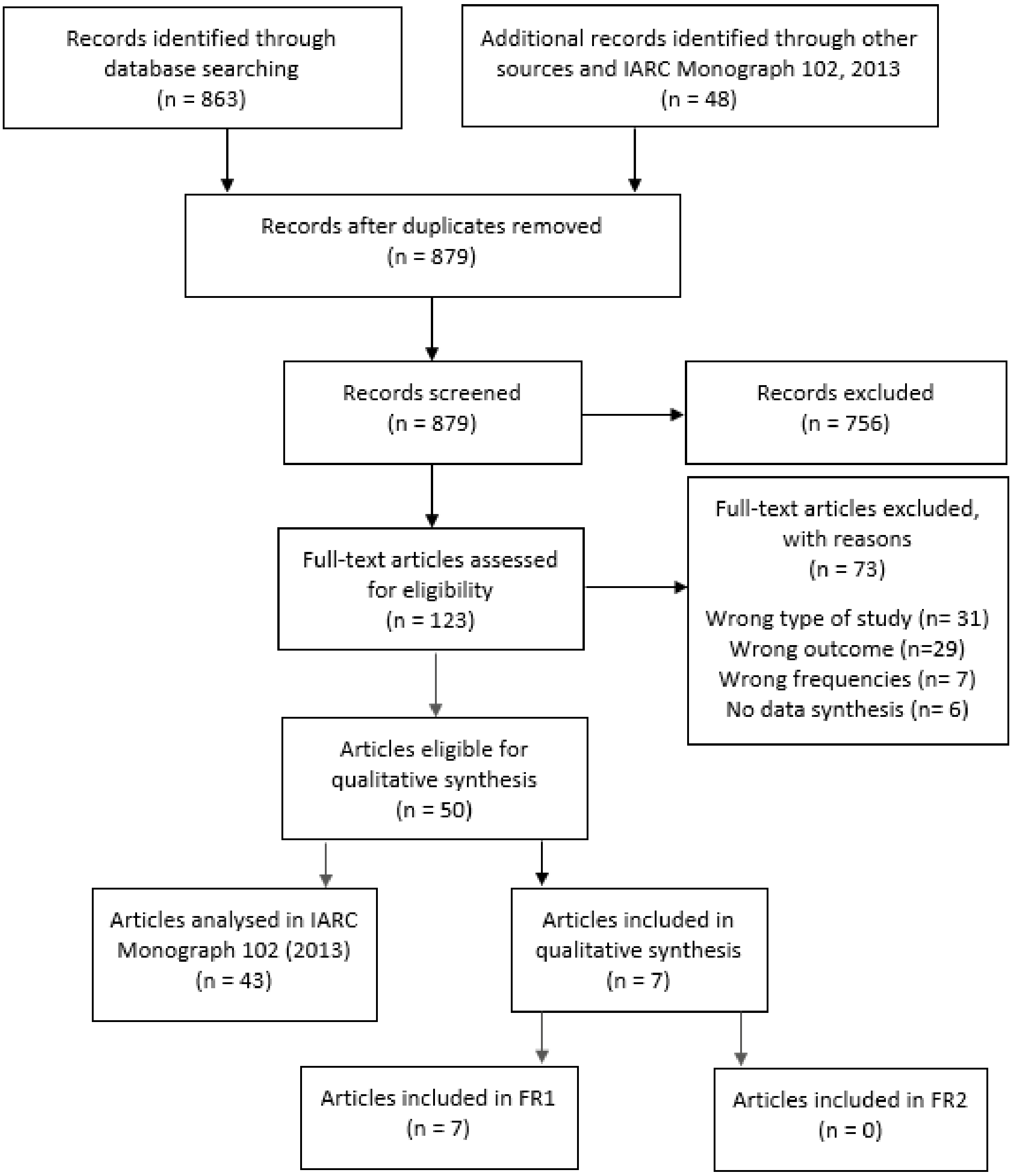
4.1.4 Cancer in experimental animals: Studies evaluating health effects due to RF at a higher frequency range (FR2: 24 to 100 GHz, MMW).

The articles identified through database searching and other sources were 911. After removing duplicates (32) and excluding non-pertinent articles (756) based on title and abstracts, 123 articles remained. Based on full-text screening, 73 papers were further excluded, so that the articles with frequencies appropriate for inclusion in this qualitative synthesis were 50 (Fig. 12).

As further explained in the methodology section, we considered IARC Monograph 102 (IARC, 2013) as our key reference for all studies on cancer in experimental animals published until 2011: all original papers (43) that were included in the IARC monograph were analysed and referenced in this report as well; of course, we considered for this report only the final IARC classification. Seven adequate studies were published after 2011.

At this stage, a separation based on frequency range was also performed: of the 7 papers included, all reported exposures belonging to the band considered in FR1, and none reported exposures regarding FR2. In conclusion, there is no available literature regarding the association between RF radiation at the range 24 to 100 GHz (MMW) in experimental carcinogenicity studies.

Figure 12 – Flow diagram. Cancer in experimental animal studies FR2



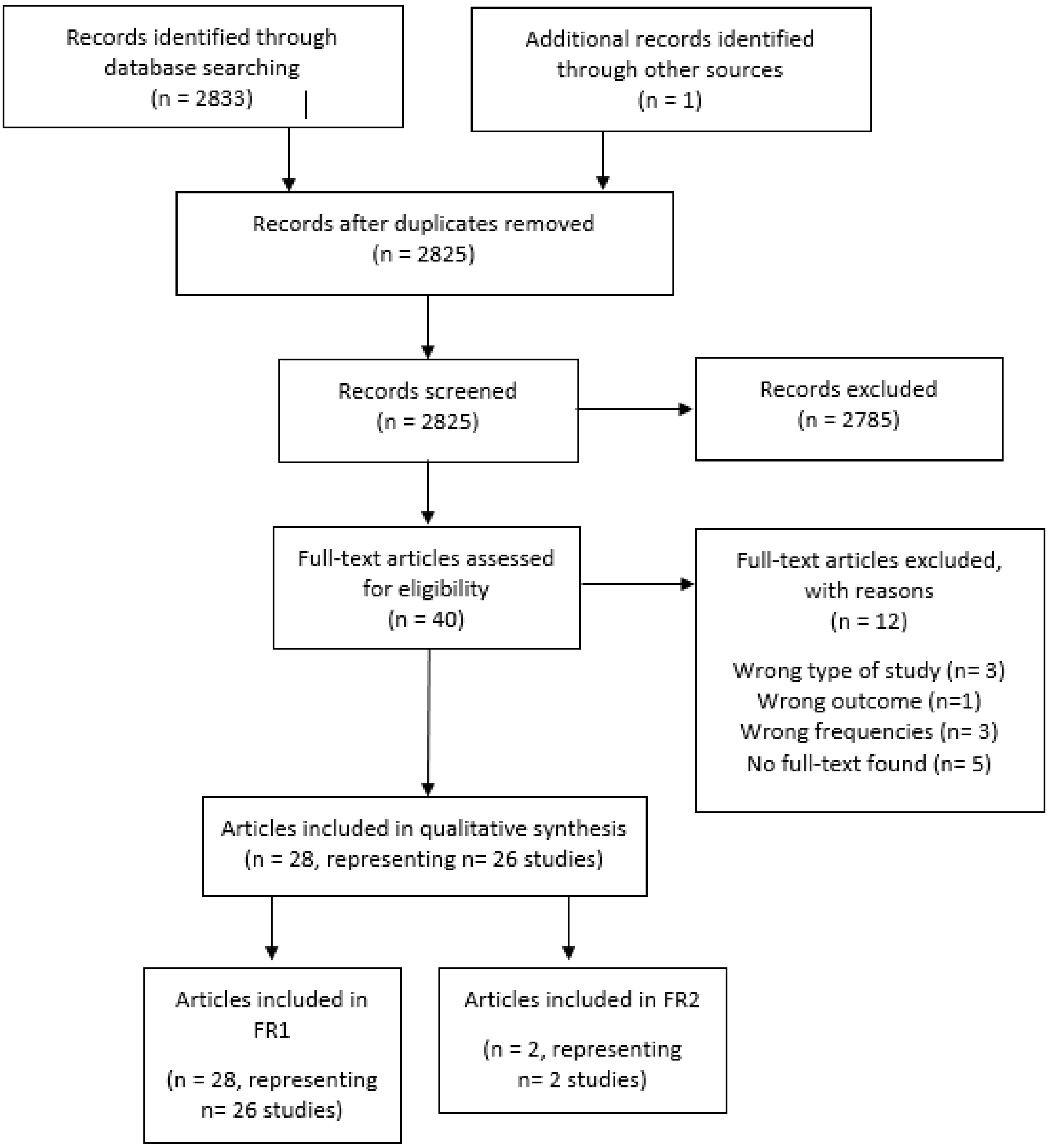
4.2 Reproductive/developmental adverse effects by frequency range

4.2.1 Reproductive/developmental effects in epidemiological studies: Studies evaluating health effects due to RF at a lower frequency range (FR1: 450 to 6000 MHZ), which also includes the frequencies used in previous generations' broadband cellular networks (1G, 2G, 3G and 4G).

The articles identified through database searching and other sources were 2834. After removing duplicates (9) and excluding non-pertinent articles (2785) based on title and abstracts, 40 articles remained. Based on full-text screening, 12 papers were further excluded, so that the published articles with appropriate frequencies to be included in this qualitative synthesis were 28, corresponding to 26 studies (in two cases, two papers were published reporting information on the same study) (Fig. 13).

At this stage, selection based on frequency range was also performed: 28 papers/26 studies referred to exposures belonging to the FR1 range, and 2 referred to FR2 as well. These 2 papers report exposures suitable for both FR1 and FR2, so they don't add up to the overall number of included studies; the same study is analysed therefore twice, once in every frequency range.

Figure 13 – Flow diagram. Epidemiological studies on reproductive/developmental effects FR1



MALE FERTILITY

Case-control studies (Tables 12a)

1. Al-Quzwini et al., 2016.

Iraq. Case-control study.

A seminal fluid analysis is clinical marker of male reproductive potential. To find out whether environmental hazard such as mobile phone tower has an effect on male reproductive ability. Two hundred couples were enrolled, one hundred subfertile couples as a study group (n=100), and one hundred fertile couples as a control group (n= 100). Environmental exposure to electromagnetic radiation from mobile phone towers and occupational state was assessed by standard questionnaire. Semen analysis was done for the subfertile males, because the fertile males (control group) refused to give semen samples. The occupational hazard expressed significant difference between the subfertile and the control groups (38% versus 12%) (p< 0.05), with odds ratio (OR) =4.5 and 95% Confidence Interval (CI): 2.175–9.288, and also the environmental factor (mobile tower within fifty meters from their house) showed significant difference (29% versus 12%) (p< 0.05), with OR= 3; 95% CI: 1.426–6.290. SFA of the subfertile males was 40% abnormal versus 60% normal semen analysis. These abnormalities were classified into 35% oligozoospermia, 55% asthenospermia, and 10% teratozoospermia. Oligozoospermia was associated with more occupational hazard (OR= 1.8, 95% CI: 0.569–5.527). Teratozoospermia was associated with more occupational hazard (OR= 5.23, 95% CI: 0.524–52.204), and with exposure to environmental hazard (OR = 2.6, 95% CI: 0.342– 19.070), and associated with smoking hazard (OR =1.7, 95% CI: 0.225–12.353). Male fertility represented by quality of semen might be affected by occupational and environmental exposures, so it seems that prevention of occupational and environmental risk factors, may lead to improvement of semen quality in subfertile men.

Comment*: *Inadequate/Inconclusive.

Cross-sectional studies (Tables 13, a-d)

2. Baste et al., 2008.

Norway. 2002-2004. Cross-sectional study, occupational exposure.

The authors performed a cross-sectional study among military men employed in the Royal Norwegian Navy, including information about work close to equipment emitting radiofrequency electromagnetic fields, one-year infertility, children and sex of the offspring. Among 10,497 respondents, 22% had worked close to high-frequency aerials to a "high" or "very high" degree. Infertility increased significantly along with increasing self-reported exposure to radiofrequency electromagnetic fields. In a logistic regression, the odds ratio (OR) for infertility among those who had worked closer than 10 m from high-frequency aerials to a "very high" degree relative to those who reported no work near high-frequency aerials was 1.86 (95% confidenceinterval (CI): 1.46–2.37), adjusted for age, smoking habits, alcohol consumption and exposure to organic solvents, welding and lead. Similar adjusted OR for those exposed to a "high", "some" and "low" degree were 1.93 (95% CI: 1.55–2.40), 1.52 (95% CI: 1.25–1.84), and 1.39 (95% CI: 1.15–1.68), respectively. In all age groups there were significant linear trends with higher prevalence of involuntary childlessness with higher self-reported exposure to radiofrequency fields. However, the degree of exposure to radiofrequency radiation and the number of children were not associated. For self-reported exposure both to high-frequency aerials and communication equipment there were significant linear trends with a lower ratio of boys to girls at birth when the father reported a higher degree of radiofrequency electromagnetic exposure.

Comment*: *Self-reported level of exposure. Higher degree of RF-EMF exposure associated to infertility and a lower ratio of boys to girls at birth.

3. Mollerlekken and Moen, 2008.

Norway. 2002. Cross-sectional, occupational exposure.

The aim of this study was to examine the relationship between workers exposed to electromagnetic fields and their reproductive health. We obtained data using a questionnaire in a cross-sectional study of naval military men, response rate 63% (n¼1487). The respondents were asked about exposure, lifestyle, reproductive health, previous diseases, work and education. An expert group categorized the work categories related to electromagnetic field exposure. We categorized the work categories "tele/communication," "electronics" and "radar/sonar" as being exposed to electromagnetic fields. Logistic regression adjusted for age, ever smoked, military education, and physical exercise at work showed increased risk of infertility among tele/ communication odds ratio (OR≤1.72, 95% confidence interval 1.04–2.85), and radar/sonar odds ratio (OR≤2.28, 95% confidence interval 1.27–4.09). The electronics group had no increased risk. This study shows a possible relationship between exposure to radiofrequency fields during work with radiofrequency equipment and radar and reduced fertility. However, the results must be interpreted with caution.

Comment*: *Self-reported exposure. Possible increased risk of infertility among telecommunication and radar/sonar operators.

4. Fejez et al., 2005.

Hungary. Cross-sectional study.

The history-taking of men in our university clinic was supplemented with questions concerning cell phone use habits, including possession, daily standby position and daily transmission times. Semen analyses were performed by conventional methods. Statistics were calculated with SPSS statistical software. A total of 371 were included in the study. The duration of possession and the daily transmission time correlated negatively with the proportion of rapid progressive motile sperm (r = 0.12 and r = 0.19, respectively), and positively with the proportion of slow progressive motile sperm (r =0.12 and r = 0.28, respectively). The low and high transmitter groups also differed in the proportion of rapid progressive motile sperm (48.7% vs. 40.6%). The prolonged use of cell phones may have negative effects on the sperm motility characteristics.

Comment*: *Exposure self-reported. Confounding factors not analysed.

5. Jurewicz et al., 2014, Radwan et al., 2016 (they published the same study).

Poland. Cross-sectional study.

The aim of the study was to examine the association between modifiable lifestyle factors and main semen parameters, sperm morphology, and sperm chromatin structure. The study population consisted of 344 men who were attending an infertility clinic for diagnostic purposes with normal semen concentration of 20–300 M/ml or with slight oligozoospermia (semen total concentration of 15–20 M/ml) [WHO 1999]. Participants were interviewed and provided semen samples. The interview included questions about demographics, socio-economic status, medical history, lifestyle factors (consumption of alcohol, tobacco, coffee intake, cell phone and sauna usage), and physical activity. The results of the study suggest that lifestyle factors may affect semen quality. A negative association was found between increased body mass index (BMI) and semen volume (p≤0.03). Leisure time activity was positively associated with sperm concentration (p≤0.04) and coffee drinking with the percentage of motile sperm cells, and the percentage of sperm head and neck abnormalities (p≤0.01, p≤0.05, and p≤0.03, respectively). Drinking red wine 1–3 times per week was negatively related to sperm neck abnormalities (p≤0.01). Additionally, using a cell phone more than 10 years decreased the percentage of motile sperm cells (p≤0.02). Men who wore boxer shorts had a lower percentage of sperm neck abnormalities (p≤0.002) and percentage of sperm with DNA damage (p≤0.02). These findings may have important implications for semen quality and lifestyle.

Comment*: *Self-reported exposure. Different confounders could affect results.

6. Yildirim et al., 2015.

Turkey. Cross-sectional study.

Semen for analyses from the male patients coming to our infertility division and also asked them to fill out an anonymous questionnaire. We queried their mobile phone and wireless internet usage frequencies in order to determine their radiofrequency-electromagnetic radiation exposure. A total of 1082 patients filled the questionnaire but 51 of them were excluded from the study because of azoospermia. There was no significant difference between sperm counts and sperm morphology excluding sperm motility, due to mobile phone usage period, ($p = 0.074$, $p = 0.909$, and $p = 0.05$, respectively). The total motile sperm count and the progressive motile sperm count decreased due to the increase of internet usage ($p = 0.032$ and $p = 0.033$, respectively). In line with the total motile sperm count, progressive motile sperm count also decreased with wireless internet usage compared with the wired internet connection usage ($p = 0.009$ and $p = 0.018$, respectively). There was a negative correlation between wireless internet usage duration and the total sperm count ($r = -0.089$, $p = 0.039$). We have also explored the negative effect of wireless internet use on sperm motility according to our preliminary results.

Comment*: *Exposure self-reported. Confounding factors were not analysed. Any difference between sperm parameters and cell phone and wireless internet usage is the authors conclusions.

7. Zilberlicht et al., 2015.

Israel. Cross-sectional.

Male infertility constitutes 30–40% of all infertility cases. Some studies have shown a continuous decline in semen quality since the beginning of the 20th century. One postulated contributing factor is radio frequency electromagnetic radiation emitted from cell phones. This study investigates an association between characteristics of cell phone usage and semen quality. Questionnaires accessing demographic data and characteristics of cell phone usage were completed by 106 men referred for semen analysis. Results were analysed according to WHO 2010 criteria. Talking for ≥1 h/day and during device charging were associated with higher rates of abnormal semen concentration (60.9% versus 35.7%, $P < 0.04$ and 66.7% versus 35.6%, $P < 0.02$, respectively). Among men who reported holding their phones ≤50 cm from the groin, a non-significantly higher rate of abnormal sperm concentration was found (47.1% versus 11.1%). Multivariate analysis revealed that talking while charging the device and smoking were risk factors for abnormal sperm concentration (OR = 4.13 [95% CI 1.28–13.3], $P < 0.018$ and OR = 3.04 [95% CI 1.14–8.13], $P < 0.027$, respectively). Our findings suggest that certain aspects of cell phone usage may bear adverse effects on sperm concentration. Investigation using largescale studies is thus needed.

Comment*: *Self-reported exposure. Some association was found.

8. Al-Bayyari, 2017.

Jordan. Cross-sectional observational study.

The objective was to study the effect of cell phone usage on semen quality and men's fertility. A cross-sectional observational study conducted on 159 men attending infertility clinics at North, Middle and South Governorates in Jordan and undergoing infertility evaluation were divided into two groups according to their active cell phone use: group A: ≤1 h/day and group B: >1 h/day. No interventions were given to patients and semen samples were collected by masturbation in a sterile container after an abstinence period of 5 days. The main outcome measures were sperm volume, liquefaction time, pH, viscosity, count, motility and morphology.

Time of talking by cell phone was recorded and the subjects were divided into 2 groups; group A ≤ 1 h/day (n = 104); group B > 1 h/day (n = 52) and participants who did not use cell phone (n = 3) were excluded from the statistical analysis regarding studying the effect of time spent in calling or receiving calls.There were no statistical significance differences ($p > 0.05$) between both groups regarding sperm quality parameters according to cell phone use, but there were statistical differences in the frequencies of sperm concentration, volume, viscosity, liquefaction time and means of immotile sperms and abnormal morphology. In addition, time spend on watching television and using wireless phones were significantly ($p \leq 0.05$) associated with decreasing mean percentages of normal morphology. The distance from telecommunication tower was significantly ($p \leq 0.05$) associated with decreasing sperms volume. Meanwhile, the time spent on sending or receiving messages was significantly ($p \leq 0.05$) associated with decreasing sperms count and carrying mobile phone in trouser pocket was significantly associated with increasing means of immotile sperms. Cell phone use might have a negative effect on semen quality parameters and further research is needed.

Comment*: *Self-reported exposure. Cell phone use might have a negative effect on semen quality parameters.

9. Shi et al., 2018.

Cross-sectional study.

Three hundred and twenty-eight subjects who underwent semen analysis were recruited. Routine SA, sperm vitality, acrosome reaction (AR) assay and sperm DNA fragmentation index (DFI) were analyzed. Demographic and lifestyle information, including (1) BMI, (2) current smoking and alcohol drinking frequency, (3) sleep habits, (4) daily fluid intake, (5) weekly meat intake, (6) sports frequency, (7) trouser cell phone use, (8) age, and (9) abstinence time, were collected. Generalized additive models were used to analyze the possible non-linear association. The results showed that total sperm count (TSC) was significantly associated with age ($P = 0.001$), abstinence time ($P = 0.001$) and daily coffee intake ($P = 0.044$). Semen volume was significantly associated with age ($P < 0.001$) and daily coffee intake ($P < 0.001$). Sperm concentration was significantly associated with abstinence time ($P = 0.011$) and average sleep duration ($P = 0.010$). Sperm motility was significantly associated with age ($P = 0.002$) and daily juice intake ($P = 0.001$). Total motile sperm count was significantly associated with age ($P = 0.003$) and abstinence time ($P = 0.009$). DFI was significantly associated with age ($P = 0.002$), irregular sleeping habit ($P = 0.008$) and abstinence time ($P = 0.032$). The percentage of AR sperm was significantly associated with daily juice intake ($P = 0.013$). In conclusion, DFI and TSC were the most sensitive semen parameters for demographic and lifestyle features, whereas age had more influence on semen parameters than other demographic and lifestyle features. Trouser cell phone use was not significantly associated with any alteration of the sperm parameters examined.

Comment*: *Self-reported exposure. Many confounders in age and lifestyle. Any association with sperm alteration.

10. Blay et al., 2020.

Ghana. Cross-sectional study.

Male infertility is known to contribute about half of all infertility cases. In Ghana, the prevalence of male infertility is higher (15.8%) than in females (11.8%). Sperm quality is associated with the likelihood of pregnancy and known to be the cause of male fertility problems 90% of the time. Exposure to certain environmental factors reduces semen quality in men. The study examined the effects of environmental and lifestyle factors on semen quality in Ghanaian men. Materials and Methods. This was a cross-sectional study involving 80 apparent healthy adult males in their reproductive age. Participants were males referred to the laboratory (Immunology Unit of the Korle-Bu Teaching Hospital) for semen analysis test and/or culture and sensitivity. Participants were made to fill out a questionnaire which entailed selected environmental factors (accidents or trauma, exposure to chemicals, radiation, and heat) and lifestyle habits (including alcohol consumption, smoking, and whether participants sat more or less than 4 hours per day).

Semen samples were then collected by masturbation into sterile containers and analysed in accordance with WHO guidance for semen analysis within 60 minutes after ejaculation and collection. Results. About 69% of participants had semen pH within the normal range compared to 15% whose pH were lower than 7.2. There was a significantly high number of immotile sperm cells (p value = 0.017) in participants who sat for more than 4 hours as compared to those that sat for less than 4 hours in a day. Active sperm motility and viability showed significant increase (p value = 0.002 and 0.009, respectively) in participants who kept their cell phones in their side pockets. Smoking produced a twofold decrease in sperm count as smokers had a significantly lower sperm count (12:28 ± 10:95 × 106/ml) compared to the smoke-free (23:85 ± 22:14 × 106/ml). For exposure to STDs, no significant differences were recorded among study groups concerning semen quality. Conclusion. Sperm quality in Ghanaian men is associated with lifestyle habits. Smoking and sitting for long hours influenced sperm motility and count, respectively. Knowledge of the factors that influence sperm quality in this geographical region can contribute to informed decisions on effective management of infertility in Ghanaian men.

Comment*: *Self-reported exposure, uncertain. Increased activity and viability associated to cell phone in their side pockets. Many confounders.

Cohort studies (Tables 14, a-c)

11. Zhang, 2016.

China. 2013-2015. Cohort study.

Recruiting participants from infertility clinic not from general population may raise the possibility of a selection bias. To investigate effects of cell phone use on semen parameters in a general population. We screened and documented the cell phone use information of 794 young men from the Male Reproductive Health in Chongqing College students (MARHCS) cohort study in 2013, followed by 666 and 568 in 2014 and 2015, respectively. In the univariate regression analyses, we found that the daily duration of talking on the cell phone was significantly associated with decreased semen parameters, including sperm concentration [β coefficient = −6.32% per unit daily duration of talking on the cell phone (h); 95% confidence interval (CI), −11.94, −0.34] and total sperm count (−8.23; 95% CI, −14.38, −1.63) in 2013; semen volume (−8.37; 95% CI, −15.93, −0.13) and total sperm count (−16.59; 95% CI, −29.91, −0.73) in 2015]. Internet use via cellular networks was also associatedwith decreased sperm concentration and total sperm counts in 2013 and decreased semen volume in 2015. Multivariate analyseswere used to adjust for the effects of potential confounders, and significant negative associations between internet use and semen parameters remained. Consistent but nonsignificant negative associations between talking on the cell phone and semen parameters persisted throughout the three study years, and the negative association was statistically significant in a mixed model that considered all three years of data on talking on the cell phone and semen quality. Our results showed that certain aspects of cell phone use may negatively affect sperm quality inmen by decreasing the semen volume, sperm concentration, or sperm count, thus impairing male fertility.

Comment*: *Self-reported exposure. Confounding not analysed. Association with impairment of male fertility.

12. Lewis et al., 2017.

USA. 2004-2015. Longitudinal cohort study, part of the EARTH Study.

This is a longitudinal cohort study that recruited couples seeking infertility treatment from the Massachusetts General Hospital (MGH) Fertility Center; difficulty conceiving may be related to a male factor, a female factor, or a combination of both male and female factors. The relationship between mobile phone use patterns and markers of semen quality was explored in a longitudinal cohort study of 153 men that attended an academic fertility clinic in Boston, Massachusetts. Men between the ages of 18–56 years were eligible to participate. Information on mobile phone use duration (no use, <2 h/day,2–4 h/day, >4 h/day), headset or earpiece use (never, occasionally, some of the time, most of the time, all of the time), and location in which the mobile phone was carried (pants pocket, belt, bag, other) was ascertained via nurse-administered questionnaire. Semen samples (n = 350) were collected and analysed onsite. To account for multiple semen samples per man, linear mixed models with random intercepts were used to investigate the association between mobile phone use and semen parameters. Overall, there was no evidence for a relationship between mobile phone use and semen quality.

Comment*: *Self-reported exposure. No evidence for a relationship between mobile phone use and semen quality.

DEVELOPMENTAL STUDIES

Case-control studies (Tables 15 a-f)

13. Tan et al., 2014.

Singapore. Case-control study.

Threatened miscarriage occurs in 20% of pregnancies. We conducted a case-control study to assess the association between maternal lifestyle factors and risk of threatened miscarriage. Cases were 154 women presenting with threatened miscarriage in the 5th to 10th weeks of gestation; controls were 264 women without threatened miscarriage seen in antenatal clinic in the 5th to 10th week of pregnancy. Lifestyle variables were: current and past cigarette smoking, current second-hand cigarette smoke exposure, computer and mobile-phone use, perceived stress, past contraceptive use, past menstrual regularity and consumption of fish oils, caffeine and alcohol. Logistic regression was performed. In multivariate analysis, we found a positive association of threatened miscarriage with second-hand smoke exposure (OR 2.93, 95% CI 1.32–6.48), computer usage (>4 hours/day) (OR 6.03, 95% CI 2.82–12.88), mobile-phone usage (>1 hour/day) (OR 2.94 95% CI 1.32–6.53) and caffeine consumption (OR 2.95 95% CI 1.57– 5.57). Any fish oil consumption was associated with reduced risk of threatened miscarriage (OR 0.20, 95% CI 0.09–0.42). Prolonged mobile phone and computer use and fish oil supplementation are potential novel correlates of threatened miscarriage that deserve further study.

Comment*: *Self-reported exposure. Stress as a confounding variable not considered. Correlation between mobile phone and computer use and threatened miscarriage observed.

14. Mahmoudabadi et al., 2015.

Iran. Case-control study.

Exposure to electromagnetic fields of cell phones increasingly occurs, but the potential influence on spontaneous abortion has not been thoroughly investigated. Methods: In a case–control study, 292 women who had an unexplained spontaneous abortion at < 14 weeks gestation and 308 pregnant women > 14 weeks gestation were enrolled. Two data collection forms were completed; one was used to collect data about socioeconomic and obstetric characteristics, medical and reproductive history, and lifestyles. Another was used to collect data about the use of cell phones during pregnancy. For the consideration of cell phone effects, we measured the average calling time per day, the location of the cell phones when not in use, use of hands-free equipment, use of phones for other applications, the specific absorption rate (SAR) reported by the manufacturer and the average of the effective SAR (average duration of calling time per day × SAR). Analyses were carried out with statistical package state software (SPSS)v.16. The association between use of cell phones and the risk of spontaneous abortions against potential confounders was supported by evidence that despite adjustments for many known or suspected risk factors in logistic regression analyses, the estimation was not significantly altered. All the data pertaining to mobile phones were different between the two groups except the use of hands-free devices ($p < 0.001$). Our result suggests that use of mobile phones can be related to the early spontaneous abortions.

Comment*: *Self-reported exposure. Use of mobile phones may be related to the early spontaneous abortions.

Cross-sectional studies (Tables 16, a,b)

15. Col-Araz, 2013.

Turkey. 2009. Cross-sectional study.

The study was conducted in Turkey at Gazintep University, Faculty of Medicine's Outpatient Clinic at the Paediatric Ward. It comprised 500 patients who presented at the clinic from May to December 2009. All participants were administered a questionnaire regarding their pregnancy history. SPSS 13 was used for statistical analysis. In the study, 90 (19%) patients had pre-term birth , and 64 (12.9%) had low birth weight rate Birth weight was positively correlated with maternal age and baseline maternal weight (r= 0.115, p= 0.010; r= 0.168, p= 0.000, respectively). Pre-term birth and birth weight less than 2500g were more common in mothers with a history of disease during pregnancy (p=0.046 and p=0.008, respectively). The habit of watching television and using mobile phones and computer by mothers did not demonstrate any relationship with birth weight. Mothers who used mobile phones or computers during pregnancy had more deliveries before 37 weeks (p=0.018, p=0.034; respectively). Similarly, pregnancy duration was shorter in mothers who used either mobile phone or computers during pregnancy (p=0.005, p=0.048, respectively). Mobile phones and computers may have an effect on pre-term birth.

Comment*: *Self-reported exposure. Mobile phones and computers may have an effect on pre-term birth.

16. Zarei S. et al., 2015.

Iran. 2014. Cross-sectional study.

The purpose of this study was to investigate whether the maternal exposure to different sources of electromagnetic fields affects the rate and severity of speech problems in their offspring. In this study, mothers of 35 healthy 3-5 years old children (control group) and 77 children diagnosed with speech problems who had been referred to a speech treatment centre in Shiraz, Iran were interviewed. These mothers were asked whether they had exposure to different sources of electromagnetic fields such as mobile phones, mobile base stations, Wi-Fi, cordless phones, laptops and power lines. A significant association between either the call time (P=0.002) or history of mobile phone use (months used) and speech problems in the offspring (P=0.003) was found. However, other exposures had no effect on the occurrence of speech problems. To the best of our knowledge, this is the first study to investigate a possible association between maternal exposure to electromagnetic fields and speech problems in the offspring. Although a major limitation in our study is the relatively small sample size, this study indicates that the maternal exposure to common sources of electromagnetic fields such as mobile phones can affect the occurrence of speech problems in the offspring.

Comment*: *Small sample size, limit in exposure assessment. Association between maternal use of mobile phone and speech problems in the offspring.

17. Abad et al., 2016.

Iran. Cross-sectional study.

Investigation of the associations between electromagnetic field exposure and miscarriage among women of Tehran. In this longitudinal study, 462 pregnant women with gestational age <12 wks from seven main regions of Teheran city in Iran with similar social and cultural status were participated. The mean age of women was 28.22±4.53 years old. The frequency of spontaneous miscarriage was 56 cases. The incidence of abortion was 12.3%. Women were interviewed face-to face to collect data. Reproductive information was collected using medical file recorded in those hospitals the subjects had delivery. The measuring device measured electromagnetic waves, Narda safety test solutions with valid calibration date at the entrance door of their houses. A significant likelihood of miscarriage in women who exposed to significant level of electromagnetic wave. However, this association was not confirmed by Wald test. This study may not provide strong or consistent evidence that electromagnetic field exposure is associated or cause miscarriage. This issue may be due to small sample size in this study.

Comment : Self-reported exposure. Small sample. Uncertain association between miscarriage and use of mobile phone.

18. Lu et al., 2017.

Japan. 2012-2014. Cross sectional study from cohort data.

The aim of the study was to determine the associations of excessive mobile phone use with neonatal birth weight and infant health status. A sample of 461 mother and child pairs participated in a survey on maternal characteristics, infant characteristics, and information about maternal mobile phone usage during pregnancy. Results showed that pregnant women tend to use mobile phones excessively in Japan. The mean infant birth weight was lower in the excessive use group than in the ordinary use group, and the frequency of infant emergency transport was significantly higher in the excessive use group than in the ordinary use group. Excessive mobile phone use during pregnancy may be a risk factor for lower birth weight and a high rate of infant emergency transport.

Comment: Self-reported exposure. Limited sample size. Limited assessment of mothers' exposure. Inconclusive.

Cohort studies (Tables 17, a-f)

19. Mjøen et al., 2006.

Norway. 1976-1995. Cohort study on adverse pregnancy outcome, occupational exposure.

The objective was to assess associations between paternal occupational exposure to RF-EMF and adverse pregnancy outcomes including birth defects using population-based data from Norway. Data on reproductive outcomes derived from the Medical Birth Registry of Norway were linked with data on paternal occupation derived from the general population censuses. Maritime occupations, telephone repair and installation workers and welders were chosen as three separate groups. An expert panel categorized occupations according to exposure. Three occupational exposure levels were assessed, reflecting probability of exposure to RFR; one group was "probably not exposed" (376,837 births), one group of "possibly exposed" (139,871 births), and one group of "probably exposed" (24,885 births). Using logistic regression 24 categories of birth defects as well as other adverse outcomes were analysed. In the offspring of fathers most likely to have been exposed, increased risk was observed for preterm birth (OR: 1.08, 95% confidence interval (CI): 1.03, 1.15). In this group we also observed a decreased risk of cleft lip (OR: 0.63, 95% CI: 0.41, 0.97). In the medium exposed group, we observed increased risk for a category of "other defects" (OR: 2.40, 95% CI:1.22, 4.70), and a decreased risk for a category of "other syndromes" (OR: 0.75, 95% CI: 0.56, 0.99) and upper gastrointestinal defects (OR: 0.61, 95% CI: 0.40, 0.93). The study is partly reassuring for occupationally exposed fathers.

Comment: Level of exposure uncertain. No evidence for a relationship between occupational exposure to RF-EMF and adverse pregnancy outcome.

20. Divan at al., 2008; Divan et al., 2011.

Denmark. Children born between 1997 and 1999, then updated to 2002. Cohort study.

The association between prenatal and postnatal exposure to cell phones and behavioral problems in young children was examined. Mothers were recruited to the Danish National Birth Cohort early in pregnancy. When the children of those pregnancies reached 7 years of age in 2005 and 2006, mothers were asked to complete a questionnaire regarding the current health and behavioral status of children, as well as past exposure to cell phone use. Mothers evaluated the child's behavior problems using the Strength and Difficulties Questionnaire. Mothers of 13,159 children completed the follow-up questionnaire reporting their use of cell phones during pregnancy as well as current cell phone use by the child. Greater odds ratios for behavioral problems were observed for children who had possible prenatal or postnatal exposure to cell phone use. After adjustment for potential confounders, the odds ratio for a higher overall behavioral problems score was 1.80 (95% confidence interval 1.45–2.23) in children with both prenatal and postnatal exposure to cell phones. Exposure to cell phones prenatally—and, to a lesser degree, postnatally—was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry.

Comment*: *Self-reported exposure and other possible confounders. Exposure to cell phone prenatally—and, to a lesser degree, postnatally—was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry.

Denmark. Children born between 1996 and 2002. Cohort study.

The aim of the second study was to examine if prenatal use of cell phones by pregnant mothers is associated with developmental milestones delays among offspring up to 18 months of age.
Methods Our work is based upon the Danish National Birth Cohort (DNBC), which recruited pregnant mothers from 1996–2002, and was initiated to collect a variety of detailed information regarding in utero exposures and various health outcomes. At the end of 2008, over 41 000 singleton, live births had been followed with the Age-7 questionnaire, which collected cell-phone-use exposure for mothers during pregnancy. Outcomes for developmental milestones were obtained from telephone interviews completed by mothers at age 6- and 18-months postpartum. Results A logistic regression model estimated the odds ratios (OR) for developmental milestone delays, adjusted for potential confounders. Less than 5% of children at age 6 and 18 months had cognitive/language or motor developmental delays. At 6 months, the adjusted OR was 0.8 [95% confidence interval (95% CI) 0.7–1.0] for cognitive/ language delay and 0.9 (95% CI 0.8–1.1) for motor development delay. At 18 months, the adjusted OR were 1.1 (95% CI 0.9–1.3) and 0.9 (95% CI 0.8–1.0) for cognitive/language and motor development delay, respectively. Conclusions No evidence of an association between prenatal cell phone use and motor or cognitive/language developmental delays among infants at 6 and 18 months of age was observed. Even when considering dose–response associations for cell phone use, associations were null.

***Comment*: *Self-reported exposure. No evidence of an association between prenatal cell phone use and motor or cognitive/language developmental delays*.**

21. Guxens et al., 2013.

The Netherlands. 2003-2004 enrolment; 2008-2009 assessment of behavioural problems; 2010-2011 retrospective exposure assessment.

The study was embedded in a population-based prospective birth cohort study. Together with cell phones, cordless phones represent the main exposure source of radiofrequency-electromagnetic fields to the head. Therefore, we assessed the association between maternal cell phone and cordless phone use during pregnancy and teacher-reported and maternal-reported child behaviour problems at age 5. The study was embedded in the Amsterdam Born Children and their Development study, a population-based birth cohort study in Amsterdam, the Netherlands (2003–2004). Teachers and mothers reported child behaviour problems using the Strength and Difficulties Questionnaire at age 5. Maternal cell phone and cordless phone use during pregnancy was asked about when children were 7 years old. A total of 2618 children were included. As compared to non-users, those exposed to prenatal cell phone use showed an increased but non-significant association of having teacher-reported overall behaviour problems, although without dose-response relationship. with the number of calls (OR=2.12 (95% CI 0.95 to 4.74) for <1 call/day, OR=1.58 (95% CI 0.69 to 3.60) for 1–4 calls/day and OR=2.04 (95% CI 0.86 to 4.80) for ≥5 calls/day). ORs for having teacher-reported overall behaviour problems across categories of cordless phone use were below 1 or close to unity. Associations of maternal cell phone and cordless phone use with maternal-reported overall behaviour problems remained non-significant. Non-significant associations were found for the specific behaviour problem subscales. Our results do not suggest that maternal cell phone or cordless phone use during pregnancy increases the odds of behaviour problems in their children.

Comment*: *Self-reported exposure and other possible confounders. Use of mobile phone during pregnancy increases specific behaviour problems, non significant.

22. Choi et al., 2017.

South Korea. 2006-2016. Multi-centre prospective cohort study (the Mothers and Children's Environmental Health (MOCEH) study).

Studies examining prenatal exposure to mobile phone use and its effect on child neurodevelopment show different results, according to the child's developmental stages. To examine neurodevelopment in children up to 36 months of age, following prenatal mobile phone use and radiofrequency radiation (RF-EMF) exposure, in relation to prenatal lead exposure, we analyzed 1198 mother-child pairs from a prospective cohort study (the Mothers and Children's Environmental Health Study). Questionnaires were provided to pregnant women at ≤20 weeks of gestation to assess mobile phone call frequency and duration. A personal exposure meter (PEM) was used to measure RF-EMF exposure for 24 h in 210 pregnant women. Maternal blood lead level (BLL) was measured during pregnancy. Child neurodevelopment was assessed using the Korean version of the Bayley Scales of Infant Development- Revised at 6, 12, 24, and 36 months of age. Logistic regression analysis applied to groups classified by trajectory analysis showing neurodevelopmental patterns over time. The psychomotor development index (PDI) and the mental development index (MDI) at 6, 12, 24, and 36 months of age were not significantly associated with maternal mobile phone use during pregnancy. However, among children exposed to high maternal BLL in utero, there was a significantly increased risk of having a low PDI up to 36 months of age, in relation to an increasing average calling time (p-trend=0.008). There was also a risk of having decreasing MDI up to 36 months of age, in relation to an increasing average calling time or frequency during pregnancy (p-trend=0.05 and 0.007 for time and frequency, respectively). There was no significant association between child neurodevelopment and prenatal RF-EMF exposure measured by PEM in all subjects or in groups stratified by maternal BLL during pregnancy. No association between prenatal exposure to RF-EMF and child neurodevelopment during the first three years of life was found; however, a potential combined effect of prenatal exposure to lead and mobile phone use was suggested.

Comment*: *Maternal blood lead level as main confounding factor. A potential combined effect is suggested.

23. Papadopoulou et al., 2017.

Norway. 1999-2008. Prospective population-based pregnancy cohort study MoBa, Norwegian Institute of Public Health.

The association between maternal cell phone use in pregnancy and child's language, communication and motor skills at 3 and 5 years was studied. This prospective study includes 45,389 mother-child pairs, participants of the MoBa, recruited at mid-pregnancy from 1999 to 2008. Maternal frequency of cell phone use in early pregnancy and child language, communication and motor skills at 3 and 5 years, were assessed by questionnaires. Logistic regression was used to estimate the associations. Results: No cell phone use in early pregnancy was reported by 9.8% of women, while 39%, 46.9% and 4.3% of the women were categorized as low, medium and high cell phone users. Children of cell phone user mothers had 17% (OR = 0.83, 95% CI: 0.77, 0.89) lower adjusted risk of having low sentence complexity at

3 years, compared to children of non-users. The risk was 13%, 22% and 29% lower by low, medium and high maternal cell phone use. Additionally, children of cell phone users had lower risk of low motor skills score at 3 years, compared to children of non-users, but this association was not found at 5 years. We found no association between maternal cell phone use and low communication skills. We reported a decreased risk of low language and motor skills at three years in relation to prenatal cell phone use, which might be explained by enhanced maternal-child interaction among cell phone users. No evidence of adverse neurodevelopmental effects of prenatal cell phone use was reported.

Comment*: *Self-reported exposure. No evidence of adverse neurodevelopmental effects of prenatal cell phone use was reported.

24. Sudan et al., 2018.

Denmark DNBC, Spain INMA, and Korea MOCEH.

The relationship between maternal cell phone use during pregnancy and cognitive performance in 5-years old children is studied. This study included data from 3 birth cohorts: the Danish National Birth Cohort (DNBC) (n=1209), Spanish Environment and Childhood Project (INMA) (n=1383), and Korean Mothers and Children's Environment Health Study (MOCEH) (n=497). All cohorts collected information about maternal cell phone use during pregnancy and cognitive performance in children at age 5. Linear regression to compute mean differences (MD) and 95% confidence intervals (CI) in children's general, verbal, and non-verbal cognition scores comparing frequency of maternal prenatal cell phone use with adjustments for numerous potential confounding factors were performed. Models were computed separately for each cohort and using pooled data in meta-analysis. No associations were detected between frequency of prenatal cell phone use and children's cognition scores. Scores tended to be lower in the highest frequency of use category; MD (95% CI) in general cognition scores were 0.78 (−0.76, 2.33) for none, 0.11 (−0.81, 1.03) for medium, and −0.41 (−1.54, 0.73) for high compared to low frequency of use. This pattern was seen across all cognitive dimensions, but the results were imprecise overall. Patterns of lower mean cognition scores among children in relation to high frequency maternal prenatal cell phone use were observed. The causal nature and mechanism of this relationship remain unknown.

Comment*: *Self-reported exposure. Patterns of lower mean cognition scores among children in relation to high frequency maternal prenatal cell phone use were observed.

25. Tsarna et al., 2019.

Denmark, Netherlands, Spain, South Korea. 1996-2011. Four population-based birth cohort studies participating in the GERoNiMO Project—namely, the Danish National Birth Cohort (DNBC), the Amsterdam Born Children and Their Development Study (ABCD), the Spanish Environment and Childhood Project (INMA), and the Korean Mothers and Children’s Environment Health Study (MOCEH).

Results from studies evaluating potential effects of prenatal exposure to radio-frequency electromagnetic fields from cell phones on birth outcomes have been inconsistent. Using data on 55,507 pregnant women and their children from Denmark (1996–2002), the Netherlands (2003–2004), Spain (2003–2008), and South Korea (2006–2011), we explored whether maternal cell-phone use was associated with pregnancy duration and fetal growth. On the basis of self-reported number of cell-phone calls per day, exposure was grouped as none, low (referent), intermediate, or high. Pregnancy duration (gestational age at birth, preterm/post-term birth), fetal growth (birth weight ratio, small/large size for gestational age), and birth weight variables (birth weight, low/ high birth weight) and meta-analysed cohort-specific estimates were examined. The intermediate exposure group had a higher risk of giving birth at a lower gestational age (hazard ratio = 1.04, 95% confidence interval: 1.01, 1.07), and exposure response relationships were found for shorter pregnancy duration ($P < 0.001$) and preterm birth ($P = 0.003$). We observed no association with fetal growth or birth weight. Maternal cell-phone use during pregnancy may be associated with shorter pregnancy duration and increased risk of preterm birth, but these results should be interpreted with caution, since they may reflect stress during pregnancy or other residual confounding rather than a direct effect of cell-phone exposure.

Comment: Stress as a confounding factor. Uncertain association.

26. Boileau et al, 2020.

France. 2014-2017.Prospective, longitudinal, multicenter observational cohort study

The aim of this study was to evaluate the association between mobile phone use by pregnant women and fetal development during pregnancy in the general population.Data came from the NéHaVi cohort ("prospective follow-up, from intrauterine development to the age of 18 years, for children born in Haute-Vienne"), a prospective, longitudinal, multicenter (three maternity units in Haute-Vienne) observational cohort focusing on children born between April 2014 and April 2017. Main objective was to investigate the association of mobile phone use on fetal growth. Univariate and multivariate models were generated adjusted for the socioprofessional category variables of the mother, and other variables likely to influence fetal growth. For the analysis 1378 medical charts were considered from which 1368 mothers (99.3 %) used their mobile phones during pregnancy. Mean phone time was 29.8 min (range: 0.0–240.0 min) per day. After adjustment, newborns whose mothers used their mobile phones for more than 30 min/day were significantly more likely to have an AUDIPOG score ≤10th percentile than those whose mothers used their mobile phones for less than 5 min/day during pregnancy (aOR = 1.54 [1.03; 2.31], p = 0.0374). For women using their cell phones 5–15 min and 15–30 min, there wasn't a significant association with an AUDIPOG score ≤ 10th, respectively aOR = 0.98 [0.58; 1.65] and aOR = 1.68 [0.99; 2.82]. Using a mobile phone for calls for more than 30 min per day during pregnancy may have a negative impact on fetal growth. A prospective study should be performed to further evaluate this potential link.

Comment: Fetal growth restriction observed when mother were using mobile phone more than 30'/day.

Table 12 - Reproductive/developmental effects in humans: man fertility, epidemiologic case-control studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjustments	Comments
1. Al-Quzwini et al., 2016. Iraq, 2014-2015. Case-control study.	100 randomly selected subfertile couples that attended the infertility clinic of Babylon Teaching Hospital for Maternity and Pediatric in Al-Hilla city in Iraq; 100 volounteers fertile couples fro staff or relatives from same hospital as control group.	Environmental exposure to electromagnetic radiation from mobile phone towers and occupational state was assessed by standard questionnaire.	Living near to mobile phone base station (<50m) and with power intensity of 71.226 mW/m2, duration of exposure to the electromagnetic radiation. Occupational exposure to work hazard (ex. "driver" sitting for long period, "worker" painters and construction workers and "militaries")	Seminal fluid analysis of the subfertile males. Odds ratios and 95% CI, and Chi-square test for differences.	**Oligozoospermia among subfertile males, OR (95% CI)**	**Asthenospermia among subfertile males, OR (95% CI)**	**Teratozoospermia among subfertile males, OR (95% CI)**			Smoking	Inadequate Semen analysis was done for the subfertile males, because the fertile males (control group) refused to give semen samples.
			Type of hazard								
			Occupational		**1.8 (0.57-5.53)**	1.07 (0.87-1.32)	**5.23 (0.52-52.20)**				
			Environmental		1.03 (0.841.19)	1.19 (0.43-3.31)	**2.6 (0.34-19.07)**				

Table 13 - Reproductive/developmental effects in humans: man fertility, epidemiologic cross sectional -studies (450-6000 MHz) (occupational) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)						Any Other Co-Exposure/adjustments	Comments
2. Baste et al., 2008. Norway. 2002-2004. Cross-sectional study	9925 current and former male military employees in the Royal Norwegian Navy, defined by the military employment list (M); mean age 49.	High-frequency aerials, communication equipment, radar. Self-assessed occupational exposure and age categories assessed by mail questionnaire.	Exposure to radiofrequency electromagnetic fields: work closer than 10 m from high-frequency aerials, work closer than 3 m from communication equipment and work closer than 5 m from radar.	Infertility. Odds ratios and 95% CI from adjusted logistic regression models; Mantel–Haenszel test for linear trend.	**Total Infertility - <10 m from high-frequency aerials, OR (95% CI)**	**Test for linear trend (Mantel–Haenszel chi-square)**	**Total Infertility - <3 m from communication equipment, OR (95% CI)**	**Test for linear trend (Mantel–Haenszel chi-square)**	**Total Infertility - <5 m from radar, OR (95% CI)**	**Test for linear trend (Mantel–Haenszel chi-square)**	Infertility. Odds ratios and 95% CI from adjusted logistic regression models; Mantel–Haenszel test for linear trend.	**Adequate/ Positive**
			Age <29									
			Not exposed									
			Low		1.00 (ref.)	0.013	1.00 (ref.)	0.077	1.00 (ref.)	0.001	Self-reported level of exposure.	
			Some		1.10 (0.30–4.07)		1.86 (0.54–6.40)		0.87 (0.25–2.99)			
			High		0.71 (0.15–3.34)		3.56 (1.05–12.08)		2.13 (0.64–7.06)			
			Very high		3.84 (1.09–13.52)		3.50 (0.83–14.78)		1.11 (0.20–6.00)			
			Age 30-39		2.70 (0.76–9.53)		2.49 (0.60–10.42)		5.09 (1.59–16.30)			
			Not exposed									
			Low		1.00 (ref.)	0.011	1.00 (ref.)	0.007	1.00 (ref.)	0.005		
			Some		1.24 (0.83–1.87)		1.53 (1.04–2.26)		1.46 (0.99–2.15)			
			High		1.36 (0.90–2.04)		1.88 (1.25–2.82)		1.32 (0.87–2.02)			
			Very high		1.51 (0.97–2.37)		1.76 (1.11–2.80)		1.79 (1.14–2.82)			
			Age 40-49		1.72 (1.08–2.74)		1.80 (1.10–2.96)		1.91 (1.19–3.07)			
			Not exposed									
			Low		1.00 (ref.)	<0.001	1.00 (ref.)	<0.001	1.00 (ref.)	0.002		
			Some		1.46 (1.03–2.07)		1.04 (0.75–1.45)		1.22 (0.87–1.71)			
			High		1.43 (0.99–2.07)		1.28 (0.91–1.81)		1.24 (0.87–1.79)			
			Very high		1.82 (1.21–2.75)		1.37 (0.91–2.08)		1.59 (1.05–2.41)			
			Age >50		1.90 (1.20–3.01)		1.86 (1.18–2.94)		1.50 (0.95–2.35)			
			Not exposed									
			Low		1.00 (ref.)	<0.001	1.00 (ref.)	<0.001	1.00 (ref.)	0.001		
			Some		1.28 (0.96–1.69)		1.02 (0.78–1.34)		1.11 (0.84–1.46)			
			High		1.59 (1.20–2.11)		1.31 (0.99–1.73)		1.58 (1.20–2.09)			
			Very high		2.02 (1.45–2.81)		1.71 (1.23–2.37)		1.39 (0.98–1.97)			

Table 13 - Reproductive/developmental effects in humans: man fertility, epidemiologic cross- sectional studies (450-6000 MHz) (occupational) (continue b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjust ments	Comments
3. Møllerløkken et al., 2008. Norway. 2002. Cross-sectional study.	2265 (M) employees who were currently serving in the Navy, both military and civilians. Mean age of 36 years of age, range 20–62.	Occupational exposure from military communication equipment. Information on occupational history from mail questionnaire. An expert group determined work categories related to electromagnetic field exposure.	Workers in the radar/sonar-, the tele/communication, electronics, other jobs (unexposed).	Infertility, Biological Children, Anomalies, Chromosomal Errors, Preterm and Stillbirths or Infant Deaths. Incidence of outcome by exposure group (%); Chi2 or Fisher Exact Tests to assess significance of differences among groups.	**Infertility - % (p-value from Chi2 tests)**	**Having biological children - % (p-value from Chi2 tests)**	**Children with anomalies or chromosomal errors - % (p-value from Chi2 or Fisher's Exact tests)**	**Children with preterm births - % (p-value from Chi2 or Fisher's Exact tests)**	**Stillbirths and infant deaths within 1 year - % (p-value from Fisher's Exact tests)**	Age, ever smoked, military education, and physical exercise at work.	Adequate /positive
			Other jobs (unexposed group)		8.6	62.0	3.5	7.9	2.3		
			Tele/communication workers (communication equipment, radio)		**14.8 (0.01)**	63.5 (0.70)	6.0 (0.18)	10.8 (0.18)	3.6 (0.22)		
			Electronics (electronics for weapons and communication systems)		12.1 (0.15)	58.6 (0.40)	1.8 (0.19)	9.5 (0.44)	1.8 (0.47)		
			Radar/sonar workers (radar)		**17.5 (<0.01)**	70.4 (0.10)	7.1 (0.11)	9.1 (0.37)	2.0 (0.61)		

Table 13 - Reproductive/developmental effects in humans: man fertility, epidemiologic cross-sectional studies (450-6000 MHz) (continued c)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjustments	Comments
4. Fejez et al. 2005. Hungary. Cross-sectional study.	611 consecutive Caucasian men of reproductive age from clinic for infertility problems.	Self reported	Duration of possession (in months), duration of standby position closer than 50 cm to the patient (in hours) and duration of daily transmission (in minutes).	Quality of semen. Parametric t-test and the Pearson correlation tests were applied.	**Volume (ml), correlation, p-value**	**Sperm concentration (mln/ml)**	**Total motility (%)**	**Total sperm count (mln/ ejaculate)**	**Total motile sperm count (mln/ ejaculate)**	Occupational exposure to some chemical pesticides, petroleum, solvents, lead and nitrosamines, tobacco consumption.	Inadequate
			Duration of possession (months)		-0.02, 0.64	-0.01, 0.91	-0.08, 0.14	-0.01, 0.81	-0.03, 0.53	Many confounders not analysed	
			Duration of daily standby (h)		0.05, 0.42	-0.01, 0.39	-0.03, 0.64	-0.05, 0.41	-0.07, 0.22		
			Duration of daily transmission (min)		-0.01, 0.84	0.04, 0.84	-0.07, 0.16	0.03, 0.58	0.00, 0.54		
5. Jurewicz et al. 2014, and Radwan et al. 2016. Poland. Cross-sectional study.	344 men, age <45 years, attending infertility clinics in Lodz, Poland in 2008-2011 for diagnostic purposes.	Modifiable lifestyle factors, among which use of cell phone, assessed using self-administered questionnaire.	Duration of exposure from use of cell phones, assessed in years.	Semen quality (WHO 1999 reference values) and DNA fragmentation. Multiple linear regressions were used to assess association.	**Coeff for cell phone use, 0-5 years (p-value)**	**Coeff for cell phone use, 6-10 years (p-value)**	**Coeff for cell phone use, 11-25 years (p-value)**			Using cell phone more than 10 years decreased the percentage of motile sperm cells	Adequate/ positive
				Volume	1.16 (ref.)	-0.06 (0.32)	-0.01 (0.84)				
				Concentration	3.03 (ref.)	0.29 (0.22)	0.42 (0.13)				
				Motility	60.77 (ref.)	-4.13 (0.30)	**-11.27 (0.01)**				
				Atypical	45.73 (ref.)	4.44 (0.42)	**19.00 (0.01)**				
				Sperm head abnormalities	32.42 (ref.)	2.28 (0.69)	**17.58 (0.01)**				
				Sperm neck abnormalities	12.04 (ref.)	-0.25 (0.86)	0.12 (0.94)				
				Sperm tail abnormalities	2.02 (ref.)	-0.01 (0.96)	-0.02 (0.93)				
				DNA fragmentation index	2.52 (ref.)	0.01 (0.97)	0.20 (0.22)				

Table 13 - Reproductive/developmental effects in humans: man fertility, epidemiologic cross-sectional studies (450-6000 MHz) (continued d)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate					Any Other Co-Exposure/adjustments	Comments
6. Yildirim et al., 2015. Turkey, 2013-2014. Cross-sectional study.	1031 healthy men from the Andrology subdivision of the Urology Dept (Turgut Ozal University)	Use of mobile cell (850-1800 MHz) and wireless internet (2400 MHz), assessed using an anonymous questionnaire.	Daily the cell phone usage duration, habits of carrying mobile phone, wireless internet usage duration, and type of internet use.	Sperm parameters. Pearson correlation Coefficients, Student t test (2-tailed) and one way analysis of variance (ANOVA).	**Volume**	**Total sperm count (mln)**	**Total motile sperm count (mln)**	**Progressive motile sperm count (mln)**	**Morphology**	-	Inadequate
		Self-reported	*Duration of cell phone use (h)*	One way analysis of variance, p-value	0.194	0.074	**0.05**	0.083	0.909	Confounding factors not analysed	
			< 0.5		2.9 ± 1.41	42.3 ± 16.3	61.1 ± 60.6	47.5 ± 50.8	2.8 ± 1.9		
			0.5-2		2.9 ± 1.19	39.2 ± 16.3	54.6 ± 50.6	42.5 ± 42.1	2.57 ± 1.76		
			>2		3.01 ± 1.45	37.8 ± 16.1	53.8 ± 59	41.6 ± 51.2	2.74 ± 1.72		
			Mobile phone carrying habits	One way analysis of variance, p-value	0.973	0.256	0.168	0.538	**0.034**		
			Trouser pocket		2.9 ± 1.37	39.1 ± 31.1	56.5 ± 60.1	43.8 ± 51	2.72 ± 1.81		
			Handbag		3.08 ± 1.4	45 ± 31.6	63 ± 48.6	49.6 ± 41.4	3.18 ± 2.47		
			Jacket pocket		3.02 ± 1.38	40.3 ± 27	53.6 ± 49.1	41.9 ± 41.1	2.43 ± 1.38		
			Duration of wireless internet use (h)	One way analysis of variance, p-value	0.43	0.093	**0.032**	**0.033**	0.305		
			< 0.5		2.99 ± 1.4	43 ± 33	61.7 ± 60.2	48.2 ± 53.7	2.73 ± 1.84		
			0.5-2		2.81 ± 1.32	41.8 ± 28.2	56.2 ± 57.5	43 ± 42.1	2.65 ± 1.75		
			>2		2.99 ± 1.36	37.4 ± 29.4	53.8 ± 57.5	41.8 ± 49.6	2.73 ± 1.85		
			Internet usage	Student t test, p-value	0.064	0.054	**0.009**	**0.018**	0.182		
			Cable		2.92 ± 1.25	42 ± 32.3	62.7 ± 61.3	48.9 ± 50.3	2.82 ± 1.72		
			Wireless		2.98 ± 1.43	38.8 ± 29.6	53.6 ± 55.2	41.1 ± 47.7	2.67 ± 1.88		
7. Zilberlicht et al, 2015. Israel, 2011–2012. Cross-sectional study.	80 male patients at infertility workup in the Fertility and IVF division of Carmel Medical Centre.	Daily habits of cell phone use assessed from self-administered questionnaire.	Daily habits of cell phone usage.	Semen quality was assessed using four parameters: volume, concentration, motility and morphology. Variables that were statistically significant in univariate analysis were included in a multivariate logistic regression analysis. OR were calculated with 95% confidence interval (CI).	**P-value of association of Sperm concentration, abnormal vs normal**	**OR (95% CI) for abnormal sperm concentration**	**p-value**			Smoking, age, residential area, occupation, n of children, years of education.	Adequate / positive
			Total daily talking time (≤1h / >1h)		0.040	Not reported	n.s.				
			Talk while charging the device (Yes/no)		0.020	4.13 (1.28-13.3)	0.018				

Table 13 - Reproductive/developmental effects in humans: man fertility, epidemiologic cross-sectional studies (450-6000 MHz) (continued e)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate	Any Other Co-Exposure/adjustments	Comments
8. Al-Bayyari, 2017. Jordan, 2015–2016. cross-sectional observational study.	159 men attending infertility clinics at North, Middle and South Governorates in Jordan.	Daily habits of cell phone use assessed from interviews using a structured questionnaire.	Time of talking by cell phone.	Semen quality. The Pearson's Chi-square (v2) and Fisher's exact tests were applied to assess the association.	**Total daily talking time (≤1 h/day vs >1h/day), p-value**	-	Inadequate
				Sperm concentration (cut-off 20 mln/ml)	0.494	All from an Infertility clinic	
				Volume (ctu-off 3 ml)	0.457		
				Viscosity (Normal vs abnormal)	0.556		
				Liquefaction time (cut-off 20 min)	0.534		
				Sperm motility (%)	n.s.		
				Sperm morphology (%)	n.s.		
9. Shi et al., 2018. China, 2015–2016. Cross-sectional study.	328 men <65 years, attending clinics for sperm analysis.	Use of cell phone assessed using self-report questionnaire.	Habit to carry phone in trousers.	SA, sperm vitality, acrosome reaction (AR) assay and sperm DNA fragmentation index (DFI). Generalized additive models were used to analyze the possible non-linear association.	**Duration of trousers pocket cell phone use (hours/day)**	BMI, smoking and alcohol drinking, sleep, daily fluid intake, weekly meat intake, sports frequency, trouser cell phone use, age, abstinence time.	Inadequate
				Volume	n.s.		
				Concentration	n.s.	All from an Infertility clinic	
				TSC	n.s.		
				Motility	n.s.		
				TMC	n.s.		
				Vitality	n.s.		
				DFI	n.s.		
				AR	n.s.		
10. Blay et al., 2020. Ghana. 2004-2015. Cross-sectional study.	80 men, 21-62 years, recruited from a fertility clinic in Accra, Ghana.	Lifestyle habits assessed using a structured questionnaire.	Mobile phones use and site of common storage on the body.	Parameters of semen quality. Independent Student t-test and Pearson's chi squared test were used to test the association between variables.	**Site of mobile phone storage (side pocket vs other place), p-value**	General characteristics, medical history, particularly disorders of the immune system, smoking habits.	Inadequate
				Volume	0.884	Increased activity and viability associated to cell phone in their side pocket	
				pH	0.741		
				Active motility (%)	**0.002**		
				Sluggish motility (%)	0.269		

				Sluggish motility (%)	0.486	All from an Infertility clinic	
				Viability (%)	**0.009**		
				Count (×106/ml)	0.109		

Table 14 - Reproductive/developmental effects in humans: man fertility epidemiologic cohort studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)				Any Other Co-Exposure/adjustments	Comments
11. Zhang et al., 2016. China, 2013-2015. MARHCS cohort study	794 (2013), 666 (2014) and and 568 (2015) young men, age < 18 years, college students, enrolled in the Male Reproductive Health in Chongqing College Students (MARHCS) study.	Use of mobile cell phones, assessed using a questionnaire.	Number of cell phones owned, presence of 3G function, duration of cell phone use, position in which they carry the cell phone, daily duration that the cell phone is turned on (within 50 cm near the body), daily internet time or monthly data traffic via cellular networks, and daily time spent talking on the cell phone in the last three months.	Sperm parameters. Mixed-effects linear regression model was used to globally assess all three years of data on cell phone use and semen parameters	**Volume (ml), Coeff from mixed effects model (95% CI), p-value**	**Sperm concentration (mln/ml), Coeff from mixed effects model (95% CI), p-value**	**Total sperm count (mln), Coeff from mixed effects model (95% CI), p-value**	**Progressive motile sperm (mln), Coeff from mixed effects model (95% CI), p-value**	Age, duration of abstinence, body mass index (BMI), smoking and drinking status, and the consumption of cola, coffee, and fried food	Adequate/ positive
			Duration of cell phone use (h)		-2.19 (-4.39, 0.06), 0.056	-2.90 (-6.91, 1.27), 0.170	**-4.87 (-9.27, -0.27), 0.038**	-0.77 (-2.71, 1.22), 0.445		
			Internet use via cellular network (h, 2013)		0.42 (-0.71, 1.56), 0.472	**-2.74 (-4.53, -0.91), 0.004**	**-2.75 (-4.76, -0.69), 0.009**	0.51 (-0.29, 1.32), 0.213		
			Monthly data traffic (GB, 2014-2015)		**-1.47 (-2.74, -0.19), 0.025**	-1.65 (-4.04, 0.80), 0.185	**-3.22 (-5.85, -0.52), 0.020**	0.19 (-1.08, 1.48), 0.770		

Table 14 - Reproductive/developmental effects in humans: man fertility epidemiologic cohort studies (450-6000 MHz) (continued b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)						Any Other Co-Exposure/adjustments	Comments
12. Lewis et al., 2017. USA. 2004-2015. Longitudinal cohort study.	384 (M); 18-56 years; Men recruited from a fertility clinic in Boston, Massachusetts, enrolled in the Environment and Reproductive Health (EARTH) Study.	Mobile phones radiofrequencies; Self - reported exposure from mobile phone.	Use, duration (no use, <2 h/day, 2–4 h/day, >4 h/day), headset or earpiece use (H/E, N H/E), and location in which the mobile phone was carried (pants pocket, belt, bag, other).	Sperm motility, total sperm count, total motile sperm count, sperm morphology. Strict Kruger scoring criteria was used to classify men as having normal or below normal morphology by blinded semen analysts. Linear mixed-effects models with random subject effects.	**Absolute differences [ß (95% CI)], Semen volume**	**Absolute differences [ß (95% CI)], Total motility**	**Relative differences [exp(ß) (95% CI)], Total sperm count**	**Relative differences [exp(ß) (95% CI)], Sperm concentration**	**Relative differences [exp(ß) (95% CI)], Total motile sperm count**	**Relative differences [exp(ß) (95% CI)], Normal sperm morphology**	General characteristics, medical history, particularly disorders of the immune system, smoking habits. All from an Infertility clinic	Adequate/ positive
			Category of use (h/day) and headset or earpiece use.									
			No Use		0 (ref.)	0 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			<2 h/day, H/E		0.74 (0.08-1.41)	13.05 (1.57-24.53)	1.60 (1.04-2.46)	1.24 (0.81-1.89)	2.43 (1.17-5.07)	0.94 (0.68-1.31)		
			<2 h/day, N H/E		0.40 (-0.06-0.86)	4.47 (-3.53-12.46)	1.09 (0.80-1.47)	0.99 (0.74-1.33)	1.39 (0.83-2.31)	0.97 (0.77-1.22)		
			>2 h/day, H/E		0.29 (-0.43-1.01)	3.06 (-9.39-15.50)	1.14 (0.71-1.82)	1.03 (0.65-1.63)	1.44 (0.65-3.20)	0.84 (0.59-1.20)		
			>2 h/day, N H/E		-0.12 (-0.93-0.68)	4.10 (-9.72-17.93)	1.47 (0.87-2.47)	1.52 (0.91-2.53)	1.89 (0.78-4.58)	0.83 (0.56-1.23)		

Table 15 - Reproductive/developmental effects in humans: developmental effects, epidemiologic case-control studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
13. Tan et al., 2014. Singapore. November 2010 and February 2011. Case-control study	Women with threatened miscarriage during the 5th to 10th weeks of gestation seen at emergency clinic KK Womens and Childrens Hospital (KKH) in Singapore. (F). Mean age of cases and controls were 30.2 and 30.7, respectively.	Potentially modifiable lifestyle factors were assessed by face to-face interview with cases and controls, conducted at the time of recruitment. Mobile phone and computer usage were quantified as self-reported number of hours of use per day based on the most recent one week.	Exposure to radiofrequency electromagnetic fields of cell phone and television. Greater duration of mobile phone use or computer use was associated with higher risk of threatened miscarriage, with dose-response relationship	Association between potential lifestyle risk factors (cell phone and TV usage) and threatened miscarriage: results of adjusted logistic regression analysis. Multivariate analysis adjusting for all confounders and for gestational age.	**Adjusted odds ratio (95% Confidence Interval):**		Maternal age, paternal age, gestational age, ethnicity, height, weight, regularity of menstrual cycle, housing type, educational level, past medical/ pregnancy/ gynaecological/ psychiatric history, urrent and past cigarette smoking, exposure to second-hand cigarette smoke at home, current and past alcohol consumption, current and past caffeine Consumption, perceived stress levels, DHA consumption, and most recent contraceptive use	**Adequate/ positive**
			Handphone use					
			0 to <1 hour		1		Stress not considered as confounder	
			≥ 1 to <2 hours		2.94 (1.32–6.53)			
			≥ 2hours		6.32 (2.71–14.75)			
			Computer use					
			0 to <1 hour		1			
			≥1 to <4 hours		2.66 (1.16–6.09)			
			≥ 4 hours		6.03 (2.82–12.88)			
14. Mahmoudabadi et al., 2015. Iran. Before 2015. Case-control study	292 women who had an unexplained spontaneous abortion at < 14 weeks gestation and 308 matching pregnant women > 14 weeks gestation were enrolled. The subjects were recruited from 10 hospitals in Tehran.	Data collection form was completed to collect data about the use of cell phones during pregnancy.	Average calling time per day, the location of the cell phones when not in use, use of hands-free equipment, use of phones for other applications, the specific absorption rate (SAR) reported by the manufacturer and the average of the effective SAR (average duration of calling time per day × SAR).	Spontaneous abortions. Logistic regression model was used to calculate OR and 95% CI; *T student test, ** Chi square test or Fisher's exact test were used to assess association.	**OR (95% CI)**	**P(2-tailed)**	Effective SAR, maternal age, paternal age, history of abortion and family relationship Life style confounders not analysed	**Adequate /positive**
			Association of spontaneous abortions with the effective SAR (Specific Absorption Rate)		**1.11 (1.07-1.16)**			
			Calling time per day* (minutes) Mean ± SD			**<0.001**		
			Use of hands free** n (%)			0.09		
			location of phones when not in use** n (%)			**<0.001**		
			use of phone for other applications **n (%)			**<0.001**		
			Effective SAR* Mean ± SD			**<0.001**		

Table 16 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cross-sectional studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
15. Col Araz et al., 2013. Turkey, 2009. Cross-sectional study.	500 mothers from the Outpatient Clinic, Dept of Paediatrics, Gaziantep University.	Use of television, computer and mobile phones during pregnancy assessed using a self-administered questionnaire	Cell phone use, computer use (user vs non-user).	Birth weight and preterm birth. The Chi-square test, independent samples t-test, and OR and 95% CI from logistic regression analysis were used.	**Delivery before 37 weeks, χ^2 (p-value)**	**Delivery week, mean ±SD**	**Delivery week, p-value**	Socio-demographic information, mothers weight, height, weight gained, consumption of tobacco and alcohol during pregnancy, disease history, observance of religious fasting during pregnancy, consumption of tea, milk and yoghurt, birth week and birth weight of the other children, if any.	Adequate /positive
			Cell phone use		**5.584 (<0.018)**		**<0.005**		
			User			38.7±1.9			
			Non user			39.2±1.6			
			Duration of cell phone use				**<0.001**		
			≤1h/day			37.6±2.2			
			>1h/day			38.8±1.8			
			Computer use		**4.510 (<0.034)**		**<0.048**		
			User			38.5±1.8			
			Non user			38.9±1.8			
			Duration of cell phone use				n.s.		
			≤1h/day			Not reported			
			>1h/day			Not reported			
16. Zarei S. et al., 2015. Iran. 2014. Cross-sectional study.	Mothers of 35 healthy children (control group) and 77 children aged 3-5 year and diagnosed with speech problems (F).	Different sources of electromagnetic fields (both RF-EMF and ELF) such as mobile phones, mobile base stations, Wi-Fi, cordless phones, laptops and power lines. Self-assessed exposure to different sources of electromagnetic fields.	The mean daily (mobile phone) call time was about 20 min. Call time, history of mobile phone use (months used), average duration of daily call time, cordless phone use and CRT use during pregnancy.	Speech problems in offspring. A P-value of less than 0.05 was considered as significant.	**Speech problems, P-value of association measure**			Age, proportion of consanguineous marriage, smoking, dental radiography history, mean number of pregnancies	Inadequate
			call time		0.002				
			history of mobile phone use		0.003				
			average duration of daily call time during pregnancy		N.S.				
			cordless phone use		0.528				
			CRT use		0.990				

Table 16 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cross-sectional studies (450-6000 MHz) (continued b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
17. Abad et al., 2016. Iran, 2009. Cross-sectional study.	413 pregnant women (18-35 years of age) from the Tehran region. Reproductive information was collected using medical file recorded in those hospitals the subjects had delivery.	Environmental exposure to EMF (range 27 MHz-3 GHz) assessed using NARDA at the entrance door of their houses three times during the pregnancy (semesters 1, 2, 3). Other information assessed using a face-to face interview.	Environmental exposure to EMF.	Miscarriage (spontaneous abortion, LBW, preterm delivery, and Intra Uterine Fetal Death). Independent samples t-test.	**Miscarriage, p-value from t-test**				Inadequate
			Digital radio and television broadcast services in central frequency 650 MHz		0.85				
			Mobile communications services 1.5 GHz		0.67				
			Wi-Fi access and MISC in central frequency 2.45 GHz		0.42				
18 Lu et al. 2017. Japan. 2012-2014. Cross sectional study from cohort data.	461 mother and child pairs (M and F). Data from the Japan Environment and Children's Study (JECS) and JECS Adjunct Study in Kumamoto.	Mobile phones radiofrequencies; Self-assessed exposure from self-administered questionnaires on maternal mobile phone usage information during pregnancy. A short version of the Self-Perception of Text-Message Dependency Scale (STDS) was used in this study for assessing text message dependency.	Daily mobile phone use times, location of the phone during the day and at night, and power state (on/off) of the mobile phone during sleep). A cut-off of 15 points for the excessive use score in the STDS was used to determine excessive mobile phone use.	Birth weight and infant health status (birth height, birth head circumference, birth chest circumference, mode of delivery, weeks of pregnancy, placental weight, low birth weight), infant emergency transport, and premature birth; linear regression analysis was used.	**ß (95%CI) for Birth weight**	**Adjusted OR (95%CI), Infant emergency transport**	**Adjusted OR (95%CI), Premature birth**	Maternal age, birth height, maternal BMI before pregnancy, maternal age, birth head circumference, primiparity, maternal smoking.	Inadequate
			Daily mobile phone use						
			Normal users		0 (ref.)	1.00 (ref.)	1.00 (ref.)		
			Mobile excessive users		-66.46 (-114.46- -18.46)	7.93 (1.40-44.85)	0.67 (0.09-4.97)		

Table 17 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cohort studies (450-6000 MHz) (a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)						Any Other Co-Exposure/adjustments	Comments
19. Mjøen et al., 2006. Norway. 1976-1995. Cohort study.	541593 births (M and F). Data on all births registered between 1976 and 1995 in Norway from the Medical Birth Registry of Norway; The Norwegian general population censuses contain data on occupations coded according to the Nordic Classification of Occupations.	Paternal occupation categorized as "probably not exposed", "possibly exposed" and "probably exposed", reflecting probability of exposure to RFR. An expert panel assessed exposure to radiofrequency fields in the various occupations.	Level of exposure assigned from experts.	Birth defects, the total number of CNS and musculoskeletal limb defects, and all categories combined, preterm delivery, low birth weight, sex ratio and perinatal mortality. Relative risks for each exposure category were calculated by approximating odds ratios (OR) with 95% confidence intervals (CI) from logistic regression models.	**Preterm delivery (<37 weeks) - OR (95% CI)**	**Low birth weight (<2,500 g) - OR (95%CI)**	**Early stillbirth (between 16 and 28 weeks) - OR (95% CI)**	**Late stillbirth (after 28 weeks) - OR (95% CI)**	**Male gender - OR (95% CI)**	**Any birth defect - OR (95% CI)**	Calendar year, place of birth and level of education.	Adequate/ negative
			Probably not exposed		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			Possibly exposed		0.99 (0.96-1.02)	1.03 (0.98-1.07)	1.01 (0.91-1.12)	1.01 (0.92-1.11)	1.01 (1.00-1.03)	0.98 (0.94-1.02)		
			Probably exposed		1.08 (1.03-1.15)	1.03 (0.94-1.13)	0.98 (0.79-1.22)	1.09 (0.89-1.29)	0.99 (0.97-1.02)	0.94 (0.86-1.01)		

Table 17 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cohort studies (450-6000 MHz) (continued b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjustments	Comments
20. Divan at al., 2008 and Divan et al. 2011. Denmark. Children born between 1997 and 2002. Cohort study.	41541 children (F and M). Mothers and live-born children constitute 2 fixed cohorts. Child's health status assessed at 7th year of age using an internet-based Questionnaire.	Cell phone and cordless phone use, assessed via four telephone interviews.	Cell phone use among children, among mothers during pregnancy (mother's use of cell phone during pregnancy, use of hands-free equipment during pregnancy (proportion of time) and location of the phone when not in use (handbag or clothing pocket), and for children, current use of cellular and other wireless phones.	Cognitive/language development delays, motor development delays and behavioural problems assessed using the "Strengths and Difficulties Questionnaire". Odds ratios and 95% CI from adjusted logistic regression models.	**Cognitive/language development delay at 6 months-Adjusted OR (95% CI)**	**Motor development delay at 6 months-Adjusted OR (95% CI)**	**Cognitive/language development delay at 18 months-Adjusted OR (95% CI)**	**Motor development delay at 18 months-Adjusted OR (95% CI)**	**Overall Behavioural Problems Score at 7 years-Adjusted OR (95% CI)**	Adjusted for gender of child, combined social-occupational status, mother's age at birth, gestational age, and child's birth weight, child care outside home at 18 months.	Adequate/ Negative Exposure to cell phones prenatally—and, to a lesser degree, postnatally—was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry.
			Prenatal Exposure Only			1.12 (0.97–1.30)		**1.21 (1.05–1.40)**	**1.58 (1.29–1.93)**		
			Postnatal Exposure Only			1.06 (0.92–1.23)		1.02 (0.89–1.18)	1.18 (0.96–1.45)		
			Both Prenatal and Postnatal Exposure			**1.25 (1.07–1.47)**		**1.49 (1.28–1.74)**	**1.80 (1.45–2.23)**		
			Prenatal: Times spoken per day								
			0-1		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			2-3		1.0 (0.7–1.4)	0.8 (0.5–1.0)	0.9 (0.6–1.3)	0.7 (0.5–1.0)	1.33 (0.99–1.79)		
			4+		0.8 (0.4–1.3)	0.6 (0.3–1.0)	0.9 (0.5–1.6)	1.2 (0.8–1.8)	**1.51 (1.02–2.22)**		
			Prenatal: Percentage of time turned on								
			0		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			<50		1.1 (0.6–1.9)	1.3 (0.8–2.7)	1.2(0.7–2.3)	1.1 (0.7–1.8)	0.62 (0.35–1.11)		
			50-99		0.9 (0.5–1.6)	1.1 (0.6–1.8)	1.2 (0.5–2.2)	1.2 (0.8–2.0)	0.93 (0.58–1.48)		
			100		1.0 (0.5–2.0)	1.1 (0.6–2.0)	1.5 (0.7–3.0)	1.3 (0.8–2.3)	1.09 (0.70–1.70)		

Table 17 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cohort studies (450-6000 MHz) (continued c)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)				Any Other Co-Exposure/adjustments	Comments
21. Guxens et al., 2013. Netherlands. 2003-2004 enrollment; 2008-2009 assessment of behavioural problems; 2010-2011 retrospective exposure assessment. Study embedded in a population-based prospective birth cohort study.	8266 pregnant women, 2618 children (F and M). Pregnant women enrolled during their first prenatal visit to an obstetric care provider. Prenatal phone use assessed retrospectively with postal or via web questionnaire at children 7th year, and child behaviour problems assessed at children 5th year.	Cell phones and cordless phones use during pregnancy. Self-assessed exposure from questionnaire. Given the introduction of Universal Mobile Telecommunications System technology in the Netherlands in the beginning of 2004, mobile phone use reports were expected to be nearly exclusively Global System for Mobile Communications (GSM) 900/1800 technology.	Frequency of cell phone calls were set to 75% of the number of calls for those reporting to use the hands-free equipment 'less than half of the calls', to 25% for those reporting to use it 'more than half of the calls', and to 0 for those reporting to use it 'nearly always'.	Children's behaviour (emotional symptoms, conduct problems, hyperactivity/inattention problems, peer relationship problems and pro-social behaviour) reported by primary school teachers and mothers using the Strengths and Difficulties Questionnaire (SDQ) at age 5. Odds ratios and 95% CI from unadjusted and adjusted logistic regression models.	**Teacher-reported child overall behaviour problems, Unadjusted model - OR (95% CI)**	**Teacher-reported child overall behaviour problems, Adjusted model - OR 95% CI)**	**Mother-reported child overall behaviour problems, Unadjusted model - OR (95% CI)**	**Mother-reported child overall behaviour problems, Adjusted model - OR**	Maternal age, maternal educational level, maternal country of birth, maternal parity, maternal pre-pregnancy weight and height, maternal smoking, maternal second-hand smoke at home, maternal alcohol consumption during pregnancy, maternal pregnancy-related anxiety and maternal anxiety and depression during pregnancy, children's birth addresses as indicator of socioeconomic position. .	Adequate/ negative
			Prenatal frequency of cell phone call							
			None		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			<1/day		2.09 (0.95 - 4.62)	2.12 (0.95 - 4.74)	0.95 (0.39 - 2.29)	0.89 (0.36 - 2.20)		
			1–4/day		1.53 (0.69 - 3.42)	1.58 (0.69 - 3.60)	0.78 (0.32 - 1.92)	0.73 (0.28 - 1.85)		
			≥5/day		1.88 (0.82 - 4.34)	2.04 (0.86 - 4.80)	0.77 (0.29 - 2.06)	0.75 (0.27 - 2.09)		
			Prenatal frequency of cordless phone call							
			None		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)		
			<1/day		0.89 (0.57 - 1.39)	1.19 (0.74 - 1.92)	0.27 (0.15 - 0.50)	0.35 (0.18 - 0.67)		
			1–4/day		0.76 (0.48 - 1.22)	1.07 (0.65 - 1.76)	0.55 (0.32 - 0.96)	0.73 (0.41 - 1.33)		
			≥5/day		0.50 (0.23 - 1.09)	0.61 (0.27 - 1.35)	0.40 (0.15 - 1.07)	0.43 (0.15 - 1.21)		

Table 17 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cohort studies (450-6000 MHz) (continued d)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)				Any Other Co-Exposure/adjustments	Comments
22. Choi et al., 2017. South Korea. 2006-2016. Multi-center prospective cohort study (the Mothers and Children's Environmental Health (MOCEH) study).	1198 mother-infant pairs (M and F). Participants were enrolled at ≤20 weeks gestation.	RFR sources of exposure, including cell phone, TV, radio, working on the internet, and mobile phone base stations. Self-assessed exposured from questionnaire regarding average calling frequency (≤2, 3–5, and ≥6 times/day) and average calling time (< 3, 3–10, 10–30, and ≥30 min/day) during pregnancy.	Heavy user defined as calling frequency >6 times per day or calling time >30 min per day. Categories by average calling time (min/day)	MDI: Mental development index, PDI: Psychomotor development index.	**OR (95% CI) for decreasing MDI (6–36 months)**				Occupational exposure to some chemical pesticides, petroleum, solvents, lead and nitrosamines, tobacco consumption.	Inadequate
			Average calling time (min/day)		**All**	**Low Maternal blood lead during pregnancy (< 75%)**	**High Maternal blood lead during pregnancy (<75%)**	**p-interaction**	Maternal blood lead level as main confounding factor	
			<3		0.50 (0.30-0.83)	0.71 (0.42-1.21)	0 (0-Inf)	0.02		
			3-10		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)			
			10-30		0.85 (0.60-1.19)	0.86 (0.57-1.28)	2.11 (0.67-6.68)			
			>30		0.63 (0.37-1.08)	0.76 (0.43-1.34)	0 (0-Inf)			
			P for trend		0.86	0.48	**0.05**			
					OR (95% CI)) for low PDI (6–36 months)					
			Average calling time (min/day)		**All**	**Low Maternal blood lead during pregnancy (< 75%)**	**High Maternal blood lead during pregnancy (<75%)**	**p-interaction**		
			<3		0.47 (0.24-0.94)	0.41 (0.19-0.92)	0.45 (0.23-0.89)	0.44		
			3-10		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)			
			10-30		0.77 (0.49-1.23)	0.81 (0.49-1.35)	1.10 (0.69-1.76)			
			>30		0.64 (0.32-1.29)	0.73 (0.36-1.48)	1.56 (0.74-3.26)			
			P for trend		0.54	0.26	**0.008**			

Table 17 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cohort studies (450-6000 MHz) (continued e)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)			Any Other Co-Exposure/adjustments	Comments
23. Papadopoulou et al., 2017. Norway, 1999 -2008. Norwegian mother and child cohort study (MoBa).	45389 mother-child pairs (M and F), participants of the MoBa, recruited at mid-pregnancy. Information assessed by questionnaires.	Maternal frequency of cell phone use in early pregnancy, assessed by a questionnaire administered at 17th and 30th weeks of gestation.	Frequency of talking on the cell phone: "seldom/never" (no use), "few times a week" (low), "daily" (medium), and "more than an hour daily" (high use).	Child language, communication and motor skills at 3 (45389 mother-child pairs) and 5 years (17310 mother-child pairs). Adjusted OR and 95% C.I. from logistic regression to estimate the associations.	**Risk for lower sentence complexity at 3 years-Adjusted OR (95% C.I.)**			Parity, maternal age, education and year of delivery.	**Adequate /negative**
			Maternal cell phone use in early pregnancy						
			No use		1 (ref)				
			Any use		0.83 (0.77, 0.89)				
			Low		0.87 (0.81, 0.94)				
			Medium		0.78 (0.72, 0.84)				
			High		0.71 (0.62, 0.81)				
			P for trend		**<0.001**				
24. Sudan et al., 2018. Denmark 1996-2002, Spain 2003-2008, South Korea 2006-2011. Data from 3 birth cohorts, part of the Generalized EMF Research using Novel Methods (GERoNiMO) Project.	3089 mother-child pairs participating in the Danish National Birth Cohort (DNBC) (n=1209), the Spanish Environment and Childhood Project (INMA) (n=1383), and the Korean Mothers and Children's Environment Health Study (MOCEH) (n=497).	Maternal cell phone use during pregnancy, assessed during pregnancy (ES and KO) or 7 years after birth (DK).	Frequency of talking on the cell phone: "seldom/never" (no use), "few times a week" (low), "daily" (medium), and "more than an hour daily" (high use). In the DNBC, ABCD, and INMA cohorts, no exposure corresponded to no cell-phone use, low exposure to ≤1 calls/day, intermediate exposure to 2–3 calls/day, and high exposure to ≥4 calls/day. In the MOCEH cohort, no exposure corresponded to no cell-phone use, low exposure to ≤2 calls/day, intermediate exposure to 3–5 calls/day, and high exposure to ≥6 calls/day.	Cognitive performance in children at age 5. Linear regression to compute mean differences (MD) and 95% confidence intervals (CI).	**General cognition , Adjusted OR (95% C.I.)**	**Verbal cognition , Adjusted OR (95% C.I.)**	**Non-verbal cognition, Adjusted OR (95% C.I.)**	Sex of child, age of child, maternal IQ, maternal age, parity, mother's history of psychological distress, maternal education, paternal education, prenatal smoking, prenatal alcohol use, and maternal pre-pregnancy BMI	**Adequate /equivocal**
			Maternal cell phone use in early pregnancy						
			No use		0.78 (-0.76, 2.33)	1.42 (-1.12, 3.96)	0.72 (-0.85, 2.28)		
			Low		1 (ref)	1 (ref)	1 (ref)		
			Medium		0.11 (-0.81, 1.03)	-0.23 (-1.29, 0.83)	-0.12 (-1.60, 1.35)		
			High		-0.41 (-1.54, 0.73)	-0.42 (-1.73, 0.89)	-0.85 (-2.23, 0.53)		

Table 17 - Reproductive/developmental effects in humans: developmental effects, epidemiologic cohort studies (450-6000 MHz) (continued f)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)				Any Other Co-Exposure/adjustments	Comments
25. Tsarna et al., 2019. Denmark 1996-2002, Spain 2003-2008, South Korea 2006-2011. Data from 3 birth cohorts, part of the Generalized EMF Research using Novel Methods (GERoNiMO) Project.	55507 mother-child pairs (M and F) participating in the Danish National Birth Cohort (DNBC), the Spanish Environment and Childhood Project (INMA), and the Korean Mothers and Children's Environment Health Study (MOCEH).	Use of mobile phone s during pregnancy. Retrospective exposure assessment (DNBC and ABCD) or prospective exposure assessment (INMA and MOCEH) were used.	Exposure were classified into 4 categories (none, low, intermediate, and high) based on daily frequency of cell-phone calls during pregnancy.	Preterm/post-term birth, fetal growth (small or large size for gestational age). Modified Wald, χ2, and Fischer exact tests. The calculated adjusted cohort-specific estimates were meta-analysed using random-effects models.	**Preterm birth - Adjusted OR (95% C.I.)**	**Post term birth - Adjusted OR (95% C.I.)**	**SGA birth - Adjusted OR (95% C.I.)**	**LGA birth - Adjusted OR (95% C.I.)**	Maternal age at child's birth (a natural spline term with 3 degrees of freedom), parity, active and passive smoking during pregnancy, alcohol consumption during pregnancy, pre-pregnancy body mass index.	Adequate/ equivocal
			None		0.96 (0.86-1.07)	0.98 (0.89-1.07)	0.94 (0.86-1.03)	0.98 (0.92-1.04)		
			Low		1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	Stress not considered as confounding	
			Intermediate		1.12 (0.97-1.28)	0.85 (0.75-0.97)	1.03 (0.88-1.21)	0.97 (0.89-1.05)		
			High		1.28 (0.87-1.88)	0.98 (0.83-1.16)	0.94 (0.78-1.13)	0.93 (0.83-1.04)		
			P for trend		**0.003**	0.863	0.872	0.488		
26. Boileau et al., 2020. France, children born in 2014-2017. Prospective, longitudinal, multicenter observational cohort study (NéHaVi cohort)	1378 mothers-child pairs (M and F). Questionnaires completed during face-to-face interviews in the post-partum period during stay at the maternity unit, and the child's and parents' medical records.	Use of mobile phone s during pregnancy. Retrospective exposure assessment (DNBC and ABCD) or prospective exposure assessment (INMA and MOCEH) were used.	Phone time recorded in minutes per day.	Fetal growth, assessed using a personalized AUDIPOG score (growth restriction at birth, defined by an AUDIPOG score ≤ 10th percentile at birth)	**AUDIPOG score ≤10th percentile- Adjusted OR (95% C.I.)**	**P-value**			Socio-professional category variables of the mother likely to influence phone time, smoking, alcohol consumption, history of diabetes or high blood pressure, gestational diabetes, gestational hypertension, and potential confounding factors.	Adequate/ positive
			Phone time (min/day)							
			0-5		1.00 (ref.)					
			5-15		0.98 (0.58-1.65)	0.9423				
			15-30		1.68 (0.99-2.82)	0.0508				
			≥30		**1.54 (1.03-2.31)**	**0.0374**				

Table 18 (summary tables 12-17) - Collected data for epidemiological studies on reproductive/ developmental effects (FR1: 450-6000 MHz)

Total studies	26				
Adequate studies	16				
Type of study	**Observed Effect**	**Total* adequate studies**	**Positive studies**	**Equivocal studies**	**Negative studies**
Reproductive- man fertility	Decline in semen quality	6	6		
Developmental- mother-offspring effects	Miscarriage	2	2		
	Preterm/post-term birth, foetal growth; chromosomal anomalies	8	2	2	4
	Language/communication/ behavioural /cognitive problems	4		2	2

*Some of the studies include more than one outcome.

SUMMARY OF THE COLLECTED DATA FOR EPIDEMIOLOGICAL STUDIES ON REPRODUCTIVE/DEVELOPMENTAL EFFECTS (FR1: 450 to 6000 MHZ) (Table 18)

The epidemiological evidence on possible associations of exposure to RF-EMF with reproductive developmental effects comes from studies of diverse design that have assessed a range of sources of exposure: the populations included people exposed in occupational settings, people exposed through sources in the general environment, e.g. radio-base stations, and people exposed through use of wireless (mobile and cordless) telephones.

In chapter 4 (Limitations) of the present document, general methodological concerns related to the assessment of individual studies are covered. The total number of epidemiological studies selected for the present review for FR1, was 26. After further deep analyses of the 26 original papers, 16 studies proved to be adequate on the basis of exposure assessment, sample size and appropriateness of confounding analyses.

Decline in semen quality, risk of miscarriage, pre-term/post-term birth, foetal growth, language/communication/ behavioural /cognitive problems were analysed in the 16 adequate studies for a possible association with exposure to RF-EMF, related to the use of mobile phone or to environmental/occupational exposure to emissions from radiobase stations. With reference to the numbers given to the studies in the respective abstracts and tables, the association of the different adverse effects to RF-EMF exposure is:

Decline in semen quality: out of 6 adequate studies regarding this outcome, all showed a positive association with RF-EMF exposure (Ref: 2, 3, 5, 7, 11, 12).

Miscarriage: both of the 2 adequate studies regarding this outcome, showed a positive association with RF-EMF exposure (Ref: 13, 14).

Pre-term/post-term birth, foetal growth: out of 8 adequate studies regarding these outcomes, 2 showed a positive association with RF-EMF exposure (Ref: 15, 26), 2 equivocal association /Ref: 24,25) whilewhile 4 were negative (Ref: 19, 20, 21, 23).

Language/communication/ behavioural /cognitive problems: out of 4 adequate studies, 2 showed equivocal evidence of association to RF-EMF exposure (Ref: 20, 24) and 2 were negative (Ref: 21, 23).

We can conclude as follows:

FR1: 450 to 6000 MHZ:

There is sufficient evidence of adverse effects on fertility in man.

There is limited evidence of adverse effects on fertility in woman.

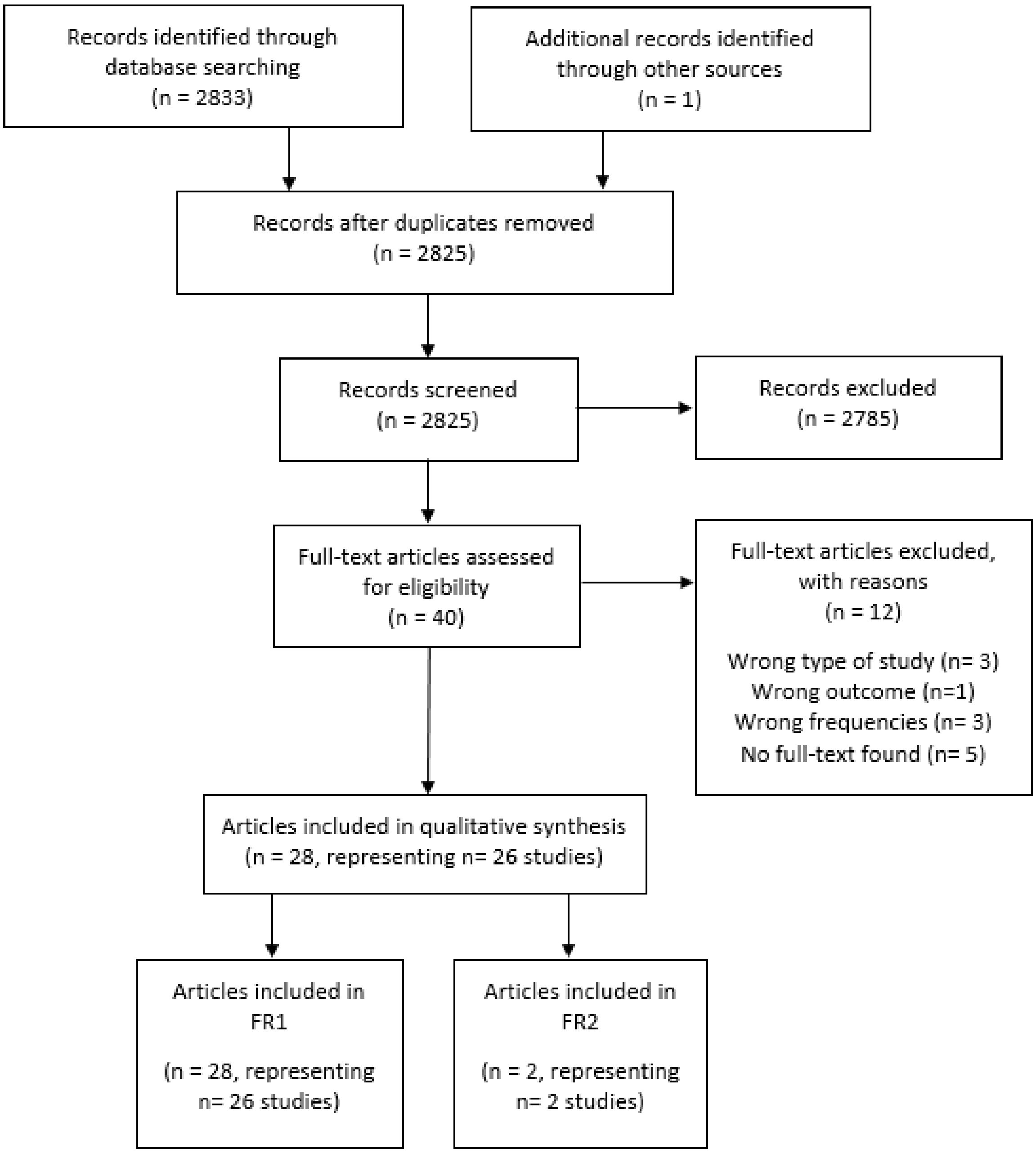
There is limited evidence for adverse effects in pregnant women and their offspring for all developmental end-point examined.

4.2.2 Reproductive/developmental effects in epidemiological studies: Studies evaluating health effects due to RF at a higher frequency range (FR2: 24 to 100 GHz, MMW).

The articles identified through database searching and other sources were 2834. After removing duplicates (9) and excluding non-pertinent articles (2785) based on title and abstracts, 40 articles remained. Based on full-text screening, 12 papers were further excluded, so that the published articles with frequencies appropriate for inclusion in this qualitative synthesis were 28, corresponding to 26 studies. Two papers were published reporting information on the same study (Fig. 14).

At this stage, a selection based on frequency range was also performed: 28 papers/26 studies referred to exposures belonging to the FR1 range, and 2 referred to FR2 as well. These papers reported exposures suitable for both FR1 and FR2, so they don't add up to the overall number of studies included; they are reported twice, once in each frequency range with related outcome.

Figure 14 – Flow diagram. Epidemiological studies on reproductive/developmental effects FR2



MALE FERTILITY

Cross-sectional studies (Table 19 a,b)

1. Baste et al., 2008.

Norway. 2002-2004. Case-control study , occupational exposure.

The authors performed a cross-sectional study among military men employed in the Royal Norwegian Navy, including information about work close to equipment emitting radiofrequency electromagnetic fields, one-year infertility, children and sex of the offspring. Among 10,497 respondents, 22% had worked close to high-frequency aerials to a ''high'' or ''very high'' degree. Infertility increased significantly along with increasing self-reported exposure to radiofrequency electromagnetic fields. In a logistic regression, the odds ratio (OR) for infertility among those who had worked closer than 10 m from high-frequency aerials to a ''very high'' degree relative to those who reported no work near high-frequency aerials was 1.86 (95% confidenceinterval (CI): 1.46–2.37), adjusted for age, smoking habits, alcohol consumption and exposure to organic solvents, welding and lead. Similar adjusted OR for those exposed to a ''high'', ''some'' and ''low'' degree were 1.93 (95% CI: 1.55–2.40), 1.52 (95% CI: 1.25–1.84), and 1.39 (95% CI: 1.15–1.68), respectively. In all age groups there were significant linear trends with higher prevalence of involuntary childlessness with higher self-reported exposure to radiofrequency fields. However, the degree of exposure to radiofrequency radiation and the number of children were not associated. For self-reported exposure both to high-frequency aerials and communication equipment there were significant linear trends with a lower ratio of boys to girls at birth when the father reported a higher degree of radiofrequency electromagnetic exposure.

Comment*: *Self-reported level of exposure. Higher degree of RF-EMF exposure associated to infertility and a lower ratio of boys to girls at birth.

2. Mollerlekken and Moen, 2008.

Norway. 2002. Case-control study, occupational exposure.

The aim of this study was to examine the relationship between workers exposed to electromagnetic fields and their reproductive health. We obtained data using a questionnaire in a cross-sectional study of naval military men, response rate 63% (n¼1487). The respondents were asked about exposure, lifestyle, reproductive health, previous diseases, work and education. An expert group categorized the work categories related to electromagnetic field exposure. We categorized the work categories ''tele/communication,'' ''electronics'' and ''radar/sonar'' as being exposed to electromagnetic fields. Logistic regression adjusted for age, ever smoked, military education, and physical exercise at work showed increased risk of infertility among tele/ communication odds ratio (OR≤1.72, 95% confidence interval 1.04–2.85), and radar/sonar odds ratio (OR≤2.28, 95% confidence interval 1.27–4.09). The electronics group had no increased risk. This study shows a possible relationship between exposure to radiofrequency fields during work with radiofrequency equipment and radar and reduced fertility. However, the results must be interpreted with caution.

Comment*: *Self-reported exposure. Possible increased risk of infertility among telecommunication and radar/sonar operators.

Table 19 - Reproductive/developmental effects in humans: man fertility, epidemiologic case-control studies (24-100 GHz)(a)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)		Any Other Co-Exposure/adjustments	Comments
1. Baste et al., 2008. Norway. 2002-2004. Case-control study	9925 current and former male military employees in the Royal Norwegian Navy, defined by the military employment list (M); mean age 49.	High-frequency aerials, communication equipment, radar. Self-assessed occupational exposure and age categories assessed by mail questionnaire.	Exposure to radiofrequency electromagnetic fields: work closer than 10 m from high-frequency aerials, work closer than 3 m from communication equipment and work closer than 5 m from radar.	Infertility. Odds ratios and 95% CI from adjusted logistic regression models; Mantel–Haenszel test for linear trend.	**Total Infertility - <5 m from radar, OR (95% CI)**	**Test for linear trend (Mantel–Haenszel chi-square)**	Infertility. Odds ratios and 95% CI from adjusted logistic regression models; Mantel–Haenszel test for linear trend.	**Adequate/ Positive for man infertility**
			Age <29					
			Not exposed					
			Low		1.00 (ref.)	0.001		
			Some		0.87 (0.25–2.99)			
			High		2.13 (0.64–7.06)			
			Very high		1.11 (0.20–6.00)			
			Age 30-39		5.09 (1.59–16.30)			
			Not exposed					
			Low		1.00 (ref.)	0.005		
			Some		1.46 (0.99–2.15)			
			High		1.32 (0.87–2.02)			
			Very high		1.79 (1.14–2.82)			
			Age 40-49		1.91 (1.19–3.07)			
			Not exposed					
			Low		1.00 (ref.)	0.002		
			Some		1.22 (0.87–1.71)			
			High		1.24 (0.87–1.79)			
			Very high		1.59 (1.05–2.41)			
			Age >50		1.50 (0.95–2.35)			
			Not exposed					
			Low		1.00 (ref.)	0.001		
			Some		1.11 (0.84–1.46)			
			High		1.58 (1.20–2.09)			
			Very high		1.39 (0.98–1.97)			

Table 19 - Reproductive/developmental effects in humans: man fertility, epidemiologic case-control studies (24-100 GHz)(continued b)

Study information	Population	Type of Exposure and assessment method	Exposure category or level	Health Outcome and measure	Risk estimate (95% CI)					Any Other Co-Exposure/adjustments	Comments
2. Møllerløkken et al., 2008. Norway. 2002. Case-control study.	2265 (M) employees who were currently serving in the Navy, both military and civilians. Mean age of 36 years of age, range 20–62.	Occupational exposure from military communication equipment. Information on occupational history from mail questionnaire. An expert group determined work categories related to electromagnetic field exposure.	Workers in the radar/sonar-, the tele/communication, electronics, other jobs (unexposed).	Infertility, Biological Children, Anomalies, Chromosomal Errors, Preterm and Stillbirths or Infant Deaths. Incidence of outcome by exposure group (%); Chi2 or Fisher Exact Tests to assess significance of differences among groups.	**Infertility - % (p-value from Chi2 tests)**	**Having biological children - % (p-value from Chi2 tests)**	**Children with anomalies or chromosomal errors - % (p-value from Chi2 or Fisher's Exact tests)**	**Children with preterm births - % (p-value from Chi2 or Fisher's Exact tests)**	**Stillbirths and infant deaths within 1 year - % (p-value from Fisher's Exact tests)**	Age, ever smoked, military education, and physical exercise at work.	**Adequate/ Positive for male infertility and developmental parameters in offspring**
			Other jobs (unexposed group)		8.6	62.0	3.5	7.9	2.3		
			Radar/sonar workers (radar)		**17.5 (<0.01)**	70.4 (0.10)	7.1 (0.11)	9.1 (0.37)	2.0 (0.61)		

Table 20 (summary tables 19 a,b) – Collected data for epidemiological studies on reproductive/ developmental effects (FR2: 24-100 GHz).

Total studies*	2				
Adequate studies	2				
Type of study	**Observed Effect**	**Total adequate studies**	**Positive results**	**Negative results**	**Equivocal results**
Reproduction- man fertility	Decline in sperm quality	2	2		
Developmental parameters	Children: preterm birth; chromosomal anomalies	1	1		

The epidemiological evidence on possible associations of exposure to RF-EMF with reproductive/ developmental effects comes from studies of diverse design that have assessed a range of sources of exposure. The studied populations for FR2 include people exposed in occupational settings, in particular military employees.

In chapter 4 (Limitations) of the present document, general methodological concerns related to the assessment of individual studies are covered. The total number of epidemiological studies up to 2020, selected for the present review for FR2, was 2, both considered adequate.

SUMMARY OF THE COLLECTED DATA FOR EPIDEMIOLOGICAL STUDIES ON REPRODUCTIVE/DEVELOPMENTAL EFFECTS (FR2: 24-100 GHz) (Table 20)

FR2 (24-100 GHz)

The two analysed studies on FR2 have limits in exposure assessment, so the real RF/ EMFs levels of exposure are uncertain. However, both studies show *sufficient* evidence of adverse effects on male fertility (Ref: 1, 2).

Limited evidence of developmental effects in offspring of exposed military workers is shown in one of the study (Ref: 2).

However, due to the small number of adequate studies available and the uncertainty about exposure assessment, these results do not allow to confirm or denie an association between exposure to FR2 and reproductive developmental outcome (*not classifiable*).

4.2.3 Reproductive/developmental effects in experimental animals: Studies evaluating health effects due to RF at a lower frequency range (FR1: 450 to 6000 MHZ), which also includes the frequencies used in previous generations' broadband cellular networks (1G, 2G, 3G and 4G).

The articles identified through database searching and other sources were 5052. After removing duplicates (77) and excluding non-pertinent articles (4886) based on title and abstracts, 89 articles remained. Based on full-text screening, 43 papers were further excluded, so that the published articles with appropriate frequencies for the inclusion in this qualitative synthesis were 46, corresponding to 39 studies. In three cases, more than one article was published reporting information on the same study for different reproductive/developmental end points (Fig. 15).

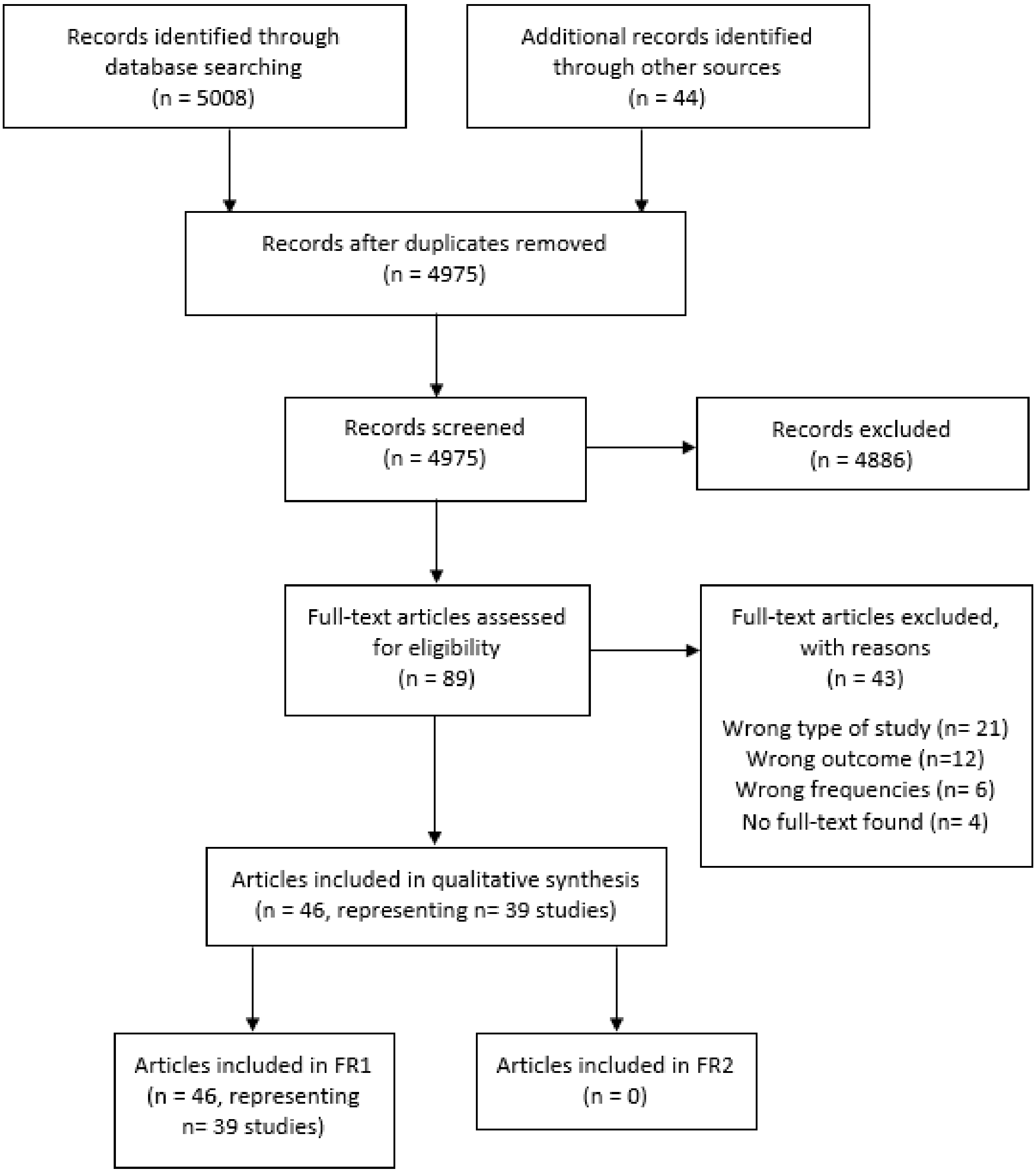
At this stage, a selection based on frequency range was also performed: out of 46 papers/39 studies, all reported exposures to the FR1 range, and none to FR2.

Another selection was based on the guidelines NTP Modified One Generation Study and OECD 443 from 2014 (Foster et al., 2014), which are globally recognised as the gold standard for the planning, conduct and monitoring of experimental bioassays on animals (rodents), aimed at finding effects on developmental pathology, endocrine disruptors, female reproduction, male reproduction, and effects on the reproductive system.

The guideline study design envisages at least 10 animals/sex/group in order to produce statistically robust results. Following this assumption, the papers were distributed by type of study, i.e., male reproduction, female reproduction, developmental pathology.

For each study, the abstract is reported, together with tables summarising the salient information; a senior expert evaluated their adequacy for assessing reproductive and developmental effects (adequate/inadequate), and expressed an overall synthesis of the results (positive/negative/equivocal), following the criteria described in the methodology section.

Figure 15 – Flow diagram. Reproductive/developmental effects in experimental animals FR1



REPRODUCTIVE TOXICITY

Male Mice (Tables 21, a, b)

1. Mugunthan et al., 2012.
   India. Mice. Reproductive toxicity.

Mice (n=18) were exposed to 2G ultra-high frequency radiation, 48 minutes per day for a period of 30 to 180 days. The amount of electromagnetic field (EMF) exposed was calculated by the radiation frequency meter. Eighteen mice were exposed to 900-1900 MHz frequency radiation emitted from 2G cell phone and eighteen mice were sham control. The sham control mice (n=18) were exposed to similar conditions without 2G exposure. Each animal's weight was recorded before sacrifice. Three animals each were sacrificed at the end of 30, 60, 90,120,150 and 180 days of exposure in the experimental group after 24 hours of last exposure. Same numbers of control animals were sacrificed on similar period. We collected blood samples to measure plasma testosterone. We measured and analyzed the size, weight and volume of the testis. Testis sections were analysed under the light microscope for structural changes. Results: In 2G exposed group animal weight was lower at first, second and fourth month (p value ≤0.05). The mean testis weight of 2G exposed mice was significantly reduced in all months except fourth month (p value <0.05) and the mean testis volume was significantly reduced in the first three months (p value 0.02). The mean seminiferous tubule density per unit area was significantly lower (p value <0.001) in the 2G exposed testis. The mean seminiferous tubule diameter was significantly reduced in 2G exposed testis (p value is highly significant <0.001) except the second month. The mean number of Sertoli cells and Leydig cells were significantly reduced in 2G radiation exposed mice (p value is highly significant <0.001). While compared with control group, mean serum testosterone level of 2G exposed mice were significantly lower (p value 0.004). The following microscopic changes were found in the testis of 2G cell phone radiation exposed mice. 1. The interstitium appeared wide 2. Sertoli cells and spermatogonia were detached from the basal lamina. 3. Vacuolar degeneration and desquamation of seminiferous epithelium. Most of the peripheral tubules showed maturation arrest in the spermatogenesis. Seminiferous tubules scored between 8 and 9 using Johnson testicular biopsy score count. Chronic exposure to ultra-high frequency radiation emitted from a 2G cell phone could cause microscopic changes in the seminiferous tubules, reduction in the number of Sertoli and Leydig cells and decreased serum testosterone level. Long term use of cell phones could cause male infertility.

Comment*: *Adequate/positive.

2. Shahin et al., 2014**.**
   India. Swiss mice (M). Reproductive toxicity.

Twelve-week-old mice were exposed to non-thermal low-level 2.45-GHz MW radiation (CW for 2/day for 30 days, power density = 0.029812 mW/cm2 and SAR = 0.018 W/Kg). Sperm count and sperm viability test were done as well as vital organs were processed to study different stress parameters. Plasma was used for testosterone and testis for 3b HSD assay. Immunohistochemistry of 3b HSD and nitric oxide synthase (i-NOS) was also performed in testis. We observed that MW irradiation induced a significant decrease in sperm count and sperm viability along with the decrease in seminiferous tubule diameter and degeneration of seminiferous tubules. Reduction in testicular 3b HSD activity and plasma testosterone levels was also noted in the exposed group of mice. Increased expression of testicular i-NOS was observed in the MW-irradiated group of mice. Further, these adverse reproductive effects suggest that chronic exposure to non-ionising MW radiation may lead to infertility via free radical species-mediated pathway.

Comment: Adequate/positive.

3. Zhu et al., 2015.
USA. ICR mice (M, SPF). Reproductive toxicity.

Adult male ICR mice were exposed to continuous wave 900 MHz radiofrequency fields (RF) After 7 days quarantine period, the animals were weighed (20 ± 2 gm) and randomized into three sep-arate groups of 10 mice each for different exposures.a. Continuous wave 900 MHzRf at 1.6 mW/cm2power intensity, 4 h/day for 15days. b. Sham exposure withoutRFtransmission (control mice. c. An acute dose of 2 Gy $_{\gamma}$-radiation (GR, positive controls). At the end of exposure, each mouse was caged with 3 mature virgin female mice for mating. After 7days, each male mouse was transferred to a fresh cage and mated with a second batch of 3 females. This process was repeated for a total of 4 consecutive weeks. Sham exposed male mice and those subjected to an acute 2 Gy -irradiation (GR) were handled similarly and used as un-exposed and positive controls,respectively. All females were sacrificed on the 18th day of gestation and presumptive mating and, the contents in their uteri were examined. The overall observations during the 4 weeks of mating indicated that the unexposed female mice mated to RF-exposed male mice showed no significant differences in the percentage of pregnancies, total implants, live implants and dead implants when compared with those mated with sham-exposed mice. In contrast, female mice mated with GR-exposed males showed a consistent pattern of significant differences in the above indices in each and all 4 weeks of mating. Thus, the data indicated an absence of mutagenic potential of RF exposure in the germ cells of male mice.

Comment*: *Adequate/negative.

4. Pandey et al., 2017.
India. Swiss mice (M). Reproductive toxicity.

Swiss albino mice were exposed to RFR (900 MHz) for 4 h and 8 h duration per day for 35 days. One group of animals was terminated after the exposure period, while others were kept for an additional 35 days post-exposure. RFR exposure caused depolarisation of mitochondrial membranes resulting in destabilized cellular redox homeostasis. Statistically significant increases in the damage index in germ cells and sperm head defects were noted in RFR-exposed animals. Flow cytometric estimation of germ cell subtypes in mice testis revealed 2.5-fold increases in spermatogonial populations with significant decreases in spermatids. Almost fourfold reduction in spermatogonia to spermatid turnover (1C:2C) and three times reduction in primary spermatocyte to spermatid turnover (1C:4C) was found indicating arrest in the premeiotic stage of spermatogenesis, which resulted in loss of post-meiotic germ cells apparent from testis histology and low sperm count in RFR-exposed animals. Histological alterations such as sloughing of immature germ cells into the seminiferous tubule lumen, epithelium depletion and maturation arrest were also observed. However, all these changes showed recovery to varied degrees following the post-exposure period indicating that the adverse effects of RFR on mice germ cells are detrimental but reversible. To conclude, RFR exposure-induced oxidative stress causes DNA damage in germ cells, which alters cell cycle progression leading to low sperm count in mice.

Comment: adequate/positive.

5. Pandey et al., 2018.
India. Swiss mice (M). Reproductive toxicity.

The present study investigated the effect of RFR Global System for Mobile communication (GSM) type, 900 MHz and melatonin supplementation on germ cell development during spermatogenesis. Swiss albino mice were divided into four groups. One group received RFR exposure for 3 h twice/day for 35 days and the other group received the same exposure but with melatonin (N-acetyl-5-methoxytryptamine) (MEL; 5 mg/kg bw/day). Two other groups received only MEL or remain unexposed. Sperm head abnormality, total sperm count, biochemical assay for lipid peroxides, reduced glutathione, superoxide dismutase activity and testis histology were evaluated. Additionally, flow cytometric evaluation of germ cell subtypes and comet assay were performed in testis. Extensive DNA damage in germ cells of RFR-exposed animals along with arrest in pre-meiotic stages of spermatogenesis eventually leading to low sperm count and sperm head abnormalities were observed. Furthermore, biochemical assays revealed excess free radical generation resulting in histological and morphological changes in testis and germ cells morphology, respectively. However, these effects were either diminished or absent in RFR-exposed animals supplemented with melatonin. Hence, it can be concluded that melatonin inhibits pre-meiotic spermatogenesis arrest in male germ cells through its anti-oxidative potential and ability to improve DNA reparative pathways, leading to normal sperm count and sperm morphology in RFR-exposed animals.

Comment*: *Adequate/positive (group treated without any supplement of melatonine).

6. Shahin et al., 2018.

India. Swiss mice. Reproductive toxicity.

The aim of present study was to investigate the underlying detailed pathway of the testicular apoptosis induced by free radical load and redox imbalance due to 2.45 GHz MW radiation exposure and the degree of severity along with the increased exposure duration. Twelve-week old male mice were exposed to 2.45 GHz MW radiation [continuous-wave (CW) with overall average Power density of 0.0248 mW/cm2 and overall average whole body SAR value of 0.0146 W/kg] for 2 hr/day over a period of 15, 30, and 60 days. Testicular histology, serum testosterone, ROS, NO, MDA level, activity of antioxidant enzymes, expression of pro-apoptotic proteins (p53 and Bax), anti-apoptotic proteins (Bcl-2 and Bcl-xL), cytochrome-c, inactive/active caspase-3, and uncleaved PARP-1 were evaluated. Findings suggest that 2.45 GHz MW radiation exposure induced testicular redox imbalance not only leads to enhanced testicular apoptosis via p53 dependent Bax-caspase-3 mediated pathway, but also increases the degree of apoptotic severity in a duration dependent manner.

Comment*: *Adequate/positive.

Female mice (Table 22, a)

7. Gul et al., 2009.

Turkey. Rats (F). Reproductive toxicity.

The aim of this study was to investigate whether there were any toxic effects of microwaves of cellular phones on ovaries in rats. In this study, 82 female pups of rats, aged 21 days (43 in the study group and 39 in the control group) were used. Pregnant rats in the study group were exposed to mobile phones that were placed beneath the polypropylene cages during the whole period of pregnancy. The cage was free from all kinds of materials, which could affect electromagnetic fields. A mobile phone in a standby position for 11 h and 45 min was turned on to speech position for 15 min every 12 h and the battery was charged continuously. On the 21st day after the delivery, the female rat pups were killed and the right ovaries were removed. The volumes of the ovaries were measured and the number of follicles in every tenth section was counted. The analysis revealed that in the study group, the number of follicles was lower than that in the control group. The decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries. We suggest that the microwaves of mobile phones might decrease the number of follicles in rats by several known and, no doubt, countless unknown mechanisms.

Comment*: *Adequate/equivocal.

8. Shahin et al., 2017.

India. Swiss mice (F). Reproductive toxicity.

The present study investigated the long-term effects of mobile phone (1800 MHz) radiation in stand-by, dialing and receiving modes on the female reproductive function (ovarian and uterine histo-architecture, andsteroidogenesis) and stress responses (oxidative and nitrosative stress). We observed that mobile phone radiation induces significant elevation in ROS, NO, lipid peroxidation, total carbonyl content and serum corticosterone coupled with significant decrease in antioxidant enzymes in hypothalamus, ovary and uterus of mice. Compared to control group, exposed mice exhibited reduced number of developing and mature follicles as well as corpus lutea. Significantly decreased serum levels of pituitary gonadotrophins(LH, FSH), sex steroids (E2 and P4) and expression of SF-1, StAR, P-450scc, 3beta-HSD, 17beta-HSD, cytochromeP-450 aromatase, ER-alfa and ER-beta were observed in all the exposed groups of mice, compared to control.These findings suggest that mobile phone radiation induces oxidative and nitrosative stress, which affects the reproductive performance of female mice.

Comment*: *Adequate/positive.

Male Rats (Tables 23, a-c)

9. Ozguner et al., 2005.

China. Sprague-Dawley rats (M). Reproductive toxicity.

The aim of this experimental study was to determine the biological and morphological effects of 900 MHz radiofrequency (RF) EMF on rat testes. The study was performed in the Physiology and Histology Research Laboratories of Süleyman Demirel University, Faculty of Medicine, Isparta, Turkey in May 2004. Twenty adult male Sprague-Dawley rats weighing 270 - 320 gm were randomized into 2 groups of 10 animals: Group I (control group) was not exposed to EMF and Group II (EMF group) was exposed to 30 minutes per day, 5 days a week for 4 weeks to 900 MHz EMF. Testes tissues were submitted for histologic and morphologic examination. Testicular biopsy score count and the percentage of interstitial tissue to the entire testicular tissue were registered. Serum testosterone, plasma luteinising hormone (LH) and follicle stimulating hormone (FSH) levels were assayed biochemically. Results: The weight of testes, testicular biopsy score count and the percentage of interstitial tissue to the entire testicular tissue were not significantly different in EMF group compared to the control group. However, the diameter of the seminiferous tubules and the mean height of the germinal epithelium were significantly decreased in EMF group ($p<0.05$). There was a significant decrease in serum total testosterone level in EMF group ($p<0.05$). Therefore, there was an insignificant decrease in plasma LH and FSH levels in EMF group compared to the control group ($p>0.05$). The biological and morphological effects resulting from 900 MHz RF EMF exposure lends no support to suggestions of adverse effect on spermatogenesis, and on germinal epithelium. Therefore, testicular morphologic alterations may possibly be due to hormonal changes.

Comment*: *Adequate/positive.

10. Lee et al., 2010.

Korea. Sprague Dawley rats (M). Reproductive toxicity.

We examined the histological changes by radiofrequency (RF) fields on rat testis, specifically with respect to sensitive processes such as spermatogenesis. Male rats (20 x group) were exposed to 848.5 MHz RF for 12 weeks. The RF exposure schedule consisted of two 45-min RF exposure periods, separated by a 15-min interval. The whole-body average specific absorption rate (SAR) of RF was 2.0 W/kg. We then investigated correlates of testicular function such as sperm counts in the cauda epididymis, malondialdehyde concentrations in the testes and epididymis, frequency of spermatogenesis stages, germ cell counts, and appearance of apoptotic cells in the testes. We also performed p53, bcl-2, caspase 3, p21, and PARP immunoblotting of the testes in sham- and RF-exposed animals. Based on these results, we concluded that subchronic exposure to 848.5 MHz with 2.0 W/kg SAR RF did not have any observable adverse effects on rat spermatogenesis.

Comment*: *Adequate/negative.

11. Imai et al., 2011.

Japan. Sprague-Dawley rats (M). Reproductive toxicity.

In recent years concern has arisen whether carrying a cellular phone near the reproductive organs such as the testes may cause dysfunction and particularly decrease in sperm development and production, and thus fertility in men. The present study was performed to investigate the effects of a 1.95 GHz electromagnetic field on testicular function in male Sprague-Dawley rats. Five week old animals were divided into 3 groups of 24 each and a 1.95-GHz wide-band code division multiple access (W-CDMA) signal, which is used for the freedom of mobile multimedia access (FOMA), was employed for whole body exposure for 5 hours per day, 7 days a week for 5 weeks (the period from the age of 5 to 10 weeks, corresponding to reproductive maturation in the rat). Whole-body average specific absorption rates (SAR) for individuals were designed to be 0.4 and 0.08 W/kg respectively. The control group received sham exposure. There were no differences in body weight gain or weights of the testis, epididymis, seminal vesicles, and prostate among the groups. The number of sperm in the testis and epididymis were not decreased in the electromagnetic field (EMF) exposed groups, and, in fact, the testicular sperm count was significantly increased with the 0.4 SAR. Abnormalities of sperm motility or morphology and the histological appearance of seminiferous tubules, including the stage of the spermatogenic cycle, were not observed. Thus, under the present exposure conditions, no testicular toxicity was evident.

Comment*: *Adequate/negative.

12. Meo et al., 2011.

Saudi Arabia. Wistar rats. Reproductive toxicity.

Forty male Wistar albino rats were divided in three groups. First group of eight served as the control. The second group [group B, n=16] was exposed to mobile phone radiation for 30 minutes/day and the third group [group C, n=16] was exposed to mobile phone radiation for 60 minutes/day for a total period of 3 months. Morphological changes in the testes induced by mobile phone radiations were observed under a light microscope. Exposure to mobile phone radiation for 60 minutes/day caused 18.75% hypospermatogenesis and 18.75% maturation arrest in the testis of albino rats compared to matched controls. However, no abnormal findings were observed in albino rats that were exposed to mobile phone radiation for 30 minutes/day for a total period of 3 months. Long-term exposure to mobile phone radiation can cause hypospermatogenesis and maturation arrest in the spermatozoa in the testis of Wistar albino rats.

Comment*: *Adequate (smaller no. of animals as controls)/equivocal.

13. Al-Damegh, 2012.

Saudi Arabia. Wistar rats (M). Reproductive toxicity.

The aim of this study was to investigate the possible effects of electromagnetic radiation from conventional cellular phone use on the oxidant and antioxidant status in rat blood and testicular tissue and determine the possible protective role of vitamins C and E in preventing the detrimental effects of electromagnetic radiation on the testes. The study population comprised 120 male Wistar albino rats, distributed at least 10xgroup. The treatment groups were exposed to an electromagnetic field, electromagnetic field plus vitamin C (40 mg/kg/day) or electromagnetic field plus vitamin E (2.7 mg/kg/day). All groups were exposed to the same electromagnetic frequency for 15, 30, and 60 min daily for two weeks. There was a significant increase in the diameter of the seminiferous tubules with a disorganized seminiferous tubule sperm cycle interruption in the electromagnetism-exposed group. The serum and testicular tissue conjugated diene, lipid hydroperoxide, and catalase activities increased 3-fold, whereas the total serum and testicular tissue glutathione and glutathione peroxidase levels decreased 3-5 fold in the electromagnetism-exposed animals. Results indicate that the adverse effect of the generated electromagnetic frequency had a negative impact on testicular architecture and enzymatic activity. This finding also indicated the possible role of vitamins C and E in mitigating the oxidative stress imposed on the testes and restoring normality to the testes.

Comment*: *Adequate/positive.

14. Celik et al., 2012.

Turkey. Wistar rats (M). Reproductive toxicity.

Wistar-Kyoto male rats were placed into either a control group or a group that was exposed to an electromagnetic field (EMF). Two cell phones with Specific Absorbation Rate values of 1.58 were placed and left off in cages that housed 15 rats included in the control group, and four cell phones were placed and left on in cages that housed 30 rats included in the experimental group. After 3 months, weights, seminiferous tubule diameters, and spermatogenic cell conditions of all testes of the rats were evaluated. One half of each testis was examined also under an electron microscope. No significant differences were observed between the testis weights, seminiferous tubule diameters, and histopathological evaluations between rats that had and had not been exposed to EMF. Electron microscope analysis revealed that the membrana propria thickness and the collagen fiber contents were increased and the capillary veins extended in the experimental group. Common vacuolisation in the cytoplasm of the Sertoli cells, growth of electron-dense structures, and existence of large lipid droplets were noted as the remarkable findings of this study. Although the cells that had been exposed to long-term, low-dose EMF did not present any findings that were contrary to the control conditions, the changes observed during ultrastructural examination gave the impression that significant changes may occur if the study period were to be extended. Longer studies are needed to better understand the effects of EMFs on testis tissue.

Comment: Adequate/negative.

15. Lee et al., 2012.

Korea. Sprague Dawley rats (M). Reproductive toxicity.

The effects of combined exposure to radiofrequency electromagnetic fields (RF-EMF) on rat testicular function, specifically with respect to sensitive processes such as spermatogenesis were examined. Male rats (20 x group) were exposed to single code division multiple access (CDMA) and wideband code division multiple access (WCDMA) RF signals for 12 weeks. The RF exposure schedule comprised 45 min/day, 5 days/week for a total of 12 weeks. The whole-body average specific absorption rate (SAR) of CDMA and WCDMA was 2.0 W/kg each or 4.0 W/kg in total. The correlates of testicular function such as sperm count in the cauda epididymis, testosterone concentration in the blood serum, malondialdehyde concentrations in the testes and epididymis, frequency of spermatogenesis stages, and appearance of apoptotic cells in the testes were investigated. Immunoblot for p53, bcl2, GADD45, cyclin G, and HSP70 in the testes of sham- and combined RF-exposed animals were performed. Based on the results, we concluded that simultaneous exposure to CDMA and WCDMA RF-EMFs at 4.0 W/kg SAR did not have any observable adverse effects on rat spermatogenesis.

Comment: Adequate/negative.

16. Ozlem-Nisbet et al., 2012.

Turkey. Wistar rats (M). Reproductive toxicity.

Male albino Wistar rats (2 days old) were exposed toexposure on reproduction in growing male rats. Male albino Wistar rats (2 days old) were exposed to EMF 1800 and 900 MHz for 2 h continuously per day for 90 days. Sham control was kept under similar conditions except that the field was not applied for the same period. After blood samples were collected, the animals were sacrificed 24 h after the last exposure and the tissues of interest were harvested. The mean plasma total testosterone showed similarity among the two study groups and was significantly higher than the sham control rats. The percentage of epididymal sperm motility was significantly higher in the 1800 MHz group ($P < 0.05$). The morphologically normal spermatozoa rates were higher and the tail abnormality and total percentage abnormalities were lower in the 900 MHz group ($P < 0.05$). Histopathologic parameters in the 1800 MHz group were significantly higher ($P < 0.05$). In conclusion, the present study indicated that exposure to electromagnetic wave caused an increase in testosterone level, epididymal sperm motility (forward), and normal sperm morphology of rats. As a consequences, 1800 and 900 MHz EMF could be considered to be a cause of precocious puberty in growing rats.

Comment: Adequate/positive.

17. Bin-Meferijand El-kott, 2015.
 Saudi Arabia. Sprague Dawley rats (M). Reproductive toxicity.

The purpose of this study was to explore the capability of polyphenolic-rich Moringa oleifera leaf extract inprotecting rat testis against EMR-induced impairments based on evaluation of sperm count, viability, motility, sperm cell morphology, anti-oxidants (SOD and CAT), oxidative stress marker, testis tissue histopathology and PCNA immunohistochemistry. The sample consisted of sixty male Wistar rats which were divided into four equal groups. The first group (the control) received only standard diet while the second group was supplemented daily and for eight weeks with 200 mg/kg aqueous extract of Moringa leaves. The third group was exposed to 900 MHz fields for one hour a day and for (7) days a week. As for the fourth group, it was exposed to mobile phone radiation and received the Moringa extract. The results showed that the EMR treated group exhibited a significantly decrease sperm parameters. Furthermore, concurrent exposure to EMR and treated with MOE significantly enhanced the sperm parameters. However, histological results in EMR group showed irregular seminiferous tubules, few spermatogonia, giant multinucleated cells, degenerated spermatozoa and the number of Leydig cells was significantly reduced. PCNA labelling indices were significant in EMR group versus the control group. Also, EMR affects spermatogenesis and causes to apoptosis due to the heat and other stress-related EMR in testis tissue. This study concludes that chronic exposure to EMR marked testicular injury which can be prevented by Moringa oleifera leaf extract.

Comment*: *Adequate/positive.

18. Liu et al., 2015.
 China. Sprague-Dawley rats (M) .Reproductive toxicity.

Twenty four rats were exposed to 900 MHz electromagnetic radiation with a special absorption rate of 0.66 ± 0.01 W/kg for 2 h/d. After 50d, the sperm count, morphology, apoptosis, reactive oxygen species (ROS), and total antioxidant capacity (TAC), representing the sum of enzymatic and nonenzymatic antioxidants, were investigated. Western blotting and reverse transcriptase PCR were used to determine the expression levels of apoptosis-related proteins and genes, including bcl-2, bax, cytochrome c, and capase-3. Results: In the present study, the percentage of apoptotic sperm cells in the exposure group was significantly increased by 91.42 % compared with the control group. Moreover, the ROS concentration in exposure group was increased by 46.21 %, while the TAC was decreased by 28.01 %. Radiation also dramatically decreased the protein and mRNA expression of bcl-2 and increased that of bax, cytochrome c, and capase-3. Conclusion: RF-EMR increases the ROS level and decreases TAC in rat sperm. Excessive oxidative stress alters the expression levels of apoptosis-related genes and triggers sperm apoptosis through bcl-2, bax, cytochrome c and caspase-3 signaling pathways.

Comment*: *Adequate/positive.

19. Saygin et al., 2015.
 Turkey. Sprague Dawley rats. Reproductive toxicity.

The aim of this study was to investigate electromagnetic radiation (EMR) transmitted by wireless devices (2.45 GHz), which may cause physiopathological or ultrastructural changes, in the testes of rats. We addressed if the supplemental gallic acid (GA) may reduce these adverse effects. Six-week-old male Sprague Dawley rats were used in this study. Forty eight rats were equally divided into four groups, which were named: Sham, EMR only (EMR, 3 h day21 for 30 days), EMR1GA (30 mg/kg/daily), and GA (30 mg/kg/daily) groups. Malondialdehyde (MDA) and total oxidant status (TOS) levels increased (p50.001 for both) in EMR only group. TOS and oxidative stress index (OSI) levels decreased in GA treated group significantly (p50.001 and p50.045, respectively). Total antioxidant status (TAS) activities decreased in EMR only group and increased in GA treatment group (p50.001 and p50.029, respectively). Testosterone and vascular endothelial growth factor (VEGF) levels decreased in EMR only group, but this was not statistically significant. Testosterone and VEGF levels increased in EMR1GA group, compared with EMR only group (p50.002), and also increased in GA group compared with the control and EMR only group (p50.044 and p50.032, respectively). Prostaglandin E2 (PGE2) and calcitonin gene releated peptide (CGRP) staining increased in tubules of the testes in EMR only group (p<0.001 for both) and decreased in tubules of the testes in EMR1GA group (p<0.001 for all parameters). In EMR only group, most of the tubules contained less spermatozoa, and the spermatozoon counts decreased in tubules of the testes. All these findings and the regenerative reaction, characterized by mitotic activity, increased in seminiferous tubules cells of the testes in EMR1GA group (p<0.001). Long term EMR exposure resulted in testicular physiopathology via oxidative damage and inflammation. GA may have ameliorative effects on the prepubertal rat testes physiopathology.

Comment*: *Adequate/positive.

20. Bilgici et al., 2018.

Turkey. Wistar rats (M). Reproductive toxicity.

Inflammatory effect and testicular damage on rats exposed to low level of electromagnetic fields (EMF) at 2.45GHz microwave radiation were investigated. Twenty two Wistar rats were divided into two groups. Group 1 was the control group and not exposed to EMF. Group 2 was exposed to low level EMF (average E-field 3.68 ± 0.36 V/m, whole body average SAR, 0.0233 W/kg, in 10 g tissue) at 2.45GHz for 1 hour/day for 30 consecutive days. At the end of the study, interleukin-6 (IL-6), interleukin-10 (IL-10), interleukin-32 (IL-32), C-reactive protein (CRP) were measured in rat serum and IL-6, IL-10, IL-32 were measured in rat testis tissue.Furthermore, testicular tissues were evaluated histopathologically in terms of spermatogenesis and coagulation necrosis. Serum IL-6 and CRP levels were found to be significantly different in the study group compared to the control group (p<.05), but no significant difference was found in serum IL-10, IL-32 levels and testis tissue IL-6, IL-10, IL-32 levels compared to the control group (p>.05). On the other hand, histopathological evaluation of testicular tissue revealed a significant difference in necrosis and spermatogenesis when compared with the control group (p<.05). It may be concluded that low level EMF at 2.45GHz increases inflammation and testicular damage and negative impact on male reproductive system function.

Comment*: *Adequate/positive.

21. Guo et al., 2019.

China.Sprague-Dawlwy rats. Reproductive toxicity.

Under some occupational conditions, workers are inevitably exposed to high-intensityradiofrequency (RF) fields. In this study, we investigated the effects of one-month exposure to a220 MHz pulsed modulated RF field at the power density of 50 W/m2on the sperm quality in maleadult rats. The sperm quality was evaluated by measuring the number, abnormality and survivalrate of sperm cells. The morphology of testis was examined by hematoxylin–eosin (HE) staining. Thelevels of secreting factors by Sertoli cells (SCs) and Leydig cells (LCs) were determined by enzymelinked immunosorbent assay (ELISA). The level of cleaved caspase 3 in the testis was detected byimmunofluorescence staining. Finally, the expression levels of the apoptosis-related protein (caspase 3,BAX and BCL2) in the testis were assessed by Western blotting. Compared with the sham group, thesperm quality in the RF group decreased significantly. The levels of secreting factors of SCs and themorphology of the testis showed an obvious change after RF exposure. The level of the secretingfactor of LCs decreased significantly after RF exposure. The levels of cleaved caspase 3, caspase 3,and the BAX/BCL2 ratio in the testis increased markedly after RF exposure. These data collectivelysuggested that under the present experimental conditions, 220 MHz pulsed modulated RF exposure could impair sperm quality in rats, and the disruption of the secreting function of LCs and increased apoptosis of testis cells induced by the RF field might be accounted for by this damaging effect.

Comment*: *Adequate/positive.

22. Yu et al., 2020.
China. Sprague Dawley rats. Reproductive toxicity (exp.1 and 2).

The correlation between long-term exposure to SRF-EMR and the decline in male fertility is gradually receiving increasing attention fromthe medical society.While male reproductive organs are often exposed to SRF-EMR, little is currently known about the direct effects of long-termSRF-EMR exposure on the testes and its involvement in the suppression of male reproductive potential. The present study was designed to investigate this issue by using 4G SRF-EMR in rats. A unique exposure model using a 4G smartphone achieved localized exposure to the scrotum of the rats for 6 h each day (the smartphone was kept on active talk mode and received an external call for 1 min over 10min intervals). Results showed that SRF-EMR exposure for 150 days decreased spermquality and pupweight, accompanied by testicular injury. However, these adverse effectswere not evident in rats exposed to SRF-EMR for 50 days or 100 days. Sequencing analysis and western blotting suggested Spock3 overexpression in the testes of rats exposed to SRF-EMR for 150 days. Inhibition of Spock3 overexpression improved sperm quality decline and alleviated testicular injury and BTB disorder in the exposed rats. Additionally, SRF-EMR exposure suppressed MMP2 activity, while increasing the activity of the MMP14–Spock3 complexes and decreasing MMP14–MMP2 complexes; these results were reversed by Spock3 inhibition. Thus, long-term exposure to 4G SRF-EMR diminished male fertility by directly disrupting the Spock3–MMP2–BTB axis in the testes of adult rats. To our knowledge, this is the first study to show direct toxicity of SRF-EMR on the testes emerging after long-term exposure.

***Comment*: *Adequate/positive*.**

DEVELOPMENTAL TOXICITY

Hamsters (Table 24, a)

23. Lerchl 2008a, 2008b, 2008c.
Germany. Djiungarian Hamsters. Developmental toxicity.

In three experiments, adult male Djungarian hamsters (Phodopus sungorus) were exposed 24 hr/day for 60 days to radio frequency electromagnetic fields (RF-EMF) at 383, 900, and 1800 MHz, modulated according to the TETRA (383 MHz) and GSM standards (900 and 1800 MHz), respectively. A radial waveguide system ensured a well defined and uniform exposure at whole-body averaged specific absorption rates of 80 -mW/kg, which is equal to the upper limit of whole-body exposure of the general population in Germany and other countries. For each experiment, using two identical waveguides, hamsters were exposed (n = 120) and sham-exposed (n = 120) in a blind fashion. In all experiments, pineal and serum melatonin levels as well as the weights of testes, brain, kidneys, and liver were not affected. At 383 MHz, exposure resulted in a significant transient increase in body weight up to 4%, while at 900 MHz this body weight increase was more pronounced (up to 6%) and not transient. At 1800 MHz, no effect on body weight was seen. The results corroborate earlier findings which have shown no effects of RF EMF on melatonin levels in vivo and in vitro. The data are in accordance with the hypothesis that absorbed RF energy may result in metabolic changes which eventually cause body weight increases in exposed animals. The data support the notion that metabolic effects of RF-EMFs need to be investigated in more detail in future studies.

Comment: Adequate/negative.

Mice (Table 25, a-c)

24. Finnie et al. a, b (2006, 2009)
 BALB/c mice. Developmental toxicity.

To determine whether whole of gestation exposure of fetal mouse brain to mobile telephone radiofrequency fields produces a stress response detectable by induction of heat shock proteins (HSPs). Using a purpose-designed exposure system at 900 MHz, pregnant mice were given a single, far-field, whole body exposure at a specific absorption rate of 4 W/kg for 60 min/day from day 1 to day 19 of gestation. Control mice were sham-exposed or freely mobile in a cage to control for any stress caused by restraint in the exposure module. Immediately prior to parturition on day 19, fetal brains were collected, fixed in 4% paraformaldehyde and paraffin-embedded. Three coronal sections encompassing a wide range of anatomical regions were cut from each brain and any stress response detected by immunostaining for HSP25, 32 and 70. Results There was no induction of HSP32 or 70 in any brains, while HSP25 expression was limited to two brainstem nuclei and occurred consistently in exposed and non-exposed brains.

Comment*: *Adequate/negative.

25. Lee et al., 2009.

 Korea. ICR mice. Developmental toxicity (teratogenesis).

The murine fetus is a very sensitiveindicator of the effects of stress or stimuli in the environment.Therefore, we investigated the teratogenic effects of multi-signal radiofrequency electromagnetic fields (RF EMFs) on mouse fetuses. Pregnant mice were simultaneously exposed to two types of RF signals, single code division multiple access (CDMA) and wideband code division multiple access (WCDMA). Mice received two 45-min RF-field exposures, separated by a 15-min interval, daily throughout the entire gestation period. The whole-body average specific absorption rate (SAR) of CDMA or WCDMA was 2.0 W/kg. The animals were killed humanely on the 18th day of gestation and fetuses were examined for mortality, growth retardation, changes in head size and other morphological abnormalities. From the results, we report for the first time that simultaneous experimental exposure to CDMA and WCDMA RF EMFs did not cause any observable adverse effects on mouse fetuses.

Comment*: *Adequate (short daily exposure)/negative.

26. Fragopoulou et al., 2010.
 Greece. Balb/c mice. Developmental toxicity.

This study focuses on foetal development following mild daily exposure of pregnant mice to near field electromagnetic radiation emitted by a mobile phone.The investigation was motivated by the fact that the potentially hazardous electromagnetic radiation emitted by mobile phones is currently of tremendous public interest. Physically comparable pregnant mice were exposed to radiofrequency radiation GSM 900MHz emitted by a mobile phone.Within 5 h after birth most cubs were fixed followed by double staining in toto, and conventional paraffin histology. Other cubs remained with their mothers until teeth eruption. Structural development was assessed by examining newborns for the presence of anomalies and/or variations in soft tissues and skeletal anatomy. Electromagnetic radiofrequency exposed newborns, externally examined, displayed a normal phenotype. Histochemical and histological studies, however, revealed variations in the exposed foetuses with respect to control ones concerning the ossification of cranial bones and thoracic cage ribs, as well as displacement of Meckelian cartilage. Littermates examined after teeth eruption displayed normal phenotypes. It is concluded that mild exposure to mobile phone radiation may affect, although transiently, mouse foetal development at the ossification level. The developmental variations observed could be explained by considering the different embryonic origin and mode of ossification of the affected skeletal elements.

Comment*: *Adequate/positive.

27. Sambucci et al., 2011.
Italy. C57BL/6 newborns mice (M and F). Developmental toxicity (immunotoxicology).

The development of the immune system begins during embryogenesis, continues throughout fetal life, and completes its maturation during infancy. Exposure to immune-toxic compounds at levels producing limited/transient effects in adults, results in long-lasting or permanent immune deficits when it occurs during perinatal life. Potentially harmful radiofrequency (RF) exposure has been investigated mainly in adult animals or with cells from adult subjects, with most of the studies showing no effects. Is the developing immune system more susceptible to the effects of RF exposure? To address this question, newborn mice were exposed to WiFi signals at constant specific absorption rates (SAR) of 0.08 or 4 W/kg, 2 h/day, 5 days/week, for 5 consecutive weeks, starting the day after birth. The experiments were performed with a blind procedure using sham-exposed groups as controls. No differences in body weight and development among the groups were found in mice of both sexes. For the immunological analyses, results on female and male newborn mice exposed during early post-natal life did not show any effects on all the investigated parameters with one exception: a reduced IFN-g production in spleen cells from microwaves (MW)-exposed (SAR 4 W/kg) male (not in female) mice compared with sham-exposed mice. Altogether our findings do not support the hypothesis that early post-natal life exposure to WiFi signals induces detrimental effects on the developing immune system.

***Comment**: Adequate/negative, except for reduced IFN-g production in spleen cells from microwaves exposed (SAR 4 W/kg) male (not in female) mice compared with sham-exposed mice.*

28. Zhang et al., 2015.
China. CD1 mice. Developmental toxicity (behavioral study).

The recent rapid development of electronic communication techniques is resulting in a marked increase in exposure of humans to electromagnetic fields (EMFs). This has raised public concerns about the health hazards of long-term environmental EMF exposure for fetuses and children. Some studies have suggested EMF exposure in children could induce nervous system disorders. However, gender-dependent effects of microwave radiation exposure on cognitive dysfunction have not previously been reported. Here we investigated whether in utero exposure to 9.417-GHz microwave throughout gestation (Days 3.5–18) affected behavior, using the open field test (OFT), elevated-plus maze (EPM), tail suspension test (TST), forced swimming test (FST) and Morris water maze (MWM). We found that mice showed less movement in the center of an open field (using the OFT) and in an open arm (using the EPM) after in utero exposure to 9.417-GHz radiation, which suggested that the mice had increased anxiety-related behavior. Mice demonstrated reduced immobility in TST and FST after in utero exposure to 9.417-GHz radiation, which suggested that the mice had decreased depression related behavior. From the MWM test, we observed that male offspring demonstrated decreased learning and memory, while females were not affected in learning and memory, which suggested that microwaves had gender-dependent effects. In summary, we have provided the first experimental evidence of microwaves inducing gender-dependent effects.

***Comment**: Adequate/ positive (gender dependent effects).*

29. Fatehi et al., 2018.
Iran. NMRI-mice. Developmental toxicity.

Two hundred male and female NMRI-mice were used. One hundred males divided in five groups (n = 20) as control and exposed groups. Those irradiated with cell-phone RF in "Standby-mode" 1, 5 and 10 h daily named groups II, III and IV; respectively. Group V irradiated with cell-phone on "Active-mode" one hour daily. After 30 days irradiation, 50 males and 50 females were kept 24 h to assess their embryos. Fifty males were scarified to evaluate both in vitro and in vivo parameters, and 50 females received PMSG and HCG for both quantitative and qualitative evaluation. Comparing groups III, IV and V with control-group showed significantly decreased in the number of two-cell embryos (p = .000); however, a significant increase was found in the number of dead embryos (p = .000). Furthermore, 5 h daily irradiation significantly decreased grade-A embryos (p = .015); while, it significantly increased grade-B, C and D embryos (p-values = 0.026, 0.007, 0.006; respectively). Moreover, comparing groups IV and V to control-group, significant increase was found in pregnancy duration (p = .005, p = .009; respectively). However, in the mentioned groups a significant decrease was seen in number of newborn mice (p = .001, p = .004; respectively). In conclusion, findings showed that the cell-phone radiation can affect development of embryos as well as the number of newborn and pregnancy duration in NMRI-mouse, which might be a significant cause of reproductive failure .

Comment* : *Adequate/positive.

Rats (Table 26, a)

30. Nelson et al., 1991, 1994, 1997, 1997. USA. Sprague-Dawley rats. Developmental toxicity (synergistic effects).

Concurrent exposures to chemical and physical agents occur in the workplace; exposed workers include those involved with microelectronics industry, plastic sealers and electrosurgical units. Previous animal research indicates that hyperthermia induced by an elevation in ambient temperature can potentiate the toxicity and teratogenicity of some chemical agents. We previously demonstrated that combined exposure to radiofrequency (r.f.; 10 MHz) radiation, which also induces hyperthermia and is teratogenic to exposed animals, and the industrial solvent 2-methoxyethanol (2ME) produces enhanced teratogenicity in rats. A subsequent study replicated and extended that research by investigating the interactive dose-related teratogenicity of r.f. radiation (sham exposure or maintaining colonic temperatures at 42.0 degrees C for 0, 10, 20 or 30 min by r.f. radiation absorption) and 2ME (0, 75, 100, 125 or 150 mg/kg) on gestation days 9 or 13 of rats. The purpose of the present research is to determine the effects of r.f. radiation (sufficient to maintain colonic temperatures at 42.0 degrees C for 10 min) on a range of doses of 2ME (0, 20, 40, 60, 80, 100, 120 and 140 mg kg-1) administered on gestation day 13 of rats. Focusing on characterising the dose-response pattern of interactions, this research seeks to determine the lowest interactive effect level. Day 20 fetuses were examined for external and skeletal malformations. The results are consistent with previous observations. Dose-related developmental toxicity was observed for 2ME both in the presence and absence of r.f. radiation. However, concurrent RF radiation exposure changed the shape of the dose-effect curve of 2ME. These data indicate that combined exposure effects should be considered when developing exposure guidelines and intervention strategies.

Comment*: *Inadequate (thermal effects are considered for studying synergistic effects).

31. Nelson et al., 2001.

USA. Sprague-Dawley rats. Developmental toxicity ((synergistic effects).

The purpose of the present research is to investigate if the interactive effects noted for RF radiation and 2ME are unique to these agents, or if similar interactions might be seen with other chemicals. Because methanol is widely used as a solvent as well as fuel additive, and, at high levels, is teratogenic in animals, we selected methanol as a chemical to address generalisability. Based on the literature and our pilot studies, 0, 2, or 3 g/kg methanol (twice, at 6-hour intervals) were administered on gestation day 9 or 13 to groups of 10 Sprague-Dawley rats. Dams treated on day 9 were given methanol and exposed to RF radiation sufficient to maintain colonic temperature at 41 degrees C for 60 minutes (or sham). Those treated on day 13 were given methanol plus either 0 or 100 mg/kg 2ME. Because we observed that methanol produced hypothermia, some groups were given the initial dose of methanol concurrently with the RF or 2ME, and others were given the first dose of methanol 1.5 hours prior to RF or 2ME. Dams were sacrificed on gestation day 20, and the fetuses were examined for external malformations. The results indicate that RF radiation or methanol on day 9 increased the incidence of resorbed fetuses, but no interactive effects were observed. The resorptions were highest in groups given the experimental treatments 1.5 hours apart. The higher dose of methanol also reduced fetal weights. Administration of 2ME or methanol on day 13 increased the rate of malformations, and there was evidence of a positive interaction between 2ME and methanol. Fetal weights were reduced by 2ME and methanol alone, but no interaction was observed. Also, separation of the dosing with the teratogens did not affect the results. These results point out that interactions in developmental toxicology, such as those of RF radiation, 2ME, and methanol that we have studied, are complex, and such interactions cannot be fully understood or predicted without more research. It is important that combined exposure effects be considered when developing both physical agent and chemical agent exposure guidelines and intervention strategies.

Comment*: *Inadequate (thermal effects are considered for studying synergistic effects).

32. Ogawa et al., 2009.

Japan. Sprague-Dawley rats (F), 10 days. Developmental toxicity.

The present study was designed to evaluate whether gestational exposure to an EMF-targeting the head region, similar to that from cellular phones, might affect embryogenesis in rats. A 1.95-GHz wideband code division multiple access (W-CDMA) signal, which is one applied for the International Mobile Telecommunication 2000 (IMT-2000) system and used for the freedom of mobile multimedia access (FOMA), was employed for exposure to the heads of four groups of pregnant CD(SD) IGS rats (20 per group) for gestational days 7–17. The exposure was performed for 90 min/day in the morning. The spatial average specific absorption rate (SAR) for individual brains was designed to be 0.67 and 2.0 W/kg with peak brain SARs of 3.1 and 7.0 W/kg for low (group 3) and high (group 4) exposures, respectively, and a whole-body average SAR less than 0.4 W/kg so as not to cause thermal effects due to temperature elevation. Control and sham exposure groups were also included. At gestational day 20, all dams were killed and fetuses were taken out by cesarean section. There were no differences in maternal body weight gain. No adverse effects of EMF exposure were observed on any reproductive and embryotoxic parameters such as number of live (243–271 fetuses), dead or resorbed embryos, placental weights, sex ratios, weights or external, visceral or skeletal abnormalities of live fetuses.

Comment*: *Adequate/negative.

33. Sommer et al., 2009.

Germany, C57BL mice (M, F). Multi-generation study. Developmental toxicity.

Male and female mice (C57BL) were chronically exposed (life-long, 24 h/day) to mobile phone communication electromagnetic fields at approximately 1966 MHz (UMTS). Their development and fertility were monitored over four generations by investigating histological, physiological, reproductive and behavioral functions. Exposure of 24 h/day, 7 days/week, using 128 M and 256 F over four generations. The mean whole-body SARs, calculated for adult animals at the time of mating, were 0 (sham), 0.08, 0.4 and 1.3 W/kg. Power densities were kept constant for each group (0, 1.35, 6.8 and 22 W/m(2)), resulting in varying SARs due to the different numbers of adults and pups over the course of the experiment. The experiment was done in a blind fashion. The results show no harmful effects of exposure on the fertility and development of the animals. The number and the development of pups were not affected by exposure. Some data, albeit without a clear dose-response relationship, indicate effects of exposure on food consumption that is in accordance with some data published previously. In summary, the results of this study do not indicate harmful effects of long-term exposure of mice to UMTS over several generations.

Comment*: *Adequate/negative.

34. Ozorak et al., 2013.

Turkey. Wistar rats. Developmental toxicity.

The present study was designed to determine the effects of both Wi-Fi (2.45 GHz)- and mobile phone (900 and 1800 MHz)-induced electromagnetic radiation (EMR) on oxidative stress and trace element levels in the kidney and testis of growing rats from pregnancy to 6 weeks of age. Thirty-two rats and their 96 newborn offspring were equally divided into four different groups, namely, control, 2.45 GHz, 900 MHz, and 1800 MHz groups. The 2.45 GHz, 900 MHz, and 1, 800MHz groups were exposed to EMRfor 60min/day during pregnancy and growth. During the fourth, fifth, and sixth weeks of the experiment, kidney and testis samples were taken from decapitated rats. Results from the fourth week showed that the level of lipid peroxidation in the kidney and testis and the copper, zinc, reduced glutathione (GSH), glutathione peroxidase (GSH-Px), and total antioxidant status (TAS) values in the kidney decreased in the EMR groups, while iron concentrations in the kidney as well as vitamin A and vitamin E concentrations in the testis increased in the EMR groups. Results for fifth-week samples showed that iron, vitamin A, and β-carotene concentrations in the kidney increased in the EMR groups, while the GSH and TAS levels decreased. The sixth week results showed that iron concentrations in the kidney and the extent of lipid peroxidation in the kidney and testis increased in the EMR groups, while copper, TAS, and GSH concentrations decreased. There were no statistically significant differences in kidney chromium, magnesium, and manganese concentrations among the four groups. In conclusion, Wi-Fi- and mobile phone-induced EMR caused oxidative damage by increasing the extent of lipid peroxidation and the iron level, while decreasing total antioxidant status, copper, and GSH values.Wi-Fi- and mobile phone-induced EMR may cause precocious puberty and oxidative kidney and testis injury in growing rats.

Comment: Adequate, positive (testes injuries too).

35. Poulletier de Gannes et al., 2013.

France. Wistar rats (M, F). Developmental toxicity.

For the first time, we evaluated the effects of exposure to the 2450 MHz Wi-Fi signal (1 h/day,6 days/week) on the reproductive system of male and female Wistar rats, pre-exposed to Wi-Fi during sexual maturation. Thirty-six Wistar Han male and female rats were purchased (Janvier, France) at 6 and 7 weeks of age, respectively and exposed 1 h/day, 6 days/week, 12 animals per group Exposure lasted 3 weeks (males) or 2 weeks (females), then animals were mated and couples exposed for 3 more weeks. On the day before delivery, the fetuses were observed for lethality, abnormalities, and clinical signs. In our experiment, no deleterious effects of Wi-Fi exposure on rat male and female reproductive organs and fertility were observed for 1 h per days. No macroscopic abnormalities in fetuses were noted, even at the critical level of 4 W/kg.

Comment: Adequate/negative.

36. Celik et al., 2016.

Turkey. Wistar rats. Developmental toxicity (neuro).

The study investigates the effects of Wi-Fi-induced EMR on the brain and liver antioxidant redox systems in the rat during pregnancy and development. Sixteen pregnant rats and their 48 newborns were equally divided into control and EMR groups. The EMR groups were exposed to 2.45 GHz EMR (1 h/day for 5 days/week) from pregnancy to 3 weeks of age. Brain cortex and liver samples were taken from the newborns between the first and third weeks. In the EMR groups, lipid peroxidation levels in the brain and liver were increased following EMR exposure; however, the glutathione peroxidase (GSH-Px) activity, and vitamin A, vitamin E and b-carotene concentrations were decreased in the brain and liver. Glutathione (GSH) and vitamin C concentrations in the brain were also lower in the EMR groups than in the controls; however, their concentrations did not change in the liver. In conclusion, Wi-Fi-induced oxidative stress in the brain and liver of developing rats was the result of reduced GSH-Px, GSH and antioxidant vitamin concentrations. Moreover, the brain seemed to be more sensitive to oxidative injury compared to the liver in the development of newborns.

Comment: Adequate/positive.

37. Shirai et al., 2016.

Japan. Sprague-Dawley rats. Developmental toxicity.

To evaluate the possible adverse effects of multifrequency RF-EMFs, an experiment in which pregnant rats and their delivered offspring were simultaneously exposed to eight different communication signal EMFs (two of 800 MHz band, two of 2 GHz band, one of 2.4 GHz band, two of 2.5 GHz band and one of 5.2 GHz band) was performed. Thirty six pregnant Sprague-Dawley (SD) 10-week-old rats were divided into three groups of 12 rats: one control (sham exposure) group and two experimental (low- and high-level RF EMF exposure) groups. The whole body of the mother rats was exposed to the RF EMFs for 20 h per day from Gestational Day 7 to weaning, and F1 offspring rats (46–48 F1 pups per group) were then exposed up to 6 weeks of age also for 20 h per day. The parameters evaluated included the growth, gestational condition and organ weights of the dams; the survival rates, development, growth, physical and functional development, memory function, and reproductive ability of the F1 offspring; and the embryotoxicity and teratogenicity in the F2 rats. No abnormal findings were observed in the dams or F1 offspring exposed to the RF EMFs or to the F2 offspring for any of the parameters evaluated. Thus, under the conditions of the present experiment, simultaneous whole-body exposure to eight different communication signal EMFs at frequencies between 800 MHz and 5.2 GHz did not show any adverse effects on pregnancy or on the development of rats.

Comment*: *Adequate/negative.

38. Stasinopouloua et al., 2016.

Greece. Wistar rats. Developmental toxicity (neuro).

In the present study, to evaluate the effects of wireless 1880–1900 MHz Digital Enhanced CommunicationTelephony (DECT) base radiation on fetal and postnatal development, Wistar rats (80 dams in 4 groups) were exposed at an average electric field intensity of 3.7 V/m, 12 h/day, during pregnancy. After parturition, a group of dams and offspring were similarly exposed for another 22 days. Controls were sham-exposed. The data showedthat DECT base radiation exposure caused heart rate increase in the embryos on the 17th day of pregnancy.Moreover, significant changes on the newborns' somatometric characteristics were noticed. Pyramidalcell loss and glia fibrilliary acidic protein (GFAP) over-expression were detected in the CA4 region of thehippocampus of the 22-day old pups that were irradiated either during prenatal life or both pre- and postnatally. Changes in the integrity of the brain in the 22-day old pups could potentially be related to developmental behavioral changes during the fetal period.

Comment*: *Adequate/positive.

39. Othman et al., 2017.

Tunisia. Wistar rats. Developmental toxicity (neuro).

The present work investigated the effects of prenatal exposure to radiofrequency waves of conventional WiFi devices on postnatal development and behavior of rat offspring. Ten Wistar albino pregnant rats were randomly assigned to two groups (n =5). The experimental group was exposed to a 2.45 GHz WiFi signal for 2 h a day throughout gestation period. Control females were subjected to the same conditions as treated group without applying WiFi radiations. After delivery, the offspring was tested for physical and neurodevelopment during its 17 postnatal days (PND), then for anxiety (PND 28) and motricity (PND 40-43), as well as for cerebral oxidative stress response and cholinesterase activity in brain and serum (PND 28 and 43). Our main results showed that the in-utero WiFi exposure impaired offspring neurodevelopment during the first seventeen postnatal days without altering emotional and motor behavior at adult age. Besides, prenatal WiFi exposure induced cerebral oxidative stress imbalance (increase in malondialdehyde level (MDA) and hydrogen peroxide (H2O2) levels and decrease in catalase (CAT) and superoxide dismutase (SOD) activities) at 28 but not 43 days old, also the exposure affected acethylcolinesterase activity at both cerebral and seric levels. Thus, the current study revealed that maternal exposure to WiFi radiofrequencies led to various adverse neurological effects in the offspring by affecting neurodevelopment, cerebral stress equilibrium and cholinesterase activity.

Comment*: *Adequate/positive.

Table 21 – Reproductive/developmental effects in experimental animals: reproductive toxicity in male mice (450-6000 MHz) (a)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
1. Mugunthan et al., 2012, Swiss albino mice (M), 30 to 180 days	2G ultra-high frequency radiation (900 - 1900 MHz); the highest SAR value for this standard handset was 1.69W/Kg	48 minutes/day; 18 mice/group	Exposed animal weight was lower at first, second and fourth month ($p<0.05$). The mean testis weight of exposed mice was significantly reduced in all months except fourth month ($p<0.05$) and the mean testis volume was significantly reduced in the first three months ($p < 0.05$). Mean seminiferous tubule density per unit area was significantly lower in exposed testis ($p< 0.01$). The mean seminiferous tubule diameter was significantly reduced in exposed testis ($p < 0.01$) except the second month. The mean number of Sertoli cells and Leydig cells were significantly reduced in exposed mice ($p < 0.01$). Mean serum testosterone level of exposed mice were significantly lower ($p < 0.01$). The following microscopic changes were found in the testis of RFR exposed mice. 1. The interstitium appeared wide 2. Sertoli cells and spermatogonia were detached from the basal lamina. 3. Vacuolar degeneration and desquamation of seminiferous epithelium. Most of the peripheral tubules showed maturation arrest in the spermatogenesis. Seminiferous tubules scored between 8 and 9 using Johnson testicular biopsy score count.	**Adequate/positive**
2.Shahin et al., 2014, Swiss mice (M), 30 days	2.45-GHz; SAR: 0.018 W/Kg	2 h/day; 20 mice group, 40 in total	RFR induced a significant decrease in sperm count and sperm viability along with the decrease in seminiferous tubule diameter and degeneration of seminiferous tubules. Reduction in testicular 3ß HSD activity and plasma testosterone levels was also observed in the exposed group of mice. Increased expression of testicular i-NOS was observed in the MW-irradiated group of mice ($p < 0.01$)	**Adequate/positive**
3. Zhu et al., 2015, ICR mice (SPF) (M adult), [12 virgin females per each male were used for mating], 15 days	900 MHz; 1.6 mW/cm2, whole body average SAR 0.731 W/kg; acute 2 Gy irradiation from Co60 source, at a dose rate of 1 Gy per minute, as positive control	4 h/day; 10 male mices per exposure group. After exposures, each male mouse was kept in a separate cage with 3 virgin females for mating. After 7 days, each male was separated from the females and transferred to a fresh cage with a new batch of 3 virgin females for mating in the second, third and fourth weeks (in total: 12 females per each male).	Not any statistically significant effect on average body weight, testes weight in male mice exposed to RFR. Comparison between the females mated to RF- and sham-exposed mice: non-significant differences in percentages of pregnancies, live and dead implants. There were no significant differences in calculated total implants, live and dead implants per pregnant female ($p > 0.05$).	**Adequate/negative**

Table 21 – Reproductive/developmental effects in experimental animals: reproductive toxicity in male mice (450-6000 MHz) (continue b)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
4. Pandey et al., 2017, Swiss albino mice (M), 35 days	900 MHz (GSM), 0.0054 - 0.0516 W/kg	4 or 8 h/day, 7 days/week, 15/group	Increased damage index in germ cells, sperm head defects, decreased sperm count, arrest in pre-meiotic stage of spermatogenesis, loss of immature germ cells into the seminiferous tubule lumen, epithelium depletion and maturation arrest ($p<0.05$)	**Adequate/positive**
5.Pandey et al., 2018, Swiss albino mice (M), 35 days	900 MHz (GSM), (Melatonin 5 mg/kg bw/day), 0.0054 - 0.0516 W/kg	6 h/day, 7 days/week, 15/group	Decreased sperm count, sperm head abnormalities, extensive DNA damage in germ cells, arrest in pre-meiotic stages of spermatogenesis, excess free radical generation resulting in histological and morphological changes in testis and germ cells morphology ($p<0.05$)	**Adequate/positive** **(group treated without any supplement of melatonine)**
6. Shahin et al., 2018, Swiss albino mice (M), 15, 30, and 60 days	2.45 GHz MW, whole body SAR 0.0146 W/kg	2 h/day; 10 mice/group	Exposure to 2.45 GHz MW leads to altered testicular histoarchitecture, decreased seminiferous tubule diameter, sperm count, sperm viability, and serum testosterone level. Duration dependent increment in total ROS, NO, and MDA level was observed in the testes of exposed animals. Exposure to RFR leads to altered expression of p53, Bax, Bcl-xL, Bcl-2, pro-caspase-3, active-caspase-3, and PARP-1. The expression of cytochrome c was found to be increased significantly in duration dependent manner in the testes of all RFR exposed mice as compared with controls. ($p < 0.05$)	**Adequate/positive**

Table 22 – Reproductive/developmental effects in experimental animals: reproductive toxicity in female mice (450-6000 MHz) (a)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
7. Gul et al., 2009, Swiss mice (F), 21 days	NR (mobile phone in standby position for 11 h and 45 min, and in call position for 15 min), NR	12 h/day, 7 days/week, 30/group	Decreased number of follicles in mice ovaries, decreased ovarian volume ($p<0.01$)	**Adequate/equivocal**
8.Shahin et al., 2017, Swiss albino mice (F), 4 months (120 days)	1800 MHz, Nokia 100 (2G, GSM) dual-band mobile phones, in different operative modes (dialing, receiving, stand-by and switched-off)	3 h/day; 24 mice/group, 2 experiments of 12mice/group, 48 female mice in total each.	Exposure caused significant elevation in ROS, NO, lipid peroxidation, total carbonyl content and serum corticosterone coupled with significant decrease in antioxidant enzymes in hypothalamus, ovary and uterus of mice. Compared to controls, exposed mice exhibited reduced number of developing and mature follicles as well as corpus lutea. Significantly decreased serum levels of pituitary gonadotrophins (LH, FSH), sex steroids (E2 and P4) and expression of SF-1, StAR, P-450scc, 3ß-HSD, 17ß-HSD, cytochrome P-450 aromatase, ER-α and ER-α were observed in all the exposed groups of mice, compared to control ($p < 0.01$)	**Adequate/positive**

Table 23 – Reproductive/developmental effects in experimental animals: reproductive toxicity in male rats (450-6000 MHz) (a)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
9. Ozguner et al., 2015, Sprague-Dawley rats (M), 4 weeks	900 MHz, 2 watts peak power, average power density 1 ± 04 mW/cm^2	30 minutes/day, 5 days/week; 10 rats/group, 20 in total	The weight of testes, testicular biopsy score count and the percentage of interstitial tissue to the entire testicular tissue were not significantly different in RFF group compared to the controls. The diameter of the seminiferous tubules and the mean height of the germinal epithelium were significantly decreased in RFF group (p<0.05). There was a significant decrease in serum total testosterone level in RFR group (p<0.05). Therefore, there was an insignificant decrease in plasma LH and FSH levels in RFF group compared to the control group (p>0.05).	**Adequate/positive**
10.Lee et al., 2010, Sprague-Dawley rats, 12 weeks	848.5 MHz, 2.0 W/kg (CDMA)	90 min/day, 5 days/week, 20/group	Not any statistically significant alteration (NS) for testicular function and spermatogenesis (p>0.05)	**Adequate/ negative**
11. Imai et al., 2011, Sprague-Dawley rats, 5 weeks	1950 MHz (CDMA), 0.4 W/kg, 0.08 W/kg	5 h/day, 7 days/week, 24/group	Not any statistically significant alteration (NS) for testicular function (p>0.05).	**Adequate/negative**
12. Meo et al., 2011, Wistar rats, 12 weeks	900, 1800 GHz (GSM). Intensities: NR	30 minutes/day, 60 minutes/day, 7 days/week 16/group (control group: 8)	Hypospermatogenesis and maturation arrest in the testis (Significance: NR)	**Adequate/equivocal**
13. Al-Damegh, 2012, Wister albino rats (M), 14 consecutive days	900/1800/1900 MHz (GSM), 0.9 W/kg, vitamin C (40 mg/kg/day) or vitamin E (2.7 mg/kg/day)	15, 30, and 60 min/day; 30/group of exposed rats; 10/group of control rats	There was a significant increase in the diameter of the seminiferous tubules with a disorganized seminiferous tubule sperm cycle interruption in RFR-exposed group. The serum and testicular tissue conjugated diene, lipid hydroperoxide, and catalase activities increased 3-fold, whereas the total serum and testicular tissue glutathione and glutathione peroxidase levels decreased 3-5 fold in RFR-exposed animals (p<0.05)	**Adequate/positive**
14. Celik et al., 2012, Wistar-Kyoto rats (M), 3 months	NR, cell phone radiations, SAR 1.58 W/kg	24 h/day (30 M exposed, 15 M controls)	No significant differences in testis weights, seminiferous tubule diameters, and histopathological evaluations (p>0.05). Electron microscope analysis: membrana propria thickness and collagen fiber contents were increased, and the capillary veins extended in exposed animals. Common vacuolisation in the cytoplasm of the Sertoli cells, growth of electron-dense structures, and existence of large lipid droplets are the remarkable findings of this study.	**Inadequate**
15.Lee et al., 2012, Sprague-Dawley rats, 12 weeks	848.5 MHz (CDMA), 1950 MHz (WCDMA), 4.0 W/kg	45 min/day, 5 days/week, 20/group (cage control group: 5)	Not any statistically significant alteration (NS) for testicular function and spermatogenesis (p>0.05)	**Adequate/negative**
16.Ozlem-Nisbet et al., 2012, Albino Wistar rats (M), 90 days	1800 and 900 MHz, SAR: 3.00, 2.7, 2.2, 1.2 mW/kg for 900 MHz for 10, 20, 50, 70 days old rats; 0.053, 0.046, 0.011, 0.011 mW/kg for 1800 MHz for 10, 20, 50, 70 days old rats	2 h/day; 11 rats/group	The mean plasma total testosterone showed similarity among the two study groups and was significantly higher than the sham control rats. The percentage of epididymal sperm motility was significantly higher in the 1800 MHz group (P < 0.05). The morphologically normal spermatozoa rates were higher and the tail abnormality and total percentage abnormalities were lower in the 900 MHz group (P < 0.05). Histopathologic parameters in the 1800 MHz group were significantly higher (P < 0.05).	**Adequate/positive**

Table 23 – Reproductive/developmental effects in experimental animals: reproductive toxicity in male rats (450-6000 MHz) (continued b)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
17. Bin-Meferij El-kott et al., 2015, Sprague-Dawley rats, 8 weeks	900 MHz for GSM, NR intensity, 200 mg/kg aqueous extract of Moringa oleifera leaves	1 h/day (15 M exposed to RF+MO extract; 15 M exposed to RF; 15 M exposed to MO extract; 15 M controls)	Statistically significant decrease of epididymal sperm counts in the exposed group (P < 0.001). Significant decrease of sperm motility. Significant (P < 0.001) increase in the frequency percentage of dead spermatozoa in exposed animals. Overall, hypospermatogenesis and maturation arrest in spermatozoa were observed in the testes of exposed rats compared to their matched control.	**Adequate/ positive**
18. Liu et al., 2015, Sprague-Dawley rats (M), 50 days (from 10 weeks of age)	900 MHz, SAR 0.66 W/kg	2 h/day (24 M exposed; 24 M controls)	Significant increase of the percentage of apoptotic sperm cells by 91.42% in exposed animals; Significant increase of the ROS concentration by 46.21%; Significant decrease of the TAC by 28%; Significant decrease of the protein and mRNA expression of bcl-2 and increase of bax, cytochrome c, and capase-3 (p<0.05)	**Adequate/ positive**
19. Saygin et al., 2015, Sprague-Dawley rats (young M), 30 days	2.45 GHz, whole body SAR 3.21 W/kg, Gallic acid (GA) ,30 mg/kg/daily	3h/day; 12 rats/ group, 48 in total	Malondialdehyde and total oxidant status (TOS) levels increased (p<0.01) in RFR only group. TOS and oxidative stress index levels decreased in GA treated group significantly (p<0.05). Total antioxidant status activities decreased in RFR only group and increased in GA treatment group (p<0.05). Testosterone and vascular endothelial growth factor levels decreased in RFR only group, but this was not statistically significant. Testosterone and VEGF levels increased in RFR+GA group, compared with RFR only group (p<0.01) and also increased in GA group compared with the control and RFR only group (p<0.05). Prostaglandin E2 and calcitonin gene releated peptide staining increased in tubules of the testes in RFR only group (p<0.01) and decreased in tubules of the testes in RFR+GA group (p<0.01). In RFR only group, most of the tubules contained less spermatozoa, and the spermatozoon counts decreased in tubules of the testes. All these findings and the regenerative reaction, characterized by mitotic activity, increased in seminiferous tubules cells of the testes in RFR+GA group (p<0.01).	**Adequate/ positive**
20. Bilgici et al., 2018, Wistar rats (M), 30 days	2.45 GHz, whole body average SAR 0.0233 W/kg	1 h/day (11 M exposed, 11 M controls)	Serum IL-6 and CRP levels were significantly different in in exposed animals (p<0.05). Significant difference in necrosis and spermatogenesis in exposed animals (p<0.05)	**Adequate/ positive**
21. Guo et al., 2019, Sprague-Dawley rats, 1 month	220 MHz (pulsed modulated), 0.030 W/kg	1h/day, 7 days/week, 20/group	Decreased sperm count and survival rate of sperm (p<0.05), increased sperm abnormalities (NS), increased expression in testes of cleaved caspase 3 (p < 0.05), caspase 3 (p<0.01), and the BAX/BCL2 ratio (p<0.01), decreased serum T level (p<0.05)	**Adequate/ positive**

Table 23 – Reproductive/developmental effects in experimental animals: reproductive toxicity in male rats (450-6000 MHz) (continued c)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
22. Yu et al., Experiment 1, 2020, Sprague-Dawley rats (M adults), 50, 100 0r 150 days	smartphone emitting SRF-EMR, 2575–2635 MHz (TD-LTE), 1.05 W/kg.	6 h/day (smartphone was kept on active talk mode and received an external call for 1 min over 10min intervals for 10 cycles); 135 rats (9 groups of 15 rats each).	After 150 days of SRF-EMR exposure, sperm concentration, motility, viability, and normal morphology were comparatively lower in the SRF group than in the control group. Mating experiment in rats exposed to SRF-EMR for 150 days: the pup weight was comparatively lower in the SRF group than in the controls. Testicular morphologic injury: after 150 days, increased disorder in spermatogenesis, as well as significant germ cell loss, and decreased epithelium height were observed, together with lower epithelium height, lower Johnsen score, and higher Cosentino score. Oxidative stress in testes: After 100 days of exposure, only CAT and GSH content was found to be significantly lower in the SRF group. After 150 days, also the levels of MDA, 4-HNE and LPO were comparatively higher, while GSH, SOD and CAT content were lower in the SRF group. Apoptosis in the testes: after 100 days, only cleaved-caspase 8 was significantly upregulated in the SRF group. After 150 days, only the level of Bcl-2 was lower, while the levels of Bax, cleaved-caspase-3, Fas, FasL and cleaved-caspase-8 were significantly higher in the SRF group ($p < 0.01$)	**Adequate/ positive**
Experiment 2, 2020, Sprague-Dawley rats (M adults), 150 days	smartphone emitting SRF-EMR, 2575–2635 MHz (TD-LTE), 1.05 W/kg.	6 h/day (smartphone was kept on active talk mode and received an external call for 1 min over 10min intervals, for 10 cycles); 10 to 15 rats/ group, 91 rats in total (7 groups)	Transcriptional profile changes: 1663 differentially expressed genes including 1446 up-regulated and 217 down-regulated. Spock3 level was higher in rats exposed to SRF-EMR for 150 days. Inhibition of Spock3 overexpression improved sperm quality decline and alleviated testicular injury and BTB disorder in the exposed rats. SRF-EMR exposure suppressed MMP2 activity, while increasing the activity of the MMP14–Spock3 complexes and decreasing MMP14–MMP2 complexes; these results were reversed by Spock3 inhibition ($p < 0.01$).	**Adequate/ positive**

Table 24 – Reproductive/developmental effects in experimental animals: : developmental toxicity in hamster in male rats (450-6000 MHz) (a)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
23. Lerchl et al., 2008 a, b, c, Djungarian hamsters (M), 60 days	a: 383 MHz (TETRA), b: 900 and c: 1800 MHz (GSM), SAR 0.08 W/kg	24 h/day (120 M exposed; 120 M sham)	a: Pineal and serum melatonin levels as well as the weights of testes, brain, kidneys, and liver were not affected; Significant transient increase in body weight up to 4%; b: Pineal and serum melatonin levels as well as the weights of testes, brain, kidneys, and liver were not affected; Significant non transient increase in body weight up to 6%; c: Pineal and serum melatonin levels as well as the weights of testes, brain, kidneys, and liver were not affected; no effect on body weight;	**Adequate/negative**

Table 25 – Reproductive/developmental effects in experimental animals: developmental toxicity in mice (450-6000 MHz) (a)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
24. Finnie et al. a, b (2006), c (2009), BALB/c mice (F)	900 MHz, 4 W/kg	1h/day, 7 days/week, 10/group	Not any statistically significant alteration (NS) in: (a): blood-brain barrier permeability in the immature brain of fetal heads, (b): immediate early gene c-fos expression as a marker of neural stress (c): stress response by induction of heat shock proteins	**Adequate/negative**
25. Lee et al., 2009, ICR mice (F breeders; F and M fetuses), Day 1-17 of gestation	CDMA (849 MHz) and WCDMA (1.95 GHz), SAR 2.0 W/kg for 2 exposure periods (total 4 W/kg)	2 exposures 45-min/day, separated by a 15-min interval (14 F sham; 17 F CDMA-exposed; 20 F sham CDMA+WCDMA controls; 20 F CDMA+WCDMA exposed). Short daily exposure	Simultaneous experimental exposure to CDMA and WCDMA RF EMFs did not cause any observable adverse effects (mortality, growth retardation, changes in head size and other morphological abnormalities) on mouse fetuses.	**Adequate/ negative**
26. Fragopoulou et al., 2010, Balb/c Mus musculus (F breeders; M and F offspring), 5 days before pregnancy; days 1-21 of gestation	GSM 900MHz, SAR 0.6–0.94 W/kg	0 (5 F control breeders, 7 M and F offspring) ; 6 min/day (7 F exposed, 20 M and F offspring); 30 min/day (7 F exposed, 20 M and F offspring)	Statistically significant variations in the ossification of cranial bones and thoracic cage ribs, and displacement of Meckelian cartilage, in exposed animals (both groups). Littermates examined after teeth eruption displayed normal phenotypes.	**Adequate/ positive**

Table 25 – Reproductive/developmental effects in experimental animals: developmental toxicity in mice (450-6000 MHz) (continued b)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
27. Sambucci et al., 2011, C57BL/6 newborns mice (M and F), 5 consecutive weeks, starting the day after birth	Wi-Fi at 2.45 GHz, 0.08 or 4 W/kg SAR	2 h/day, 5 days/week; 16 newborns/group, each with 4 adoptive mothers assigned (48 pups in total)	No differences in body weight and development among the groups were found in mice of both sexes. For the immunological analyses, results on female and male newborn mice exposed during early post-natal life did not show any effects on all the investigated parameters ($p>0.05$), with one exception: a reduced IFN-γ production in spleen cells from microwaves (MW)-exposed (SAR 4 W/kg) male (not in female) mice compared with sham-exposed mice ($p<0.05$).	**Adequate/negative**
28. Zhang et al., 2015, CD1 mice (M and F), in utero exposure, throughout gestation (Days 3.5–18)	9.417 GHz, SAR: 2.0 W/kg	12 h/day; 4 pregnant female mice per group. Previously, to obtain pregnancies: 12 breeding cages were set up, each containing one CD1 female mouse and two CD1 male mice, all aged 6 weeks.	Mice did not differ in motor ability by open field test (OFT); however, frequency of entries into and duration of time spent in the center zone for the treated group were lower compared to controls. Exposed mice had increased anxiety-related behavioral elevated-plus maze test (EPM). Tail suspension test (TST) and forced swimming test (FST) showed that RFR exposure significantly decreased immobility time, demonstrating that the offspring of exposed mice had decreased depression-related behavior. By Morris water maze (MWM), treated mice showed a progressive decline in escape latency. On the fourth and fifth days of MWM, only male mice in Radiation group spent more time trying to find the platform, indicating reduced spatial learning ability ($p < 0.01$).	**Adequate/ positive**
29. Fatehi et al., 2018, NMRI mice (M and F offspring), 30 days	900 MHz, intensity NR	Cell phone in "Standby-mode": 1, 5 and 10 h/day (group 2,3,4); cell-phone on "Active-mode": 1 h/day (group 5); 20 mice/group	Irradiated mice (at any exposure duration) had significant increases in pregnancy duration. Furthermore, when the cellphone changed from off mode to active mode, a significant delay was seen in pregnancy duration. RFR exposure leads to a significant decrease in the number of newborn mice compared to the control group. The results also demonstrated that the increase of the exposure time from 1 h per day (group 2) to 10 h per day (group 4) in the Standby mode caused a significant difference in the number of the newborns ($p < 0.05$).	**Adequate/positive**

Table 25 – Reproductive/developmental effects in experimental animals: developmental toxicity in mice (450-6000 MHz) (continued c)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
30. Nelson et al., 1991, 1994, 1997, 1997; Sprague-Dawley rats (F); 10, 20, 30 minutes	10 MHz (2-methoxyethanol at 20, 40, 60, 75, 80, 100, 120, 125, 140 or 150 mg/kg), 0.8-6.6 W/Kg . Thermal effects (temp. 42C°)	10, 20, 30 minutes; 10-27/group	Synergism between RFR and 2ME administration in the induction of teratogenic effects: increased incidence of external malformation of fetuses (p<0.05)	**Inadequate**
31. Nelson et al., 2001, Sprague-Dawley rats (F), 60 minutes	10 MHz (Methanol 2, 3 g/kg); 0.8-6.6 W/Kg Thermal effects (temp. 42C°)	60 minutes; 10/group	Increased incidence of resorbed fetuses (p<0.05). No synergistic effects.	**Inadequate**
32. Ogawa et al., 2009, Sprague-Dawley rats (F), 10 days	1950 MHz CDMA, 0.4 W/kg	90 min/day, 7 days/week, 20/group	Not any statistically significant alteration (NS) for: landmarks of sexual maturity, viable litter size/live birth index, neonatal growth, neonatal survival indices, sex ratio in progeny, physiologic endpoints revealing unique toxicities of pregnancy and lactation (p>0.05).	**Adequate/negative**
33. Sommer et al., 2009, C57BL mice (M, F), Multi-generation study	1966 MHz (UMTS), 0.08, 0.4, 1.3 W/kg	24 h/day, 7 days/week, 128 M and 256 F over four generations (1M and 2F per cage)	Not any statistically significant alteration (NS) for: viable litter size/live birth index, neonatal growth, neonatal survival indices, prenatal mortality, assessment of sperm quality, weight and morphology of reproductive organs, mating and fertility indices and reproductive outcome, landmarks of sexual maturity, sexual behavior (p<0.05)	**Adequate/negative**
34. Ozorak et al., 2013, Wistar albino rat offspring (and F pregnant adult), from pregnancy to 6 weeks of age	Wi-Fi (2.45 GHz) and mobile phone (900 and 1800 MHz) RFR, whole body SAR 0.1 W/kg	1 h/day, 5 days/week; 24 rats/group, 96 in total	Results from the fourth week showed that the level of lipid peroxidation in the kidney and testis and the copper, zinc, reduced glutathione (GSH), glutathione peroxidase, and total antioxidant status (TAS) values in the kidney decreased in the RFR groups, while iron concentrations in the kidney as well as vitamin A and vitamin E concentrations in the testis increased in the RFR groups. Results for fifth-week samples showed that iron, vitamin A, and β-carotene concentrations in the kidney increased in the RFR groups, while the GSH and TAS levels decreased. The sixth week results showed that iron concentrations in the kidney and the extent of lipid peroxidation in the kidney and testis increased in the RFR groups, while copper, TAS, and GSH concentrations decreased (p<0.05). There were no statistically significant differences in kidney chromium, magnesium, and manganese concentrations among the four groups (p>0.05).	**Adequate/positive**
35. Poulletier de Gannes et al., 2013, Wistar rats (M, F), 5 weeks F, 6 weeks M	2450 MHz (Wi-Fi signal), 0.08, 4 W/kg	1 h/day, 6 days/week, 12/group	Not any statistically significant alteration (NS) for: number of live and dead fetuses per uterine horn, number and location in each uterine horn of early and late resorption sites, distribution of implantation sites on each uterine horn (Significance: NR).	**Adequate/negative**

Table 26 – Reproductive/developmental effects in experimental animals: developmental toxicity in rats (450-6000 MHz) (a)

Reference, Strain, Species (Sex), Exposure duration	Frequency, Intensity Any other co-exposure	Exposure time, Number of animals	Observed effects	Comments
36. Celik et al., 2016, Wistar albino rats (F breeders, M offspring), from gestation to 21 days of age	2.45 GHz EMR with 217 Hz pulses, SAR 0.1 W/kg	1 h/day for 5 days/week (8 F exposed breeders, 24 M exposed offspring; 8 F control breeders, 24 M control offspring)	Oxidative stress was observed in the brain and liver of developing rats, due to reduced GSH-Px, GSH and antioxidant vitamin concentrations. Moreover, the brains were more sensitive to oxidative injury compared to the liver in the development of newborns ($p<0.05$).	**Adequate/positive**
37. Shirai et al., 2016, Sprague–Dawley rats (F adults and their offspring), Mothers: from Gestational Day 7 to weaning; F1 offspring rats from birth up to 6 weeks of age	Eight different communication signal RFR (two of 800 MHz band, two of 2 GHz band, one of 2.4 GHz band, two of 2.5 GHz band and one of 5.2 GHz band), 0.4 W/kg, each frequency contributing for 0.05 W/kg	20 h/day; mothers: 12 rats/group; 46–48 F1 pups per group.	No abnormal findings were observed in the dams or F1 offspring exposed to the RFR or to the F2 offspring for any of the parameters evaluated ($p>0.05$).	**Adequate/negative**
38. Stasinopoulou et al., 2016, Wistar rats (F adults and their offspring), Pregnant rats throughout the pregnancy, and a group of dams and their offspring for further 22 days	1880–1900 MHz, whole body SAR ranging from 0.016 to 0.020 W/kg	12 h/day; 40 rats/group	RFR exposure caused heart rate increase in the embryos on the 17th day of pregnancy. Significant changes on the newborns' somatometric characteristics were noticed. Pyramidal cell loss and glia fibrilliary acidic protein over-expression were detected in the CA4 region of the hippocampus of the 22-day old pups that were irradiated either during prenatal life or both pre- and postnatally ($p>0.05$).	**Adequate/positive**
39. Othman et al., 2017, Albino Wistar rats, Gestation period (19–20 days)	2.45 GHz from Wi-Fi, Intensity NR (Wi-Fi: Exposed group was placed at distance of 25 cm from the Antennas. D-Link DWL-3200 AP with 802.11 g mode and WPA2 net-work protection)	2 h/day; 63 control offsprings and 37 treated offspring, 5 adult pregnant exposed rats/group	In-utero WiFi exposure impaired offspring neurodevelopment during the first 17 postnatal days without altering emotional and motor behavior at adult age. Besides, prenatal WiFi exposure induced cerebral oxidative stress imbalance (increase in malondialdehyde level and hydrogen peroxide levels and decrease in catalase and superoxide dismutase activities) at 28 but not 43 days old, also the exposure affected acethylcolinesterase activity at both cerebral and seric levels ($p<0.05$)	**Adequate/positive**

Table 27 (summary tables 21-26) (a, b) – Collected data for experimental studies on reproductive/developmental effects (FR1: 450-6000 MHz)

Total studies	39								
Adequate studies	37								
Type of study	Mouse					Rat			
	Observed effects	**Total adequate studies***	**Positive results**	**Equivocal results**	**Negative results**	**Total adequate studies***	**Positive results**	**Equivocal results**	**Negative results**
Reproductive-male fertility	Semen quality Histopathological alterations Fertility	9	6		3	14	10	1	3
Reproductive-female fertility	Fertility Gestation period Number of pups Weight of litters	2	1	1					
Development-Female-litters	Neuro/behavioural effects Foetal growth Litter haematochemical characteristics	10	4		6	4	3		1

*Some of the studies include more than one outcome. One study (Ref. 23) was performed on Djungarian hamster, and was considered adequate/negative.

SUMMARY OF THE RESULTS OF REPRODUCTIVE/DEVELOPMENTAL EFFECTS IN EXPERIMENTAL ANIMALS STUDIES (FR1: 450 to 6000 MHZ)(Table 27)

From the present review, 39 studies on reproductive/developmental effects in experimental animals were selected. 20 studies were performed on mice, 18 were performed on rats, 1 on hamsters. Various end points were studied in both mice and rats in adequate studies. Summaries of the results are presented in Table 27.

Out of the 37 adequate studies, the results were:

Reproduction, male fertility (Semen quality, Histopathological alterations, Fertility).

Twentythree adequate studies were performed to investigate possible non-thermal adverse effects on reproduction in male rats and mice. In mice, 6 of 6 adequate studies, showed a positive association between exposure and adverse effects (Ref: 1, 2, 4, 5, 6, 8) and 1 was negative (Ref: 3). In rats, out of 14 studies,10 were positive (Ref: 9, 13, 16, 17, 18, 19, 20, 21, 22, 23), 1 showed equivocal outcomes (Ref: 12), 3 were negative (Ref: 10, 11, 15).

The most convincing evidence regards the statistically significant decline of sperm quality, in both rats and mice. For this outcome there is *sufficient* evidence of association between RF-EMF exposure and the decline of sperm quality.

Reproduction, female fertility (Fertility, gestation period, number of pups, weight of litters).

Only 2 studies on mice were considered adequate for the present review. One of them (Ref. 8) showed positive evidence for the association of adverse effects with RF-EMF exposure, one was equivocal (Ref: 7). Female fertility was not enough investigated, so, although statistically significant effects were found, evidence is *limited* to allow for any conclusive evaluation.

Development - Dams and litters (litter hematochemical characteristics, neuro/behavioural effects, foetal growth, etc)

Fourteen adequate studies were analysed for developmental outcomes. Out of 14, 10 were performed on mice, 4 on rats. In mice, 4 showed a positive association with exposure (Ref: 26, 28, 29, 34) and 6 were negative (Ref: 24, 25, 27, 32, 33, 35). In rats, out of 4 adequate studies, 3 were positive (Ref: 36, 38, 39) and 1 negative.

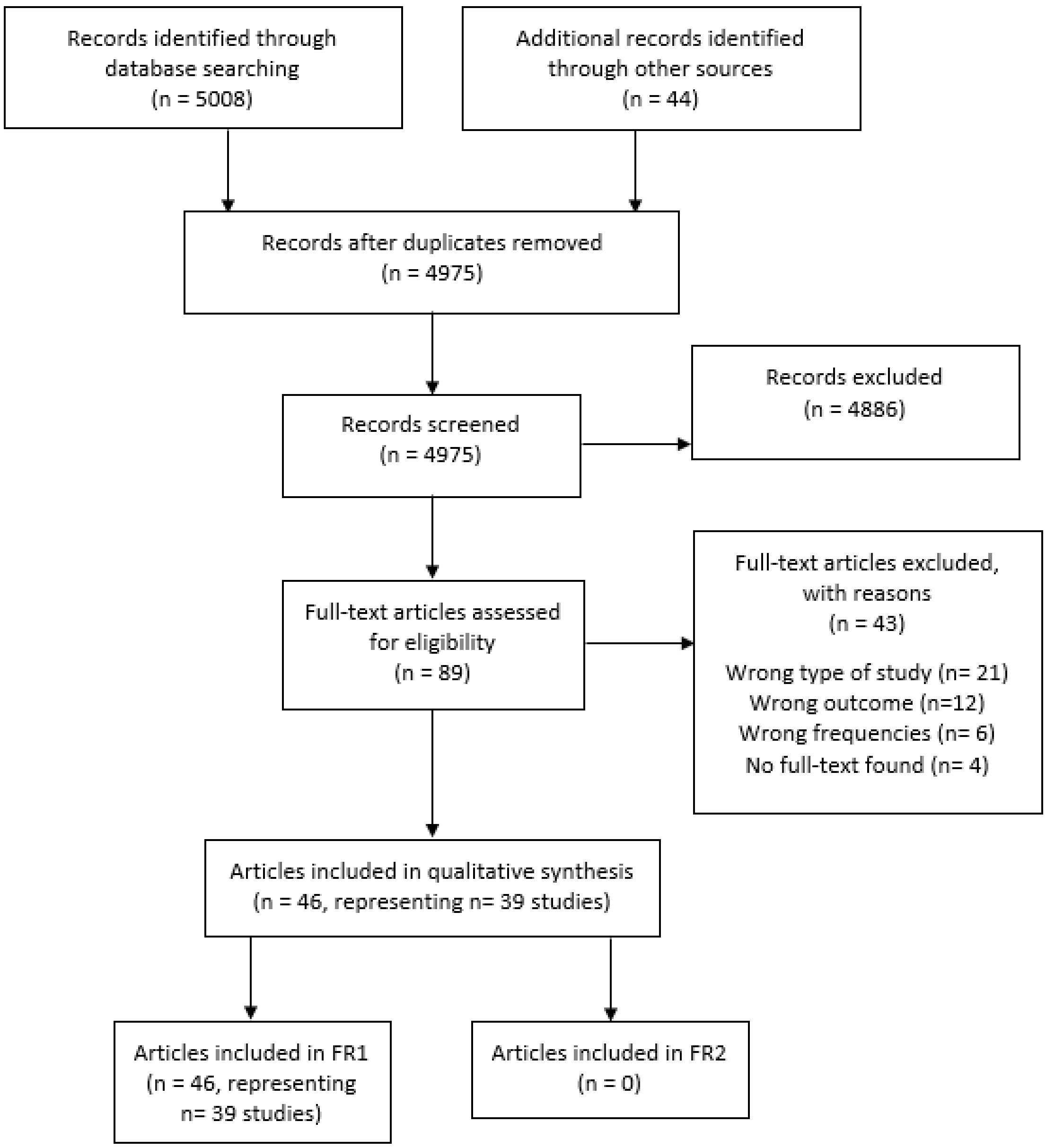
The results on this end point are mixed (conflicting) and the evidence of a possible association of developmental adverse effects with the exposure to RF-EMF is *limited.*

4.2.4 Reproductive/developmental effects in experimental animals: Studies evaluating health effects due to RF at a higher frequency range (FR2: 24 to 100 GHz, MMW) .

The articles identified through database searching and other sources were 5052. After removing duplicates (77) and excluding non-pertinent articles (4886) based on title and abstracts, 89 articles remained. Based on full-text screening, 43 papers were further excluded, so that the published articles with frequencies appropriate for inclusion in this qualitative synthesis were 46, corresponding to 39 studies. In three cases, more than one article was published reporting information on the same study for different reproductive/developmental end points (Fig. 16).

At this stage, a selection based on frequency range was also performed: out of 46 papers/39 studies, all reported exposures to the FR1 range, and none to FR2.

Figure 16 – Flow diagram. Reproductive/developmental effects in experimental animals (FR2)



5. Discussion

In its latest publication ICNIRP states that: "(…) reported adverse effects of RF-EMFs *on health need to be independently verified, be of sufficient scientific quality and consistent with current scientific understanding, in order to be taken as "evidence" and used for setting exposure restrictions. Within the guidelines, "evidence" will be used within this context, and "substantiated effect" used to describe reported effects that satisfy this definition of evidence. The reliance on such evidence in determining adverse health effects is to ensure that the exposure restrictions are based on genuine effects, rather than unsupported claims* (…)*"* (ICNIRP, 2020a).

Both in humans and in animal models, effects that ICNIRP defines as "*unsupported claims*" have been observed; and, some of them represent "*substantiated effects*", i.e. objective and relevant observations from epidemiological and experimental studies, including those on cancer and adverse effects on reproduction and development.

Epidemiological studies, when conducted with adequate information on the exposure scenarios and correct methodology, can provide strong evidence of "substantiated effects" of an agent, factor or situation. However, epidemiological studies can often have several limitations in small sample size, low statistical power, and confounding factors. These limitations include: i) Small exposed or follow up populations which may be insufficient to provide adequate statistical power; ii) The nature, amount and timing of exposures to the hazardous agent may lead to exposure misclassifications and false negative results; iii) Clear results due to confounding factors may be difficult to derive; iv) Methodological factors, such as recall bias, or publication bias, may also prevent clear results; v) The inherent delay in establishing robust epidemiological results due to the long period of tumour latency in humans (ie from first exposure to tumour indentification) on average can be 10-40 years; iv) Wide spread and diffuse exposure to other hazardous agents which may have synergistic or protective effects in combination with the agent being studied; vii) Widespread exposures to EMF creates difficulties in finding a large enough unexposed control group: which then may require the use of lowest exposure groups for comparison as the controls, which can be less robust.

The main direction of bias from many of these methodological and other limitations of human studies tends to produce "false negatives", i.e. results that exonerate the agent from being harmful but which later turn out to be wrong (Grandjean, 2013).

While sufficient evidence of carcinogenicity from RF-EMF was observed in studies on experimental animals, the following reasons suggest that the findings are important/relevant for risk assessment in humans. Animal studies (bioassays) have few limitations, and when adequately conducted to the high standards recommended (OECD, 2018b) can therefore, by comparison to human studies, provide relatively rapid and robust evidence of the association of exposure with the specific outcome.

Since the period of latency is proportional to the average lifespan of an organism, latency is proportionally shorter in the rodents that are commonly used in the laboratories. A latency time of one year in rats is equivalent to slightly more than 30 years of latency in humans, so animal bioassays, even over the rats full life time of approximately 2.5 years, allow cancer identification within a relatively short time compared to human studies.

Animal bioassays can therefore provide important information on the human risk of cancer from exposure to different agents. These data can enhance our confidence in the evidence on human cancer risks from epidemiological data.

Many human carcinogens have first been reliably identified in adequately tested laboratory animals, often many years before the human evidence was established (Huff, 1999; Huff, 2013; Maronpot et al., 2004).

There can also be consistent evidence between well conducted (OECD, 2016) animal and human studies on reproductive and developmental adverse effects.

The importance of experimental bioassays for safeguarding human health also emerges from risk assessments for chemicals as based on well conducted animal studies. Thus, animal studies are used to find the Lowest-Observed-Adverse-Effect Level (LOAEL i.e the lowest concentration of the chemical agent; or sometimes the No-Observed-Adverse-Effect Level- NOAEL) causing adverse alteration of morphology, functional capacity, growth, development, or life span of the target organism distinguishable from unexposed animals/organisms of the same species and strain under the same exposure conditions (Gaylor, 1999).

With RF-EMF, the epidemiological study results have so far only provided "*limited evidence*" of an association with cancer, largely because of the above limitations of epidemiological studies, and the absence of sufficient independent funding of such research.

In studies on laboratory animals, however, where confounding factors and other limitations are minimal, the evidence for RF-EMF having a carcinogenic effect , particularly on peripheral and central nervous system cells, is more robust than in 2011, following publications by the US- NTP and the Ramazzini Institute in 2018/19, and now attains "*sufficiency*" of animal evidence as per IARC evidence evaluation (IARC, 2019).

5.1 Cancer and lower telecommunication frequencies (FR1: 450 to 6000 MHz)

In 2011, in view of the limited evidence in humans and in experimental animals, the Working Group of IARC classified RF-EMF as "possibly carcinogenic to humans" (Group 2B). This evaluation was supported by a large majority of Working Group members. The overall evaluation was: *Radiofrequency electromagnetic fields are possibly carcinogenic to humans* (Group 2B).

Almost 10 years later many new studies have been published and an update is necessary. An Advisory Group of 29 scientists from 18 countries met at the International Agency for Research on Cancer (IARC) in March 2019 to recommend priorities for the IARC Monographs programme during 2020–2024, and among them there are RF-EMF (IARC, 2019).

5.1.1 RF-EMF (FR 1: 450 to 6000 MHz) and cancer in humans

Our review of the literature up to 2020 has found that several new epidemiological studies have been published on the association between RF-EMF and cancer since the publication of IARC Monograph 102 (IARC, 2013), yet the evidence remains mixed (conflicting results). In the Million Women Study cohort, there was no evidence of increased risk of glioma or meningioma. There was an increased risk of vestibular Schwannoma (neurinoma of the acoustic nerve) with long-term use and a significant dose–response relationship (Benson et al., 2013).

Updated follow-up in the Danish nationwide subscribers study did not find increased risks of glioma, meningioma, or vestibular schwannoma, even among those with subscriptions of 10 years or longer (Frei et al., 2011; Schüz et al., 2011).

New reports from case–control studies that assessed long-term use also found mixed results; for example, increased risks of glioma and acoustic neuroma were reported by Hardell and Carlberg, (2015) and Hardell et al., (2013 a, b), but no evidence of increased risks for these tumours was reported by Yoon et al., (2015) and Pettersson et al., (2014).

Several large-scale studies are still in progress and should yield results within the next few years. Mobi-Kids is a multicentre case–control study of brain tumours in those aged 10–24 years. Cohort Study of Mobile Phone Use and Health (COSMOS) is a new European cohort of adult cell phone users. There will also be updated results from the Million Women Study (IARC, 2019).

Some authors state that the elevated risk of brain cancer and neurinoma evidenced by various epidemiological studies do not mirror the observed incidence time trends, which are considered informative on this specific topic. This is not what we found in the recent available literature.

Concerning malignant tumours of the central nervous system (CNS), in 2019 the Global Burden of Diseases, Injuries, and Risk Factors (GBD) Study 2016 (GBD 2016, published on Lancet Neurol, 2019) reports a 4.63 per 100 000 person-years global incidence of malignant CNS tumours, which represents a 17.3% increase from 1990 to 2016. The top three countries with the highest number of incident cases were China, the USA, and India.

An increase in the incidence of glioblastoma multiforme in the frontal and temporal lobes and cerebellum was also reported in USA (Little et al., 2012; Zada et al., 2012).

A register based study in Sweden (Hardell and Carlberg, 2017) showed increasing rates of tumours of unknown type in the brain with higher rate during 2007–2015, in both sexes (Fig. 17 and 18).

Figure 17 – The Swedish National Inpatients Registry (source: Hardell and Carlberg, 2017): men

Joinpoint regression analysis of number of patients per 100,000 inhabitants according to the Swedish National Inpatient Register for men, all ages during 1998–2015 diagnosed with D43 = tumour of unknown type in the brain or CNS (http://www.socialstyrelsen.se/statistik/statistikdatabas/diagnoserislutenvard).

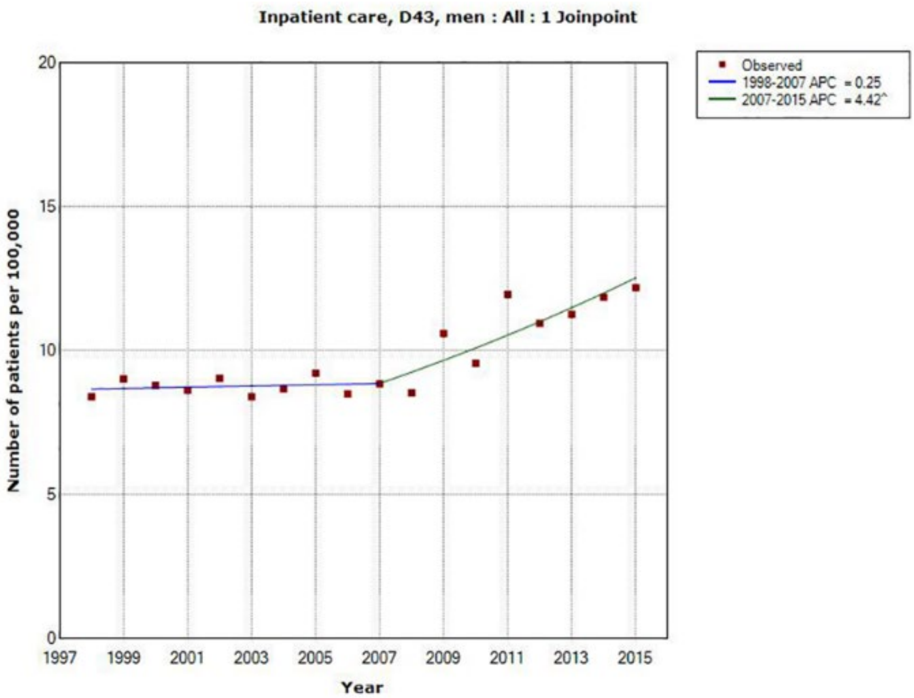
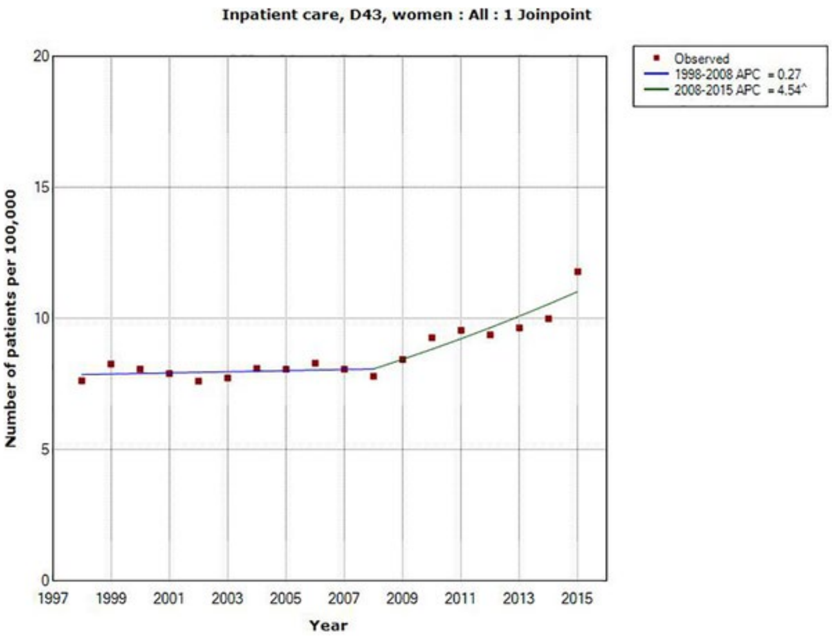


Figure 18 – The Swedish Nnl. Inpatients Registry (source: Hardell and Carlberg, 2017): women

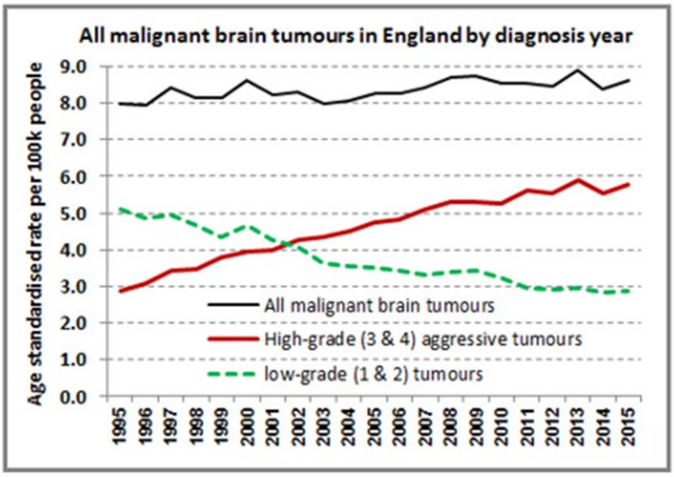
Joinpoint regression analysis of number of patients per 100,000 inhabitants according to the Swedish National Inpatient Register for women, all ages during 1998–2015 diagnosed with D43 = tumour of unknown type in the brain or CNS. (http://www.socialstyrelsen.se/statistik/statistikdatabas/diagnoserislutenvard).



Furthermore, ANSES (2019), in the volume "Estimations nationales de l'incidence et de la mortalité par cancer en France métropolitaine entre 1990 et 2018" reports the trend of the incidence (new cases by year) of glioblastomas (malignant tumours of the brain), histologically confirmed. Between 1990 and 2018 the number of new cases by year, both in men and women, increased: this is essentially attributable to the (environmental, occupational) increase in risks related to this type of cancer (ANSES, 2019)

In a UK study of national incidence data on malignant brain tumours, there was a rise in the rates of the more aggressive type identified in the epidemiological case control studies (Fig. 19). The authors looked at the incidence of brain tumours in three "major cancer registries" over a 15-year period (1992-2006). The study showed "decreased rates of primary brain tumours in all sites with the notable exception of increased incidence of glioblastoma multiforme (GBM) in the frontal lobes, temporal lobes and cerebellum. The increase in GBMs in the temporal lobe (the region of the brain closest to the ear and potentially to a phone) was seen in all three registries, ranging from approximately 1.3% to 2.3% per year, a finding that is statistically significant (Philips et al., 2018).

Figure 19 – Trends in the incidence of of all malignant brain tumours in England
(Philips et al., 2018)



http://www.saferemr.com/2018/03/brain-tumor-incidence-trends.html

In conclusion, referred to our research on FR1, positive *limited* associations have been observed in the literature between exposure to RF-EMF from wireless phones and glioma, and acoustic neuroma in humans.

5.1.2 RF-EMF (FR1: 450 to 6000 MHz) and cancer in experimental animals

New data in experimental animals for exposure to RF-EMF (FR1) have been published since the previous IARC Monographs evaluation in 2011 (IARC, 2013).

The large study by the United States National Toxicology Program (NTP) found an increased risk of malignant schwannomas of the heart in male rats with high exposure to radiofrequency radiation at frequencies used by cell phones, as well as possible increased risks of certain types of tumour in the brain and adrenal glands, and equivocal increased risks in mice or female rats (NTP, 2018a, b).

The Ramazzini Institute (RI) study also found a statistically significant increase in schwannomas of the heart in highly exposed (50 V/m) male rats and an increase in gliomas in female rats (Falcioni et al., 2018). In the Lee et al. study (2011) on Eμ-piml transgenic mice, prone to getting lymphomas, any increase of tumour incidence was observed. Lerchl et al. (2015), in a promotion study found that tumours of the lung and liver in exposed animals were significantly higher than in sham-exposed controls. In addition, lymphomas were also found to be significantly elevated by exposure, suggesting a promotion effect of RF-EMF.

The $30 million NTP study includes both mice and rats. It took more than 10 years to complete and is one of the most comprehensive assessments to date of health effects in animals exposed to RF-EMF, mice and rats. The FDA called for this research in 1999.

In this study, in the far GSM-exposed mice, the NTP found skin tumours and lung tumours in males, and malignant lymphomas in females. Far CDMA-exposed mice showed an increase of liver hepatoblastomas in males and malignant lymphomas in females. The results were labelled as equivocal (a marginal increase of neoplasms that may be test agent related even if the increased incidence of the tumours were statistically significant).

The long term study on rats (NTP, 2018a) found that exposure to high levels of RF-EMF, like that used in 2G and 3G cell phones, was associated with:

- Clear evidence of tumours in the hearts of male rats (malignant schwannomas).

- Some evidence of tumours in the brains of male rats (malignant gliomas).

- Some evidence of tumours in the adrenal glands of male rats (pheochromocytomas).

An expert peer-review panel concluded that the NTP studies were well designed, and that the results demonstrated that both GSM- and CDMA-modulated RFR were carcinogenic to the heart (schwannomas) and brain (gliomas) of male rats (Final evaluation: *Clear evidence of carcinogenicity*) (NTP, 2018c).

The RI in Italy performed a life-span carcinogenicity study on Sprague-Dawley rats to evaluate the carcinogenic effects of RF-EMF in the far field situation, reproducing the environmental exposure to RF-EMF generated by 1.8 GHz GSM antennae at radio-base stations for mobile phones. This is the largest long-term study ever performed in rats on the health effects of RF-EMF, including 2,448 animals. The authors reported the final results regarding brain and heart tumours, confirming and strengthening the same observation as NTP on rats: a statistically significant increase in Schwannomas of the heart in males and an increase in glial malignant tumour in females.

The recent NTP and RI RF-EMF studies presented similar findings in heart schwannomas and brain gliomas, strengthening the reciprocal results. Both NTP and RI studies were well performed, no bias affecting the results. Blinding was applied in both NTP and RI experiments, following their respective Standard Operating Procedures (SOPs) or specifications. It is quite common to have a different response in carcinogenesis for mice and rats, and gender differences in the response to carcinogens are common in both experimental animals and humans. Schwannomas are tumours arising from the Schwann cells, which are peripheral glial cells that cover and protect the surface of all nerves diffused throughout the body; so vestibular (acoustic nerve) and heart schwannomas have the same tissue of origin. In rats, increases in malignant heart schwannomas, malignant glial tumours of the brain and Schwann cell hyperplasia (a pre-malignant lesion) are rare. However, these lesions were observed in exposed animals in two independent laboratories, in a wide range of RF-EMF exposures studied. As a consequence, the findings of the two laboratories could not be interpreted as occurring “by chance”. The NTP and the RI studies show that the assumption that RF radiation is incapable of causing adverse health effects other than by tissue heating is not scientifically based.

It’s noteworthy that both NTP and the RI in the last 40 years strongly contributed with their results to the risk assessment of various chemical and physical agents. Their results were often predictive for human health. The NTP is the world's largest toxicology program; as far as number of agents studied, the RI is second only to NTP. The NTP and RI two-year carcinogenicity studies and their publications are also considered as the "gold standard" of cancer studies due to their high quality, their utility in evaluating human health hazards, and the rigour, transparency, and independency they bring to the evaluation of the data.

In conclusion, for FR1 exposed experimental animals, positive associations, with *sufficient* evidence, have been observed between exposure to RF-EMF and glioma and neuromas (synonymous with shwannoma).

5.2 Cancer and higher telecommunication frequencies (FR2: 24 to 100 GHz)

5.2.1 RF-EMF (FR2: 24 to 100 GHz) and cancer in humans

Very few studies were performed on frequencies between 24 to 100 GHz (FR2). The largest part of them regarded occupational exposure in workers involved in radar telecommunication. The exposure was self-reported or related to job title, and based on the distance from the source of RF emissions. In conclusion, while there are weak suggestions of a possible increase in risk of brain cancers and of lymphomas and leukaemias in workers occupationally exposed, exposure misclassification and insufficient attention to possible confounders limit the interpretation of the findings. In IARC Monograph 102 the conclusion was:

Tumours of the brain*: "exposure misclassification and insufficient attention to possible confounding limit the interpretation of findings. Thus, there is no clear indication of an association of occupational exposure to RF radiation with risk of cancer of the brain"* (IARC, 2013).

"Leukaemia/Lymphoma*: In summary, while there were weak suggestions of a possible increase in risk of leukaemia or lymphoma associated with occupational exposure to RF radiation, the limited exposure assessment and possible confounding make these results difficult to interpret"* (IARC, 2013).

Other kinds of tumour emerged as potentially associated with exposure to high frequencies (uveal melanoma, cancer of the testis, breast, lung, and skin), but many of the studies showed methodological limitations and the results were inconsistent (IARC, 2013).

The present review confirms the IARC remarks, where the highest 5G frequency (FR2) is concerned, there are no adequate epidemiological studies upon which to assess the impact on health.

5.2.2 RF-EMF (FR2: 24 to 100 GHz) and cancer in experimental animals

Seventy six studies were examined for cancer in experimental animals. No available literature regarding the possible association between experimental carcinogenicity and RF radiation, at the range 24 to 100 GHz (FR2), was found.

5.3 Adverse effect on reproduction/development and lower telecommunication frequencies (FR1: 450 to 6000 MHz)

5.3.1 RF-EMF (450 to 6000 MHz) and adverse effects on reproduction /development in humans.

About 2800 studies in this review conformed to pre-set inclusion criterion. Additional records identified through reviewed articles revealed some further eligible articles. However, only a total of 40 articles were used for data extraction, and 26 epidemiological studies were reviewed as being adequate in methodology. The result of the review are presented in Table 18.

- **Man fertility**

In recent years, we have observed a general increasing percentage of male infertility. It has been attributed to an array of environmental, health and lifestyle factors.

Sperm count, motility, DNA integrity, sperm viability and morphology were the most affected parameters when men are exposed to RF-EMF.

FR1 (450 to 6000 MHz): There is sufficient evidence of the association between RF-EMF exposure and adverse effect on fertility in man.

- **Pregnant women exposure**

Miscarriage and pre-term birth among women heavily using mobile-phones during pregnancy was described as possibly associated to the exposure of the embryo/foetus during gestation; the studies are too limited in number and inadequate for exposure assessment in order to reach definitive conclusions. An association can neither be excluded nor confirmed.

FR1 (450 to 6000 MHz): There is limited evidence of the association between RF-EMF exposure and adverse effect on fertility woman.

- **Developmental effects in offspring**

In offspring, behavioural difficulties and motor/cognitive/language delay were examined by epidemiological cross-sectional and cohort studies; the results are mixed (conflicting) and not conclusive. An association can neither be excluded nor confirmed.

FR1 (450 to 6000 MHz): There is limited evidence of the association between RF-EMF exposure and adverse effect on offspring health.

5.3.2 RF-EMF (450 to 6000 MHz) and adverse effects on reproduction /development in experimental animals.

An important aspect of safety assessment of chemical and physical agents is determining their potential reproductive and developmental toxicity. A number of guidelines have outlined a series of separate reproductive and developmental toxicity studies from fertilisation through adulthood and in some cases to second generation.

The OECD Test Guideline 443 is designed to provide an evaluation of reproductive and developmental effects that may occur as a result of pre- and postnatal chemical exposure as well as an evaluation of systemic toxicity in pregnant and lactating females and young and adult offspring. This Test Guideline is designed to provide an evaluation of reproductive and developmental effects that may occur as a result of pre- and postnatal chemical exposure as well as an evaluation of systemic toxicity in pregnant and lactating females and young and adult offspring.

The Extended One-Generation Reproductive Toxicity Study (EOGRTS) is the most recent and comprehensive guideline in this series. EOGRTS determines toxicity during preconception, development of embryo/fetus and newborn, adolescence, and adults, with specific emphasis on the nervous, immunological, and endocrine systems, EOGRTS also assesses maternal and paternal toxicity.

The objective of the prenatal developmental toxicity study is to provide general information concerning the effects of prenatal exposure on the pregnant test animal and on the developing organism. More specifically, the developmental toxicity study aims to identify direct and indirect effects on embryonic and foetal development resulting from exposure to the agent; identify any maternal toxicity; establish the relationship between observed responses and dose in both dam and offspring; establish NOAELs (no observed adverse for maternal toxicity and pup development).

We selected and analysed animal studies considering their compliance with the guidelines mentioned, though our approach tended to be inclusive when the number of animals, exposure assessment and procedure were considered acceptable.

Table 27 summarises the results. Among the different adverse effects of FR1, the most evident was the impairment of sperm quality.

Structural and/or physiological analyses of the testes showed degenerative changes, reduced testosterone level, increased apoptotic cells, and increased production of reactive oxygen species (ROS).

For all other parameters results were limited and they do not allow conclusive evaluation.

➢ **Male fertility**

As regards RF-EMF exposure, sperm count, motility, DNA integrity, sperm viability and morphology were the most affected parameters when experimental animals are exposed to RF-EMF.

FR1 (450 to 6000 MHz): There is sufficient evidence of the association between RF-EMF exposure and adverse effect on fertility in male experimental animals.

➢ **Female fertility**

The studies are too limited in number in order to reach definitive conclusions. The two adequate studies examined, show adverse effects, but an association cannot be denied, nor confirmed.

FR1 (450 to 6000 MHz): There is limited evidence of the association between RF-EMF exposure and adverse effect on fertility in female experimental animals.

➢ **Developmental effects in offspring**

In offspring, gestation duration, foetal growth, litter characteristics, neurobehavioural effects were examined by experimental bioassays in rodents. Some studies were positive, but results are often conflicting for different studies and limitations were observed in exposure assessment. So, results were not conclusive. An association cannot be denied, nor confirmed.

FR1 (450 to 6000 MHz): There is limited evidence of the association between RF-EMF exposure and adverse effect on developmental parameters both in dams and offspring.

5.4 Adverse effect on reproduction/development and higher telecommunication frequencies (FR2: 24 to 100 GHz)

5.4.1 Adverse effect on reproduction/development in humans (FR2: 24 to 100 GHz)

The few available epidemiological studies we have analysed were performed on occupationally exposed men (Table 20). Adverse effects on sperm fertility were reported. However, the two available cross-sectional studies have the limit of self-reported exposure or assessment done by job title. An association cannot be denied, or confirmed. From our search, developmental adverse effects on these higher frequencies were not adequately studied in the human population.

FR2 (24 to 100 GHz): No adequate studies were performed on this band of higher frequencies.

5.4.2 Adverse effect on reproduction/development in experimental animal studies (FR2: 24 to 100 GHz)

In the few studies designed for the higher frequencies, only thermal adverse effects were adequately studied.

FR2 (24 to 100 GHz): No adequate studies were performed on this band of higher frequencies.

6. Conclusions

6.1 Telecommunication frequencies FR1 450 MHz – 6000 MHz

6.1.1 Cancer in humans

There is limited evidence in humans for the carcinogenicity of radiofrequency radiation. Starting from 2011, positive associations have again been observed between exposure to radiofrequency radiation from wireless phones and glioma and acoustic neuroma, but the evidence is not yet sufficiently strong to establish a direct relationship.

6.1.2 Cancer in experimental animals

There is sufficient evidence in experimental animals for the carcinogenicity of radiofrequency radiation.

6.1.3 Reproductive/developmental effects in humans

There is sufficient evidence of adverse effects on the fertility of men. There is *limited* evidence of adverse effects on fertility in women. There is *limited* evidence on developmental effects in offspring of mothers who were heavy users of mobile phones during pregnancy.

6.1.4 Reproductive/developmental effects in experimental animals

There is sufficient evidence of adverse effects on male rat and mouse fertility. There is *limited* evidence of adverse effects on female mouse fertility. There is *limited* evidence of adverse effects on the development in offspring of rats and mice exposed during embryo life.

6.2 Telecommunication frequencies FR2: 24 to 100 GHz

6.2.1 Cancer in humans

The few inadequate data available do not allow any evaluation.

6.2.2 Cancer in experimental animals

No available data.

6.2.3 Reproductive/developmental effects in humans

No available data.

6.2.4 Reproductive/developmental effects in experimental animals

No available data.

6.3 Overall evaluation

6.3.1 Cancer

FR1 (450 to 6000 MHz): As a synthesis of what we have managed to analyse in the available scientific literature, in both human and animal studies, we can say that RF-EMF at FR1 frequencies exposure probably cause cancer, and in particular gliomas and acoustic neuromas in humans.

FR2 (24 to 100 GHz): No adequate studies were performed on non thermal effects of the higher frequencies.

6.3.2 Reproductive developmental effects

FR1(450 to 6000 MHz): These frequencies *clearly* affect male fertility. These frequencies *possibly* affect female fertility. They *possibly* have adverse effects on the development of embryos, foetuses and newborns.

FR2 (24 to 100 GHz): *No adequate* studies were performed on non-thermal effects of the higher frequencies.

7. Policy options

The policy options resulting from the present report – applying to the 5G frequencies (700 MHz, 3600 MHz, 26 GHz) and bearing in mind that the 2G, 3G and 4G frequencies will continue to be used for many years – are reported below.

7.1 Opting for novel technology for mobile phones that enables RF exposures to be reduced

The source of RF emissions that seems at present to pose the greatest threat is the mobile phone. Though transmitting installations (radiobase masts) are perceived by some people as providing the greatest risk, actually the greatest burden of exposure in humans generally derives from their own mobile phones, and epidemiological studies have observed a statistically significant increase in brain tumours and Schwann cell tumours of the peripheral nerves, mainly among heavy cell-phone users.

We accordingly need to ensure that increasingly safer telephone devices are manufactured, emitting low energy and if possible only working when at a certain distance from the body. The cable earpiece solves much of the problem, but is inconvenient and hence puts users off; on the other hand, it is not always possible to use a speakerphone mode.

The option of lowering RF-EMF exposure as much as possible in connection with telephones still applies whatever the frequencies, from 1G to 5G. Countries such as the USA and Canada, which enforced stricter mobile phone SAR limits than Europe, were still able to build efficient 2G, 3G and 4G communications (Madjar, 2016). Since 5G aims to be more energy-efficient than the previous technologies, adopting stricter limits in the EU for mobile phone devices will be simultaneously a sustainable and a precautionary approach.

7.2 Revising the exposure limits for the public and the environment in order to reduce RF exposures from cell towers

Recently European policies (European Commission, 2019) have promoted the sustainability of a new economic and social development model which uses new technologies to constantly monitor the planet's state of health, including climate change, the energy transition, agro-ecology and the preservation of biodiversity. Using the lowest frequencies of 5G and adopting precautionary exposure limits such as those used in Italy, Switzerland, China and Russia, among others, and which are significantly lower than those recommended by ICNIRP, could help achieve these European sustainability objectives.

What epidemiological studies already showed in 2011 (IARC, 2013) has been confirmed by studies on laboratory animals, especially concerning the connection between exposure to RF-EMF and the carcinogenic effect in the nervous system. The safety level currently allowed in Europe is 61 V/m (ICNIRP, 2020a). The lowest dose at which those effects have been experimentally observed for far-field exposure is 50 V/m. In the same experimental study (Falcioni et al, 2018) any carcinogenic effect was observed at 5 V/m.

In light of this result, one policy option might be to revise residential and public exposure maxima throughout Europe. Levels could be reduced by at least 10 times, i.e. to around 6 V/m, which is an exposure level at which no cancer effects in experimental animals have been observed. 6 V/m seems also to be the precautionary limit where no adverse effects on fertility are concerned. It may sound impractically low if we are to expand telecommunications by 5G, but it is not so.

In Italy, for example, the law sets a top limit of 20V/m, though wherever people are constantly exposed for over four hours (homes, workplaces, schools, centres of congregation, etc.) the critical value is set at 6 V/m. This limit is very close to the 5 V/m we mentioned before as being safe for experimental animals. NOAEL values ("*No Observed Adverse Effect Level*") in experimental studies are commonly used in risk assessments and research (Gaylor, 1999).

In many Italian towns, including Bologna, 5G has already been operating at a frequency of 3600 MHz. Monitoring data show that the mean exposure in the municipality of Bologna was 1.97 V/m for 2019 (peaking at 4.62 V/m in one specific instance). Statistics for 2020 are still being processed, but in no cases have the values prescribed by Italian law been exceeded. For the moment, then, it does seem possible to develop new installations whilst keeping within the legal limit.

Another example is Paris. The city has reached an agreement with France's four main mobile network operators aimed at introducing stricter network radiation norms. The RF-EMF exposure limit was lowered to 5 V/m from the previous 7 V/m for indoor spaces, representing a 30 percent reduction at the frequency reference of 900 MHz, setting a lower limit than the one adopted in Brussels (6 V/m) or Rome (6 V/m). The agreement, approved by the municipality of Paris in 2017, also includes plans for a new monitoring service to help measure EMF levels within buildings. Brussels is a third example of the adoption of a 6 V/m lower limit.

7.3 Adopting measures to incentivise the reduction of RF-EMF exposures

Much of the remarkable performance of new wireless 5G technology can also be achieved by using optic-fibre cables and by adopting engineering and technical measures to reduce exposures from 2-4G systems (Keiser, 2003; CommTech Talks, 2015; Zlatanov, 2017). This would minimise exposure, wherever connections are needed at fixed sites. For example, we could use optic fibre cables to connect schools, libraries, workplaces, houses, public buildings, all new buildings etc. Public gathering places could be 'no RF-EMF' areas (as we have for cigarette smoking) so as to avoid the passive exposure of people not using a mobile phone or long-range transmission technology, thus protecting many vulnerable elderly or immune-compromised people, children, and those who are electro-sensitive.

7.4 Promoting multidisciplinary scientific research to assess the long-term health effects of 5G and to find an adequate method of monitoring exposure to 5G

The literature contains no adequate studies by which to exclude the risk that tumours and adverse effects on reproduction and development may occur upon exposure to 5G MMW, or to exclude the possibility of some synergistic interactions between 5G and other frequencies that are already being used. This makes the introduction of 5G fraught with uncertainty concerning both health issues and forecasting/monitoring the actual exposure of the population: these gaps in knowledge are invoked to justify the call for a moratorium on 5G MMW, pending adequate research being completed.

In light of these uncertainties, one policy option is to promote multidisciplinary team research into various factors concerning exposure assessment and also into the biological effects of 5G MMW, both on humans and on the flora and fauna of the environment, non-human vertebrates, plants, fungi and invertebrates, at frequencies between 6 and 300 GHz. The results of these studies could form the basis for developing evidence-based policies regarding RF-EMF exposure of human and non-human organisms to 5G MMW frequencies. Further studies are needed to better and independently explore the health effects of RF-EMF in general and of MMW in particular.

REACH aims to improve the protection of human health and the environment through better and earlier identification of the intrinsic properties of chemical substances. EU REACH regulates the registration, evaluation, authorisation and restriction of chemicals. It also aims to enhance innovation and competitiveness of the EU chemicals industry. EU REACH is based on the principle, "*no data no market*", placing responsibility on industry to provide safety information on substances. Manufacturers and importers are required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database at the European Chemicals Agency (ECHA) in Helsinki. One policy option can be to apply the same approach used for chemical agents to all types of technological innovation.

7.5 Promoting information campaigns on 5G

Unfortunately, there is a lack of information on the potential harms of RF-EMF. The information gap creates scope for deniers as well as alarmists, giving rise to social and political tension in many EU countries (OECD, 2017). Campaigns to inform the citizens should be therefore a priority.

Information campaigns should be carried out at all levels, beginning with schools. They should show the potential health risks, but also the opportunities for digital development, what infrastructural alternatives exist for 5G transmission, the safety measures (exposure limits) taken by the EU and Member States, and the correct use of the mobile phone. Only by sound and accurate information can we win back citizen trust and reach a shared agreement over a technological choice which, if properly managed, can bring great social and economic benefits.

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Recent decades have experienced an unparalleled development in wireless communication technologies (mobile telephony, Wi-Fi). The imminent introduction of 5G technology across the EU is expected to bring new opportunities for citizens and businesses, through faster internet browsing, streaming and downloading, as well as through better connectivity. However, 5G, along with 3G and 4G, with which it will operate in parallel for several years, may also pose threats to human health. This STOA report aim to take stock of our present understanding of health effects of 5G.

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Case Report

How does long term exposure to base stations and mobile phones affect human hormone profiles?

Emad F. Eskander *, Selim F. Estefan, Ahmed A. Abd-Rabou

Hormones Department, Medical Research Division, National Research Centre, Cairo, Egypt

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ABSTRACT

Objectives: This study is concerned with assessing the role of exposure to radio frequency radiation (RFR) emitted either from mobiles or base stations and its relations with human's hormone profiles.

Design and methods: All volunteers' samples were collected for hormonal analysis.

Results: This study showed significant decrease in volunteers' ACTH, cortisol, thyroid hormones, prolactin for young females, and testosterone levels.

Conclusion: The present study revealed that high RFR effects on pituitary–adrenal axis.

Introduction

Because of the increase in the usage of wireless communication devices of mobile phones in recent years, there is an anxious concern on the possible hazardous effects of prolonged exposure to radio frequency radiation (RFR) [1]. In considering the biological effects of RFR, the intensity and frequency of the radiation and exposure duration are important determinants of the responses.

It has been reported that exposure to RFR could affect the nervous system [2]. Hardell et al. found that cell phone users had an increased risk of malignant gliomas [3]. Subjecting human spermatozoa to RFR showed decrease in sperms motility and vitality and increase in DNA fragmentation [4]. The authors hypothesize that the high sporadic incidence of the clinical symptoms of the autoimmune multiple Sclerosis disease [5] may be a result of long exposure to RFR from mobiles.

This study is concerned with assessing the effect of RFR emitted from mobile phones and base stations on human hormone profiles, with anticipation to offer recommendations to assure health care and safety for humans continuously exposed to radio frequency radiation.

Design and methods

Study subjects

This study was conducted for 6 years on 82 mobile phone volunteers with age ranges 14–22 years ($n=41$) and 25–60 years ($n=41$). Those users were divided into three subgroups according to the time of their exposure to RFR: (weak $n=19$), (moderate $n=9$), and (strong $n=13$) per day, in addition to 20 negative control subjects.

On the other hand, volunteers exposed to RFR emitted from base stations ($n=34$) were selected with age ranges 14–22 years ($n=17$), and 25–60 years ($n=17$) and living at distances 20–100 m and 100–500 m apart from the base station. Additional 10 subjects of each age range living at a distance more than 500 m apart from the base station were considered as negative control group.

The source of the RFR (base stations or mobile phones) was GSM-950 MHz magnetic field and the ICNIRP-Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic field (up to 300 GHz) (International Commission on Non-Ionizing Radiation Protection). The present study was approved by the Ethics Committee of National Research Centre.

Volunteers inclusion criteria

Volunteers participated in the study fulfilled the following inclusion criteria: age 14–60 years, mobile phone users, or living at distances 20–100 m and 100–500 m apart from the base station.

* Corresponding author at: Hormones Department, Medical Research Division, National Research Centre, Cairo, 12622, Egypt. Fax: +20 2 33370931.
E-mail address: gysi_pharma@yahoo.com (E.F. Eskander).

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Blood samples collection

Blood samples of the volunteers were analyzed for estimation of the following hormones: plasma ACTH, serum cortisol, total T_3, T_4, prolactin, progesterone, and testosterone levels. All volunteers followed for 6 years and the blood samples were collected regularly from mobile phone users, volunteers exposed to RFR emitted from base stations, and the controls for time intervals after 1 year, 3 years and 6 years for hormonal analysis. The determination of the hormonal profile was performed on serum samples whereas ACTH was detected in EDTA plasma. The whole blood was collected in EDTA tube.

Blood samples were withdrawn from females to measure serum prolactin and progesterone levels. Whereas, blood samples were withdrawn from males to measure serum testosterone level. Blood samples were withdrawn from both males and females to measure plasma ACTH level, serum cortisol, total T_3 and T_4 levels.

Methods

Plasma ACTH, serum total T_3, and T_4 levels were determined quantitatively using DSL-ELISA Kits provided by (Diagnostic Systems Laboratories Inc.). Measurement of serum cortisol level was carried out using ELISA kit provided by Adaltis Italia SPA Company (Italy). Serum prolactin, progesterone, and testosterone concentrations were measured using ELISA kit supplied by (DRG International, Inc., USA).

Statistical analysis

The data were analyzed using SPSS program (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA, 2001).

Results

Volunteers mean hormone values

Follow up data were available for all volunteers who were exposed to RFR either from mobiles or base stations. The clinical features of all individuals were summarized in tables.

Tables 1 and 2 illustrate that persons of ages 14–22 years or 25–60 years who were exposed, for time intervals extended to 6 years, to RFR either from mobile phones or from base stations suffered significant decreases in their plasma ACTH and serum cortisol levels as compared to the control group. High significant decrease ($P<0.01$) in plasma ACTH and serum cortisol levels was observed for persons exposed to RFR from base stations at distances extended from 20 to 500 m for a period of 6 years as compared to the control group.

Tables 1 and 2, also show that persons of ages 14–22 years and 25–60 years who were exposed, for time intervals extended to 6 years, to RFR either from mobile telephones or from base stations suffered high significant ($P<0.01$) decrease in their serum T_3 and T_4 levels.

Tables 1 and 2 show that young females (14–22 years) exposed to RFR from mobile phones or from base stations at distances 20–100 m and 100–500 m suffered decrease in their serum prolactin level and the rate of decrease significantly rose with increased time of exposure from 1 year up to 6 years. Conversely, the serum prolactin level for adult females (25–60 years) showed significant increase along the time of exposure 1 year up to 6 years.

Table 1 shows that serum progesterone levels in young and adult females exposed to RFR from mobile phones were non-significantly changed through exposure for 1 year up to 6 years as compared to healthy controls.

Table 2 shows that both young (14–22 years) and adult (25–60 years) females exposed to RFR from base stations did not suffer any change in their serum progesterone levels throughout the first year of exposure. However, with increasing exposure periods from 3 up to 6 years they suffered significant decrease in their serum progesterone levels.

Tables 1 and 2 illustrate that both young males (14–22 years) and adult males (25–60 years) exposed to RFR from mobile phones or from base stations experienced gradual decrease in their serum testosterone level with increasing the period of exposure.

Discussion

The intensity and frequency of RFR and exposure duration are important determinants of the cumulative effect that could occur and lead to an eventual breakdown of homeostasis and adverse health consequences. Therefore, greater commitment from policy makers, health care officials and providers is needed to raise public awareness about the hazardous outcomes of long term exposure to RFR.

As mentioned in our results, persons who were exposed to RFR suffered significant decreases in their ACTH and cortisol levels as compared to controls. This result is agreed with the previous study indicating that cortisol levels were decreased after exposure to RF [12]. The current result is in contradiction with a previous study indicating that electromagnetic fields have a slight elevation in human cortisol production [6] and with other previous study suggesting that cortisol concentration as a marker of adrenal gland function was not affected with RFR [11]. Djeridane et al. (2008) added that ACTH was not disrupted by RFR emitted by mobile phones [12].

Our results reveal that persons who were exposed to RFR either from mobile phones or base stations suffered highly significant decrease in their serum T_3 and T_4 levels which agree in case of low T_4 levels and disagree in case of low T_3 concentrations with previous study which suggested that serum T_3 remains in normal range [7].

In the present study, females exposed to RFR from mobile phones or base stations suffered change in their serum prolactin level and the rate of change significantly rose with increased time of exposure which is in converse with previous studies indicating that serum prolactin concentration remained within normal ranges after exposure to radiocellular phones [8,12]. Therefore, it is suggested that the menstrual cycle and the pregnancy will be affected by changing the level of serum prolactin which seems necessary to be optimized in these two processes.

Our study suggested that serum progesterone levels in young and adult females exposed to RFR from mobile phones non-significantly changed from 1 year up to 6 years as compared to healthy controls. So, the menstrual cycle and pregnancy may not be affected by serum progesterone concentration. Previous study revealed that microwaves produced significant increases in serum progesterone level only in pregnant rats [9].

In the present study, both young and adult males exposed to RFR from mobile phones or base stations experienced gradual decrease in their serum testosterone level with increasing the period of exposure which is almost the same as previously recent reported studies suggested that exposure to mobile radiation leads to reduction in serum testosterone and it possibly affects reproductive functions [10,11]. The present study is in converse with a previous study indicating that testosterone was not disrupted by RFR emitted by mobile phones [12].

In conclusion, the present study revealed that high RFR emitted from either mobile phone or base station has tangible effects on pituitary–adrenal axis represented in the reduction of ACTH and consequently cortisol levels. Also, exposure to RFR is associated with decrease in the release of thyroid hormones.

Moreover, our data suggested that each of serum prolactin in young females, and testosterone levels in males significantly dropped due to long-term exposure to RFR. Conversely, the serum prolactin levels for the adult females significantly rose with increasing exposure time. Finally, the degenerative effects of exposure to RFR were more pronounced for persons who used mobile phones for long periods of 6 years. Also, the effect of this type of radiation was more

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Table 1
Plasma ACTH, serum cortisol, T3, T4, prolactin, progesterone, and testosterone of volunteers exposed to RFR from mobile phones.

Hormones (mean ± SE)	Groups											
	Controls						Mobile phone users					
	1 Year		3 Years		6 Years		1 Year					
	Age_1	Age_2	Age_1	Age_2	Age_1	Age_2	Age_1			Age_2		
							S	M	W	S	M	W
Plasma ACTH (pg/mL)	61.1 ± 1.1	63.2 ± 0.1	59.9 ± 0.2	62.3 ± 1.0	59.9 ± 0.3	60.2 ± 1.7	49.1 ± 0.3[b]	55.0 ± 1.1[b]	59.2 ± 0.1[NS]	53.2 ± 1.2[b]	58.3 ± 0.4[b]	62.1 ± 1.1[NS]
Serum cortisol (μg/mL)	30.0 ± 1.2	31.2 ± 0.1	30.0 ± 0.1	31.7 ± 0.3	29.9 ± 0.2	28.8 ± 2.3	20.3 ± 1.1[b]	27.3 ± 0.1[a]	30.1 ± 0.3[NS]	23.9 ± 1.0[b]	28.2 ± 0.9[b]	30.3 ± 1.1[NS]
Serum T_3 (ng/dL)	105.2 ± 1.3	102.0 ± 1.1	101.7 ± 1.2	98.6 ± 2.1	103.6 ± 1.1	99.0 ± 1.4	96.3 ± 1.2[b]	100.0 ± 0.6[b]	102.1 ± 1.3[NS]	93.9 ± 1.1[b]	98.1 ± 0.3[a]	99.0 ± 0.7[a]
Serum T_4 (μg/dL)	7.8 ± 0.6	6.9 ± 1.4	7.7 ± 1.1	6.5 ± 0.7	7.1 ± 0.3	6.6 ± 2.1[b]	6.9 ± 0.1[NS]	7.0 ± 0.1[NS]	6.9 ± 0.1[NS]	6.3 0.8[b]	6.2 ± 1.2[NS]	6.0 ± 1.0[NS]
Serum prolactin (ng/mL)	17.8 ± 1.1	17.2 ± 1.2	17.3 ± 1.1	16.9 ± 1.3	17.0 ± 2.1	16.8 ± 0.5	14.9 ± 1.4[a]	14.7 ± 0.3[a]	17.3 ± 0.2[NS]	18.3 ± 0.1[a]	16.9 ± 0.3[a]	17.1 ± 0.2[NS]
Serum progesterone (pg/mL)	14.0 ± 1.3	17.1 ± 1.0	13.8 ± 1.2	16.9 ± 0.9	12.9 ± 1.3	16.8 ± 0.2	12.3 ± 1.1[NS]	12.2 ± 1.2[NS]	14.1 ± 0.7[NS]	16.1 ± 1.4[NS]	17.6 ± 0.3[NS]	16.5 ± 0.4[a]
Serum testosterone (pg/mL)	29.5 ± 1.2	25.2 ± 1.6	28.9 ± 1.8	24.3 ± 0.6	28.4 ± 0.3	24.0 ± 0.1	25.2 ± 0.2[a]	24.9 ± 0.1[a]	23.7 ± 0.4[a]	22.7 ± 1.2[a]	23.8 ± 0.4[NS]	19.9 ± 0.1[a]

Age_1: represents age from 14 to 22 years, Age_2: represents age from 25 to 60 years.S: represents Strong, M: represents Moderate, W: represents Weak.N Control = 10, N Strong = 13, N Moderate = 9, N Weak = 19.Strong use: more than 60 min/day, Moderate use: between 30–60 min/day, Weak use: less than 10 min/day.NS: non-significant change when comparing mobile phone users with controls.aSignificant difference at $P > 0.05$ when comparing mobile phone users with controls.bSignificant difference at $P > 0.01$ when comparing mobile phone users with controls.

Table 1 (*continued*)

Hormones (mean ± SE)	Groups											
	Mobile phone users											
	3 Years						6 Years					
	Age_1			Age_2			Age_1			Age_2		
	S	M	W	S	M	W	S	M	W	S	M	W
Plasma ACTH (pg/mL)	45.3 ± 0.6[b]	51.2 ± 1.3[b]	55.0 ± 1.1[b]	50.2 ± 0.4[b]	55.1 ± 1.1[b]	60.0 ± 0.3[b]	40.3 ± 0.4[b]	41.3 ± 1.1[b]	47.2 ± 0.2[b]	48.2 ± 0.4[b]	51.3 ± 1.3[b]	57.2 ± 1.1[b]
Serum cortisol (μg/mL)	18.3 ± 1.4[b]	20.2 ± 1.1[b]	25.1 ± 0.1[b]	20.3 ± 1.1[b]	25.9 ± 0.9[b]	20.3 ± 1.2[b]	18.0 ± 0.1[b]	17.3 ± 1.1[b]	20.3 ± 0.2[b]	17.0 ± 0.2[b]	22.0 ± 0.4[b]	24.1 ± 0.2[b]
Serum T_3 (ng/dL)	87.2 ± 1.3[b]	90.2 ± 1.6[b]	94.3 ± 1.1[b]	89.8 ± 1.1[b]	92.9 ± 1.3[b]	95.0 ± 1.1[b]	80.3 ± 1.1[b]	84.2 ± 0.5[b]	85.7 ± 1.1[b]	83.2 ± 1.3[b]	80.3 ± 1.1[b]	90.2 ± 0.7[b]
Serum T_4 (μg/dL)	7.9 ± 1.1[b]	7.6 ± 1.7[NS]	7.1 ± 1.3[NS]	6.4 ± 0.3[NS]	6.3 ± 0.8[NS]	6.1 ± 0.3[NS]	10.5 ± 0.1[b]	9.5 ± 1.1[NS]	8.9 ± 0.4[b]	7.4 ± 0.9[NS]	7.7 ± 1.3[NS]	8.0 ± 1.1[NS]
Serum prolactin (ng/mL)	17.4 ± 1.2[a]	9.8 ± 0.3[b]	9.7 ± 0.1[b]	23.5 ± 0.2[b]	19.2 ± 1.1[b]	18.7 ± 0.9[b]	10.1 ± 1.0[b]	8.7 ± 0.3[a]	8.7 ± 0.4[NS]	24.9 ± 0.1[b]	21.1 ± 0.3[b]	20.6 ± 0.1[b]
Serum progesterone (pg/mL)	13.9 ± 0.2[NS]	13.6 ± 0.7[NS]	13.4 ± 0.4[NS]	15.1 ± 0.3[a]	14.9 ± 0.1[a]	13.0 ± 0.5[b]	12.9 ± 0.2[a]	11.8 ± 0.1[a]	10.9 ± 0.3[a]	14.8 ± 1.1[b]	13.5 ± 1.3[NS]	12.8 ± 0.1[NS]
Serum testosterone (pg/mL)	19.8 ± 0.1[b]	18.7 ± 0.2[a]	16.5 ± 0.1[a]	17.5 ± 0.2[b]	16.9 ± 1.1[a]	16.1 ± 0.3[a]	13.1 ± 0.4[b]	12.7 ± 0.2[b]	12.3 ± 0.1[b]	11.1 ± 1.1[b]	11.4 ± 0.2[b]	9.8 ± 0.3[b]

Table 2
Plasma ACTH, serum cortisol, T3, T4, prolactin, progesterone, and testosterone of volunteers exposed to RFR from base stations.

Hormones (mean ± SE)	Groups								
	Controls (distance 500 m)						Volunteers exposed to RFR from base stations		
	1 Year		3 Years		6 Years		1 Year		
	Age_1	Age_2	Age_1	Age_2	Age_1	Age_2	Age_1		Age_2
							D_1	D_2	D_1
Plasma ACTH (pg/mL)	62.8 ± 1.2	58.3 ± 0.9	62.5 ± 0.3	58.4 ± 0.5	62.4 ± 0.7	58.9 ± 0.1[a]	61.9 ± 0.2[NS]	62.3 ± 0.1[NS]	57.9 ± 1.3[NS]
Serum cortisol (μg/mL)	33.3 ± 2.6	30.1 ± 1.4	32.9 ± 1.1	30.3 ± 1.4	32.7 ± 1.1	29.9 ± 1.9	32.4 ± 1.2[NS]	32.9 ± 0.3[NS]	28.8 ± 1.6[NS]
Serum T3 (ng/ dl)	108.3 ± 1.6	100.0 ± 1.1	107.0 ± 1.9	100.0 ± 0.1	107.0 ± 0.1	99.9 ± 1.2	107.0 ± 1.1[NS]	107.9 ± 0.4[NS]	106.0 ± 1.1[NS]
Serum T4 (μg/dL)	7.2 ± 1.3	6.3 ± 0.3	6.8 ± 1.2	6.3 ± 0.1	6.7 ± 1.2	6.2 ± 2.4	6.9 ± 0.3[NS]	7.1 ± 1.1[NS]	5.9 ± 1.1[NS]
Serum prolactin (ng/mL)	18.3 ± 1.1	14.3 ± 1.6	18.0 ± 1.0	13.9 ± 1.2	18.0 ± 1.2	13.1 ± 0.2	17.6 ± 0.2[NS]	17.6 ± 1.3[NS]	19.1 ± 0.3[b]
Serum progesterone (pg/mL)	12.4 ± 1.1	10.0 ± 0.8	12.3 ± 1.6	10.0 ± 0.5	12.2 ± 1.9	9.8 ± 2.4	12.3 ± 1.1[NS]	12.3 ± 1.0[NS]	10.1 ± 0.9[NS]
Serum testosterone (pg/mL)	27.1 ± 0.3	24.2 ± 1.1	26.3 ± 1.1	23.2 ± 1.3	25.8 ± 1.4	22.9 ± 2.1	243 ± 1.1[b]	24.9 ± 1.9[NS]	20.1 ± 1.1[b]

Age_1: represents age from 14 to 22 years, Age_2: represents age from 25 to 60 years. D_1: represents distance from 20 to 100 m, D_2: represents distance from 100 to 500 m. N Control = 10, N Strong = 13, N Moderate = 9, N Weak = 19. NS: non-significant change when comparing persons exposed to base stations with controls. a Significant difference at $P > 0.05$ when comparing persons exposed to base stations with controls. b Significant difference at $P > 0.01$ when comparing persons exposed to base stations with controls.

Table 2 (*continued*)

Hormones (mean ± SE)	Groups								
	Volunteers exposed to RFR from base stations								
	1 Year	3 Years				6 Years			
	Age_2	Age_1		Age_2		Age_1		Age_2	
	D_2	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
Plasma ACTH (pg/mL)	58.0 ± 0.9[NS]	51.8 ± 1.7[b]	54.6 ± 1.1[b]	54.2 ± 0.6[b]	45.2 ± 1.8[NS]	47.3 ± 1.3[b]	48.3 ± 1.4[b]	40.7 ± 0.3[b]	43.1 ± 1.1[b]
Serum cortisol (μg/mL)	29.1 ± 1.3[NS]	27.2 ± 1.2[b]	27.4 ± 2.1[NS]	25.6 ± 0.1[b]	26.6 ± 1.1[NS]	21.2 ± 0.4[b]	22.4 ± 1.1[b]	22.9 ± 1.1[b]	24.2 ± 0.3[b]
Serum T3 (ng/ dl)	100.1 ± 0.2[NS]	97.3 ± 1.6[b]	98.1 ± 0.9[b]	97.4 ± 1.1[NS]	98.2 ± 1.9[NS]	78.0 ± 1.1[b]	82.3 ± 1.9[b]	91.3 ± 1.5[b]	93.4 ± 1.9[b]
Serum T4 (μg/dL)	6.1 ± 0.3[NS]	4.4 ± 1.8[NS]	4.9 ± 0.3[NS]	5.1 ± 0.3[b]	5.9 ± 0.8[NS]	2.7 ± 0.1[b]	2.8 ± 1.2[b]	3.8 ± 1.2[b]	3.9 ± 1.9[b]
Serum prolactin (ng/mL)	19.6 ± 1.1[b]	97.3 ± 1.6[b]	98.1 ± 0.9[b]	97.4 ± 1.1[NS]	98.2 ± 1.9[NS]	78.0 ± 1.1[b]	82.3 ± 1.9[b]	91.3 ± 1.5[b]	93.4 ± 1.9[b]
Serum progesterone (pg/mL)	10.5 ± 1.1[NS]	4.4 ± 1.8[NS]	4.9 ± 0.3[NS]	5.1 ± 0.3[b]	5.9 ± 0.8[NS]	2.7 ± 0.1[b]	2.8 ± 1.2[b]	3.8 ± 1.2[b]	3.9 ± 1.9[b]
Serum testosterone (pg/mL)	20.3 ± 1.6[NS]	20.2 ± 0.4[b]	20.9 ± 0.9[b]	18.1 ± 1.1[b]	18.6 ± 1.3[b]	11.8 ± 0.3[b]	10.9 ± 1.6[b]	15.3 ± 1.2[b]	16.1 ± 1.5[b]

obvious for persons living nearby base stations and exposed for a period of 6 years.

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Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study

Claudio Gómez-Perretta,[1] Enrique A Navarro,[2] Jaume Segura,[3] Manuel Portolés[1]

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[1]Research Center, University Hospital La Fe, Valencia, Spain
[2]Department of Applied Physics, Universitat de València, Valencia, Spain
[3]Department of Computer Sciences, ETSE-Universitat de València, Valencia, Spain

Correspondence to
Professor Enrique A Navarro; enrique.navarro@uv.es

ABSTRACT

Objectives: We performed a re-analysis of the data from Navarro *et al* (2003) in which health symptoms related to microwave exposure from mobile phone base stations (BSs) were explored, including data obtained in a retrospective inquiry about fear of exposure from BSs.

Design: Cross-sectional study.

Setting: La Ñora (Murcia), Spain.

Participants: Participants with known illness in 2003 were subsequently disregarded: 88 participants instead of 101 (in 2003) were analysed. Since weather circumstances can influence exposure, we restricted data to measurements made under similar weather conditions.

Outcomes and methods: A statistical method indifferent to the assumption of normality was employed: namely, binary logistic regression for modelling a binary response (eg, suffering fatigue (1) or not (0)), and so exposure was introduced as a predictor variable. This analysis was carried out on a regular basis and bootstrapping (95% percentile method) was used to provide more accurate CIs.

Results: The symptoms most related to exposure were lack of appetite (OR=1.58, 95% CI 1.23 to 2.03); lack of concentration (OR=1.54, 95% CI 1.25 to 1.89); irritability (OR=1.51, 95% CI 1.23 to 1.85); and trouble sleeping (OR=1.49, 95% CI 1.20 to 1.84). Changes in −2 log likelihood showed similar results. Concerns about the BSs were strongly related with trouble sleeping (OR =3.12, 95% CI 1.10 to 8.86). The exposure variable remained statistically significant in the multivariate analysis. The bootstrapped values were similar to asymptotic CIs.

Conclusions: This study confirms our preliminary results. We observed that the incidence of most of the symptoms was related to exposure levels—independently of the demographic variables and some possible risk factors. Concerns about adverse effects from exposure, despite being strongly related with sleep disturbances, do not influence the direct association between exposure and sleep.

Strengths and limitations of this study

- We used a robust statistical analysis with a highly homogeneous sample in a homogeneous environment.
- A participation bias cannot be ruled out. The late query about concerns (as a possible confounder) may render the results less valid.
- We observed that the incidence of most of the symptoms was related to exposure levels.

The health risk due to exposure to radiofrequency electromagnetic fields (RF EMFs) continues to be discussed today. The study that led to this debate was initiated after verification that the US embassy in Moscow was being subjected to such radiation from 1953 to May 1975.[1] Recently, a review of that episode[2] reopened the debate about the potential harmfulness of RF EMFs. The increasing number of base stations (BSs) on masts and buildings has increased public awareness. This issue has prompted scientific research to establish to what extent low-intensity EMFs may affect the health of humans and other organisms.[3 4] Furthermore, the term electromagnetic hypersensitivity has been recently introduced in discussions attributing symptoms to exposure to EMFs.[5–8] A review of this topic[9] in 2010 found that 8 of the 10 studies evaluated through PubMed had reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances <500 m from BSs.

None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting health. Thus, the need emerges to revaluate our pioneering work in this field in order to add new procedures and data. Few articles have addressed the possible association between microwave sickness and microwave exposure from Global System for Mobile Communications (GSM) BSs since the publication of our first study.[10] Chronologically, Santini *et al*[11] and Gadzicka *et al*[12] reported differences in the distance-dependent prevalence of symptoms such as headache, impaired concentration and irritability. A later Austrian study[13] showed a positive association between the measured electrical field (GSM 900/1800) in bedrooms and headaches, cold hands and feet and difficulties in concentration. An Egyptian study[14] showed a prevalence of neurological symptoms, such as headache, memory changes, dizziness, tremors, depressive symptoms and sleep disturbances among participants directly exposed to GSM signals from BSs.

The symptoms reported by all the above cited authors belong to those attributed to the microwave syndrome.[15] However, one article[16] using personal monitored data from GSM-UMTS frequency bands found no statistical association in adults. More recently, the same authors observed no association in children,[17] contradictory results in children and adolescents,[18] and concluded that the *few observed significant associations were not causal but rather occurred by chance*. Blettner *et al*[19] reported in phase 1 of their study more health problems closer to BSs, but in phase 2[20] they concluded that measured EMF emissions were not related to adverse health effects.

Other researchers focused their work on the possible existence of participants with sensitivity to GSM or UMTS signals according to psychological, cognitive or autonomic assessment. These researchers used short-term exposure (only 30–50 min) under laboratory conditions[21–23] and revealed a large disparity between participants. Recently, a study measuring several biological stress markers[24] found that RF EMF emitted by mobile phone BSs from 5.2 to 2126.8 $\mu W/m^2$ increased cortisol and salivary α-amylase, while IgA concentration was not significantly modified.

The Selbitz study[25] in 2010 described a significant dose–response relationship in symptoms related with sleep, mood, joints, infections, skin condition, as well as neurological, cardiovascular, visual and auditory systems and the gastrointestinal tract.

The existence of short-term physiological effects of EMF on sleep quality was not evident in the work of Danker-Hopfe *et al*[26]; however, it was stated that the presence of BSs per se (not the EMF) may have a negative impact on sleep quality.

A Polish study in 2012 did not show a correlation between electrical field strength and frequency of subjective symptoms; however, it showed a correlation between subjective symptoms and the distance to BSs.[27] A study carried out in Egypt[28] revealed that exposure to EMF emitted either from mobile phones or BSs had significant effects on the pituitary–adrenal axis. More recently, work developed in Iran[29] indicated that symptoms such as nausea, headache, dizziness, irritability, discomfort, nervousness, depression, sleep disturbance, memory loss and lowering of libido were statistically significant in people living near BSs (<300 m distances) compared with those living far from the BSs (>300 m).

In our cross-sectional analysis,[10] 11 of 16 symptoms showed statistically significant higher scores in the group with the maximum exposure level. The symptoms are included in the microwave syndrome. We also reported statistically significant correlation coefficients between the measured electrical field and 14 of 16 symptoms.

A review[30] recently established several conditions for epidemiological studies to be eligible for introduction in general analysis: *eligible studies must quantify exposure using objective measures (such as distance to the nearest BS, spot or personal exposure measurements in a specific frequency range); possible confounders must be considered and the selection of the study population must be clearly free of bias in terms of exposure and outcomes.*

Accordingly, in this reanalysis of our previous study,[10] possible confounders were included in addition to the specific RF EMF measurements made in 2001 (covering the specific range between 900 and 1800 MHz). Therefore, we coanalysed the effects of other variables such as sociodemographic data and the use of electronic devices. Concern about being damaged by radiation from antennas was also analysed.

The new statistical approach tested the possible influences of other variables, such as demographic data and the use of electronic devices. Moreover, since some concerns have been raised about possible health consequences caused by the emitted microwaves, we analysed whether these symptoms might be related to fear of exposure. As some participants refused to allow measurements in their homes, we analysed whether symptom status or subjective distance to the BS could be a bias of participation in the study. Interestingly, this period was free of other sources of RF such as WIFI or UMTS or the massive use of mobile phones, enabling a specific study of GSM technology. Finally, the suitability of the size of the sample was analysed.

METHODS

Study design

We chose a small urban area with mixed rural characteristics: low levels of environmental pollution (more agricultural than industrial); no major differences in socioeconomic characteristics throughout the region (excluding large cities); similar ethnicity (white Caucasian) and language (Spanish) and with mobile phone communication operative for at least 2 years. La Ñora was chosen because it had the features of a small city, and was located near the capital (Murcia) in a rural environment without any particular health or environmental problems. Consequently, La Ñora was representative of small urban areas in eastern Spain with fewer than 20 000 inhabitants—such rural areas accounting for 19.8% of the population and 35.9% of the territory in Spain.

Two BS masts, each about 30 m height, were sited at different positions to provide GSM-900-1800 coverage. The GSM 900 BS was positioned not before 1997 while the GSM 1800 BS was built in December 1999.

Data regarding the main demographic characteristics of the sample and their use of electronic devices was collected through a Spanish-language questionnaire.[11] All of the participants were of the same ethnic origin, shared similar family income levels and general standard of living, and were born in La Ñora or nearby. All the residents in the study were living in the village before the erection of both BSs. All of the residents were at home for more than 8 h a day for at least 6 days a week and normally slept at home.

The core of the questionnaire was a symptom checklist for estimating the frequency of 15 health-related symptoms attributed to microwave sickness. These symptoms were fatigue, irritability, headaches, nausea, loss of appetite, sleep disorders, depressive tendency, dizziness, concentration difficulties, memory loss, skin lesions, visual and hearing deficiencies, walking difficulties and cardiovascular problems. The frequency was quantified as never suffer = 0, sometimes = 1, often = 2 and very often =3.

The percentage of residents who reported electrical transformers less than 10 m from their home was 21.6%, while 42% reported high-voltage power lines less than 100 m from home. Finally, 40% of residents reported a TV transmitter within a radius of around 4 km.

The questionnaire included a statement that its purpose was health research and that the data gathered would be confidential.

Some 215 questionnaires were randomly distributed through 17 streets representing practically the entire village. The houses were selected using a street map of the village. In total, 150 questionnaires were collected with the remainder being uncollected because nobody was at home (31) or there was a refusal by the householder to complete the questionnaire (34).

During 2001, 101 RF EMF measurements in bedrooms were made. The other (49) residents who refused admittance for taking the measurements (16) were not at home for the scheduled measurement appointment (10) or had serious health problems (23).

However, some changes are now being introduced in this reanalysis. Thirteen of the participants included in the original study have now been eliminated: 2 participants were eliminated (one regarding alcohol abuse and another regarding pregnancy) to increase the requirement on health criteria and 11 participants were eliminated to increase the homogeneity of the RF EMFs measurements because there was a change (it was raining) in the usual dry weather conditions when the respective broadband measurements were registered.

The reanalysis of the dataset, which is the main focus of this paper, was finally performed with 88 participants (45 women and 43 men) instead of the 101 analysed in 2001.

Concerns about microwave exposure

Sixty-six of the 88 participants were reached by telephone in February 2012 and asked two questions:

A. Were you worried about the masts (BSs) when they were erected?
B. Did you believe their radiation (BSs) could damage your health?

In all cases, those who were worried about the masts were concerned about health consequences. Twenty-seven participants (40.9%) responded 'no' and 39 (59.1%) responded 'yes'. Responses were analysed relative to age (analysis of variance (ANOVA) test), sex (λ statistic) and subjective distance to BS (Somers' D statistic).

Exposure assessment

Broadband measurements were made on two Saturdays in February and March 2001 from 11:00 to 19:00 with a portable electrical field (400 MHz–3 GHz) detector (Nuova Elettronica Model LX-1435). This meter was calibrated with an HP-8510C network analyser inside an anechoic chamber at the University of Valencia. During the bedroom exposure assessment, the electric field probe was held for approximately 5 min about 1 m from the walls and 1.2 m above the ground—and moved around a circle of 0.25 m radius, orientating the antenna in different directions to obtain the maximum electrical field strength above the bed.

To check the intensity of TV and radio channels, as well as the intensity of working channels and broadcast channels for the GSM-900-1800 BSs, measurements of the spectral power density were carried out with a probe antenna and a portable spectrum analyser.

The probe was mounted on a linen phenolic tripod 1.2 m above the ground. The position of the probe was the same on both days—on a hill next to the village and 20 m from the BS. With the spectrum analyser we scanned the frequency bands and the levels were averaged for 6 min. The measurement of the spectrum was similar on both days—with a difference in the peak estimation (channel carriers) of about 1 dB.

The measured broadband exposure was almost invariable during the time interval of the measurements. Exposure changed with the position or place but it did not change over time, and this could be related with a low intensity of traffic (few phone calls) and the high and constant intensity of the broadcast channel.[10]

Statistical analysis

Demographic data were analysed using the Mann-Whitney one-way ANOVA and χ^2 test. Differences between groups were performed through variance (ANOVA) and covariance analysis.

The main statistical analysis was made using binary logistic regression (mode enter) carried out on a regular basis with subsequent bootstrapping (1000 bootstrap replications, 95% percentile method and simple sampling)[31] to provide more accurate SE and CIs. After producing (1000) bootstrap replicates θb of an estimator θ, the bootstrap SE was the SD of the bootstrap replicates.

$$\mathrm{SE}(\theta) = \sqrt{\left[\sum (\theta b - \theta)^2 / (r - 1)\right]}$$

$$b = 1 \rightarrow r$$

where θ is the mean of the θb. Owing to our small sample size, a non-parametric CI for the estimate (mean) was constructed from the quartiles of the bootstrap sampling distribution of θ. The 95% percentile interval (θ (lower) <θ<θ (upper)) is shown, where θb are the r-ordered bootstrap replicates: lower=0.025×r (sample 25) and upper=0.975×r (sample 975).

The dependent variables (health-related symptoms) given in four ordinal categories (0=never, 1=sometimes, 2=often and 3=very often) were dichotomised (0, 1=0 vs 2, 3=1).

The 15 health-related symptoms described above constituted the dichotomous dependent variables. Univariate analysis was then performed for each symptom and for each of the predictor variables: exposure to BS (μW/m^2 as a natural logarithmic) and age were used as continuous variables, while gender, computer use >2 h/day, mobile phone use >20 min/day and worry about the antennae were used as dichotomous variables. The covariates with predictive value were considered for the multivariate analysis. Thus possible confounder effects were evaluated.

In all cases, changes in −2 log likelihood, OR, 95% CIs and the p value were calculated. For all tests, a p value below 0.05 was considered statistically significant.

We used the GSM exposure (the measurement of RF EMF in the bedroom) as a continuous variable because it is recognised that categorisation of continuous variables introduces major problems in the analysis and interpretation of models derived in a data-dependent fashion.[32–34]

We chose exposure values in the logarithmic form because these values are well grouped around their median, while the raw values showed a high dispersion of values, with 2 outliers and 10 extreme values (data not shown).

Confounding was assessed by adding the potentially confounding variable to the model and making a subjective decision as to whether or not the coefficient of the variable of interest, ORs of GSM exposure, had changed substantially. A 10% variation was accepted as a considerable change.

Possible interactions between covariates were also evaluated.

The maximum number of covariates included in each multivariate analysis was calculated following this formula.[35] Let π be the smallest of the proportions of negative or positive cases in the population and k the number of covariates, then the minimum number of cases to include is:

$$N = 10\,k/\pi$$

Goodness-of-fit tests such as the classification table, the Hosmer-Lemeshow statistic, receiver operating characteristic (ROC) curves, Cox and Snell's and Nagelkerke's Pseudo R^2 measures were used. The Wald statistic was also evaluated to test the significance of individual independent variables. Moreover, possible multicollinearity was also tested.

With the predicted probability scores derived from the regression analysis, ROC curves were constructed for all symptoms or modalities in order to analyse sensitivity and specificity levels. For each curve, the best cut-offs for GSM exposure that maximises (sensitivity+specificity) were also calculated.

For statistical analysis, we used the Statistical Package for Social Sciences, V.21.0 (IBM SPSS Inc, Chicago, Illinois, USA) for Windows.

Owing to an exposure assessment for transformers, high-voltage power lines and radio or TV transmitters based on self-estimated distances would not produce a reliable exposure estimate, it was decided to omit these covariates in the analysis.

RESULTS

Demographic data and the percentage of users of personal computers and mobile phones were analysed. The mean age was 42 and 17 years (SD±17. 61, interval 15–81). Women totalled 51.1% (mean age=45.08 years, SD=17.98; interval=15–81) and 48.9% were men (mean age = 39.12 years, SD=16.88; interval=15–75). A total of 13.6% participants regularly used computers and 23.9% used mobile phones.

No differences related with age and use of mobile phones or computers were found between the sexes.

The univariate logistic regression indicated that age was inversely associated with irritability (OR=0.97, 95% CI 0.95 to 0.99) and that the oldest had the greatest difficulties hearing (OR=1.03, 95% CI 1.01 to 1.06) and walking (OR=1.04, 95% CI 1.01 to 1.07). However, gender clearly did not influence the outcome of any dependent variable. Use of mobile phones was linked with lack of appetite and vertigo, while worry about the radiation from BSs was associated with trouble sleeping (table 1). However, concern about radiation from BSs was unrelated to age (ANOVA test), sex (λ statistic) or subjective distance to BS (Somers' D statistic).

Most of the symptoms were related with GSM exposure, especially fatigue, irritability, lack of appetite, trouble sleeping, depression and lack of concentration. Change in −2 log likelihood showed similar results (table 2). Figure 1 shows the distribution of EMF measurements throughout the sample.

ROC curves for each of the logistic regression models (GSM exposure vs each symptom) oscillated between 0.65 and 0.87 (table 3). Headaches (0.84), nausea (0.86), appetite (0.87) and vascular problems (0.85) showed the highest values, while memory (0.67), skin (0.67) and visual disturbances (0.65) showed the lowest values. The Hosmer and Lemeshow test indicated that most analyses showed no significant p values. The exceptions were fatigue (0.003), depression (0.003) and vertigo (0.03). In the majority of the cases, the models predicted better specificity than sensitivity. Only in the

Table 1 Univariate ORs and 95% CIs of all clinical symptoms related with various possible confounders

Symptom/variable	Worry about BSs (1) OR (95% CI)		Computer use (2) OR (95% CI)		Mobile use (3) OR (95% CI)	
Fatigue	0.67	0.23 to 1.90	2.62	0.76 to 9.04	1.56	0.56 to 4.35
Irritability	1.13	0.43 to 3.03	1.56	0.45 to 5.34	2.62	0.94 to 7.33
Headaches	1.75	0.62 to 4.94	1.39	0.34 to 5.58	1.56	0.51 to 4.83
Nausea	0.68	0.18 to 2.24	0.34	0.04 to 2.84	1.43	0.44 to 4.67
Lack of appetite	1.05	0.33 to 3.40	3.16	0.87 to 11.44	4.28**	1.43 to 12.78
Trouble sleeping	3.12*	1.10 to 8.86	0.55	0.16 to 1.88	0.74	0.27 to 2.02
Depression	1.06	0.39 to 2.93	0.81	0.22 to 2.93	1.03	0.38 to 2.84
Lack of concentration	0.92	0.35 to 2.47	1.11	0.33 to 3.76	2.79	0.99 to 7.80
Memory loss	1.71	0.62 to 4.75	0.41	0.10 to 1.64	1.35	0.50 to 3.61
Skin alterations	0.74	0.23 to 2.35	ϕ	ϕ	0.63	0.16 to 2.45
Visual disturbances	1.31	0.48 to 3.60	0.77	0.21 to 2.77	1.63	0.60 to 4.39
Vertigo	0.61	0.20 to 1.91	0.77	0.19 to 3.10	2.90*	1.04 to 8.07
Vascular alteration	0.96	0.27 to 3.43	1.48	0.35 to 6.17	2.04	0.65 to 6.41
Hearing problems	0.59	0.20 to 1.70	0.77	0.19 to 3.10	0.48	0.15 to 1.60
Walking difficulty	0.60	0.20 to 1.79	ϕ	ϕ	0.42	0.11 to 1.60

*p<0.05; **p<0.01.
(1) Not worried, as reference codes. (2) and (3) no device use, as reference code, ϕ any participant affected using computer.
BS, base station.

case of headaches and sleep disorder, did sensitivity prevail over specificity (table 3—classification table). In the extreme case, skin and vascular problems showed null or minimum sensitivity and 100% specificity. Nagelkerke pseudo R^2 showed acceptable coefficients with the exception of the symptoms related with vertigo and skin problems (table 3).

Threshold cut-off values of GSM for sleep, attention, irritability and memory are also shown (table 3). The remaining cut-off values were not considered since sensitivity or specificity was reported at below 0.50%.

The influence of other covariates on the GSM ORs coefficients, such as age, cellular use and concern about the BS, was always less than 10% (table 2).

There was no observed multicollinearity among variables. The κ values according to factor analysis were always lower than 2 and well below the critical value of 30.

Finally, no interactions between covariates were observed.

SEs and CIs obtained by resampling were similar to those calculated from the asymptotic approximation (table 4). There was a small bias or difference between

Table 2 ORs and 95% CIs for GSM exposure: increase in risk per increase in log GSM (μW/m^2)

Symptom	OR (95% CI)	Change in −2 log likelihood	OR (95% CI)
Fatigue	1.39*** (1.14 to 1.70)	11.74***	2.13*** (1.34 to 3.83)
Irritability	1.51*** (1.23 to 1.85)	19.36***	2.58*** (1.61 to 4.12)
Irritability (adjusted with age)	1.47*** (1.20 to 1.81)	–	2.44*** (1.52 to 3.94)
Headaches	1.43** (1.15 to 1.78)	12.32***	2.28** (1.37 to 3.78)
Nausea	1.38** (1.09 to 1.73)	8.3**	2.09** (1.23 to 3.55)
Lack of appetite	1.58** (1.23 to 2.03)	16.31***	2.86*** (1.60 to 5.09)
Lack of appetite (adjusted to cellular use)	1.53** (1.19 to 1.99)	–	2.68*** (1.48 to 4.84)
Trouble sleeping	1.49*** (1.20 to 1.84)	16.38***	2.49*** (1.52 to 4.08)
Trouble sleeping (adjusted to worry to BSs)	1.64*** (1.22 to 2.19)	–	3.11*** (1.59 to 6.09)
Depression	1.41*** (1.16 to 1.72)	13.99***	2.22*** (1.42 to 3.48)
Concentration	1.54*** (1.25 to 1.89)	20.75***	2.68*** (1.67 to 4.32)
Memory	1.27** (1.06 to 1.52)	7.29**	1.73** (1.14 to 2.60)
Skin	1.24* (1.001 to 1.54)	4.08*	1.65* (1.01 to 2.71)
Visual	1.23 * (1.03 to 1.46)	5.30*	1.59* (1.06 to 2.40)
Vertigo	1.36** (1.11 to 1.66)	10.14***	2.02** (1.28 to 3.20)
Vertigo (adjusted to cellular use)	1.32** (1.08 to 1.62)	–	1.91** (1.20 to 3.04)
Vascular	1.32* (1.05 to 1.64)	6.30*	1.88* (1.12 to 3.14)
Hearing	0.96 (0.80 to 1.15)		0.90 (0.59 to 1.37)
Walking	0.95 (0.78 to 1.15)		0.88 (0.57 to 1.37)

Changes in −2 log likelihood are also shown. The third column represents the ORs for a 10-fold increase in GSM ($\log_{10}$ GSM).
*p<0.05; **p<0.01; ***p<0.001.
BS, base station; GSM, Global System for Mobile Communication.

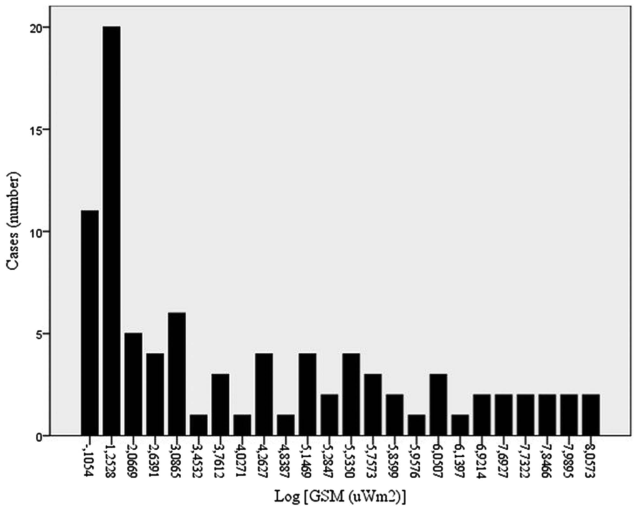

Figure 1 Distribution of electromagnetic field (EMF) measurement throughout the sample.

the average bootstrap coefficients (not shown) and the respective estimates obtained from the original sample.

There were no global health differences between those who permitted a bedroom exposure measurement (88 in our previous model) and those who refused RF measurements (26), and these results were unaltered when using age as a covariate. Square partial eta measured a 0% contribution of the willing participation variable to symptoms, such as irritability, headaches, walking difficulties and hearing loss that correlated with age. There was no relationship between subjective distance to the BS and willingness to participate (Pearson χ^2=2.80, df=1; p=0.094).

However, ANOVA showed that the group with recorded RF EMF levels was more prone to symptoms of memory loss (F=5.07; p=0.027), while participants without EMF measures showed more skin problems (F=10.66; p=0.001).

DISCUSSION

In the present reanalysis, a more robust statistical method was employed that was indifferent to the assumption of normality. To reduce the limitation of the sample size effect and extrapolate our results to the entire population from which the sample was obtained, a resample method or bootstrapping was used.

This new study partially confirms our preliminary results—namely, that most of the symptoms are related to GSM levels independent of the demographical variables and some possible risk factors. Related to microwave radiation, the spectral power density analysis maintained that the most important contribution to broadband measurements was from GSM 900/1800, and the main variability of the measurements between different places was due to a different coverage of the GSM 900/1800 signals, that is, spatial variability. This was further supported by the fact that the antenna used was fairly insensitive to frequencies below 400 MHz. Therefore, the radio channels 80–110 MHz were not a significant part of the broadband measurements. Moreover, the narrow band measurements showed TV channels with substantially lower intensities than the GSM 900/1800 signals. The effects from these exposures will therefore not confound the effects of BSs. Moreover, some authors[13] found that the only relevant contribution to the variance of the high microwave exposure was from BSs—up to 93% of variance. Moreover, at the time of our study, the GSM signal was almost invariable in time because there were very few calls. The main contribution was made from the broadcast channels working almost constantly throughout the day. Short-range evaluations of exposure could be acceptable for describing a 24 h period and the measurements were made in bedrooms—a location where the participants were assumed to spend significant periods of time.

However, some participants were mobile phone users at the time of this study and exposure to a mobile

Table 3 Goodness-of-fit of the outcome binary response variable related to GSM exposure (log=ln)

Symptom	ROC curves area	Classification table SSV	SPF	AV	Pseudo-R**2 (1)	Cut-off (2) (log GSM)	Cut-off (2) GSM (µW/m^2)
Headaches	0.84***	0.90	0.23	0.72	0.41	–	1.77
Sleep	0.78***	0.82	0.66	0.76	0.28	1.66	5.26
Attention	0.78***	0.67	0.72	0.69	0.28	3.61	36.97
Irritability	0.76***	0.67	0.73	0.71	0.26	3.61	36.97
Memory	0.67**	0.54	0.77	0.67	0.11	4.99	146.94
Depression	0.75***	0.46	0.76	0.65	0.20	–	184.93
Visual	0.65*	0.24	0.83	0.60	0.08	–	368.71
Fatigue	0.73***	0.22	0.90	0.69	0.18	–	685.4
Vertigo	0.74***	0.16	0.87	0.67	0.19	–	685.4
Appetite	0.87***	0.40	0.94	0.85	0.43	–	1495.18
Nausea	0.86***	0.46	0.93	0.87	0.38	–	1495.18
Vascular	0.85***	0.20	1.0	0.90	0.34	–	3041.18
Skin	0.67*	0.00	1.00	0.81	0.072	–	8604.15

Cut-off values of exposure to microwaves according to ROC analysis. The data are presented in the ascending order.
*p<0.05; **p<0.01; ***p<0.001 (1) Nagelkerke (2) cut-off (ROC curve): only values showing SSV and SPF above 0.5 are reported.
AV, average; GSM, Global System for Mobile Communication; ROC, receiver operating characteristic; SPF, specificity; SSV, sensitivity.

Table 4 Statistics for r=1000 bootstrapped binary logistic regression (GSM exposure coefficients: increase in risk per increase in log GSM (μW/m²)

		Bootstrap				Normal		
				95% percentile intervals			95% CI	
Symptom	B*	Bias	SE	Lower	Upper	SE	Lower	Upper
Fatigue	0.329	0.012	0.097	0.155	0.539	0.102	0.128	0.529
Irritability	0.411	0.016	0.110	0.241	0.670	0.104	0.207	0.615
Headache	0.358	0.022	0.139	0.149	0.688	0.113	0.137	0.578
Nausea	0.319	0.013	0.124	0.099	0.590	0.118	0.088	0.550
Appetite	0.456	0.026	0.134	0.264	0.784	0.128	0.205	0.707
Sleep	0.396	0.022	0.124	0.193	0.690	0.109	0.181	0.610
Depression	0.346	0.012	0.102	0.174	0.583	0.100	0.151	0.541
Attention	0.429	0.020	0.118	0.254	0.711	0.106	0.222	0.636
Memory	0.237	0.009	0.098	0.057	0.448	0.091	0.058	0.415
Skin	0.217	0.008	0.110	0.011	0.451	0.110	0.001	0.433
Visual	0.203	0.004	0.093	0.037	0.398	0.090	0.026	0.379
Hearing	−0.05	−0.002	0.089	−0.219	0.143	0.093	−0.228	0.135
Vertigo	0.306	0.010	0.101	0.127	0.530	0.102	0.107	0.505
Walking	−0.05	−0.006	0.098	−0.265	0.120	0.098	−0.246	0.138
Vascular	0.274	0.010	0.109	0.084	0.520	0.114	0.051	0.497

Asymptotic SEs and 95% CIs are also shown for comparison.
*β coefficient (log OR).
GSM, Global System for Mobile Communication.

phone during a phone call is much higher than that received from BSs. Nevertheless, some authors[13] stated about that *there is no* a priori *argument why these lower levels should have no effect on the presence of a widespread use of mobile telephones*. Exposure to a BS will be at a low but almost constant level for many hours of the day and especially at night.

While GSM exposure was associated with most of the symptoms, walking difficulties and hearing loss were correlated only with age. Age also remained slightly inversely associated with irritability. Users of cellular phones were more prone to symptoms of loss of appetite and vertigo, while those who expressed worry about the BSs were associated with sleep problems. This later finding was in concordance with two other articles.[13 20 26] However, worry about the BSs was unrelated with age, gender or subjective distance to BSs. This agrees with an article[36] claiming that there was no statistically significant association between symptom occurrence associated with perceived proximity to BSs, psychological components, sociodemographic characteristics and distance to BSs or power lines.

Some authors indicated that opponents of mobile phone towers generally do not express anxieties about EMF exposure, indicating that the risk rating is comparable with other commonly perceived hazards in the modern world.[37]

None of the analysed covariates behaved as confounders. The relationship of GSM exposure with irritability, sleep troubles, lack of appetite and vertigo remained statistically significant despite the introduction of the above covariates.

When the conventional multivariate analysis was tested using bootstrapping it was observed that the SE and CIs obtained by resampling were similar to those calculated from asymptotic approximation and this supports the adequacy of our conventional analysis. Our sample, chosen at random, represents the population from which it came.

The model appeared generally well adjusted while the cut-off values could constitute good guidance for predicting the threshold of symptom appearance.

We cannot truly state that residents were more worried, equally worried or less worried than elsewhere in this region, since we cannot provide the percentage of those worried about the BS masts in La Ñora compared with other nearby places. However, information about this issue was widespread in this region at the time, and the circumstances at La Ñora were shared with most other small urban and rural areas. The sample was randomly selected but a participation bias cannot be ruled out since most of our participants expressed fear regarding BSs and this could contribute to their participation in the study. It is also possible to speculate that the percentage of participants who refused to participate did so for the opposite reasons (indifference about BSs). In this regard, neither health status nor subjective distance to the BS explained a willingness to participate in the study.

Concerns about radiation from BSs were not related to age, sex or subjective distance to BSs. This agrees with statements from several authors[13] that living near a BS does not make people generally fearful, but people who generally worry about fields express stronger fears when they live close to a station.

Nevertheless, irrespective of these explanations, there seems to be effects of exposure that occur independently of the fear felt by the participants, since controlling for fear did not change the association between exposure and symptoms. However, the late query about concerns (as a possible confounder) may render the results less valid. In contrast to our findings, note that biological grounds explaining non-thermal effects have not been clearly established. Recently, it has been stated that voltage-gated calcium channels are essential to the beneficial or adverse responses to microwave EMFs, nanosecond EMF pulses and static electrical and magnetic fields.[38]

In summary, the results of this study indicate that effects of very low but long-lasting exposure to emissions from mobile telephone BSs on well-being cannot be ruled out. The effects almost completely matched the symptoms described within the microwave syndrome. Finally, unravelling the causal pathways would be best performed with an experimental study design.

CONCLUSIONS

This new study partially confirms our preliminary results about microwave sickness resulting from exposure to emissions from GSM mobile phone BSs. Fatigue, irritability, lack of appetite, sleep troubles, depression and lack of concentration were especially related with GSM exposure.

These results were independent of the main sociodemographic variables, other EMF exposures and anxiety about being irradiated. Nevertheless, we confirm that apprehension about modern technology could predict some symptoms, especially those related with sleep problems.

Our results agree with those who claimed that *by distorting perceptions of risk, disproportionate precaution might paradoxically lead to illness that would not otherwise occur.*[39] However, health changes related with GSM exposure seem to occur in a manner unrelated with those fears. Finally, exposure was very low during the period and also very low in comparison with Spanish recommendations[40] and international guidelines.[41]

Recommendations

We subscribe to the guidelines observed by other authors[42] in following the principle of prevention while the non-thermal effects are not considered in any official standard. This includes exposure minimisation within the limits of technical feasibility to guarantee a significant reduction in long-term radiation exposure to cellular phone towers in residential areas. Epidemiological and clinical studies should continue to observe possible health changes in the population. Finally, clear information about the correct use of newer electronic devices should be implemented.

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Contributors CG-P was mainly responsible for designing and writing the manuscript and also made the main statistical contribution. EAN was one of the researchers responsible for the design and acquisition of radiofrequency electromagnetic field (RF EMF) data, as well as writing and reviewing the manuscript. JS contributed mainly in processing the RF EMF data, while MP was responsible for the design and final review of the manuscript.

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Competing interests None.

Patient consent Obtained.

Ethics approval Ethical Committee of the University of Valencia in accordance with the Declaration of Helsinki (http://www.wma.net/e/policy/b3.htm).

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The data used in this statistical analysis can be obtained from Dr CG-P on request by email (gomez_cla@gva.es).

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BMJ Open

Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study

Claudio Gómez-Perretta, Enrique A Navarro, Jaume Segura, et al.

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doi: 10.1136/bmjopen-2013-003836

Supervisors,

Allowing RF-microwave transmitting facilities without prior notice is for the electrically disabled and those prone to contracting the disability like adding stairs everywhere for the wheelchair-bound disabled. The Americans With Disabilities Act (ADA) stipulates that disabled people may not request a "fundamental alteration" to the environment – this means that you may not make or allow fundamental alterations to the environment that do not accommodate the disabled. Allowing willy-nilly radiation emitters on the public does just that. Government Agencies and Courts recognize electromagnetic disability.:

The SSA has found Electromagnetic Field Sensitivity to be a "severe impairment"[1] and a disability.[2]

- **The Social Security Administration**
- **The Department of Education**[3]
- **The National Institute of Building Sciences**[4]
- **Job Accommodation Network** (JAN)[5]
- **HUD.**[6]

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1 Electromagnetic-Sensitivity-Found-to-be-a-Severe-Impairment-by-the-Social-Security-Administration-2003-and-2020-.pdf
2 All EMF*d Up (*Electromagnetic Fields): My Journey Through Wireless Radiation Poisoning plus How You Can Protect Yourself by Anne Mills | Goodreads (p.188)
Backyard Secret Exposed - Electromagnetic Sensitivity (pp. 174-5)
3 Sub-Regulatory Guidance | Rehabilitation Services Administration
4 IEQ-Report.pdf
5 Electrical Sensitivity
6 Ecology House – HUD funded housing for the electrically and chemically disabled.
HUD-meter-settlement-Redacted.pdf
FHEO successfully settled a cell tower accommodation complaint, 2014, HUD-FHEO-FOIA-Response-Regarding-RF-and-EMF-Disability-Complaints-2000-2020-—II.pdf (pp. 19 and 121)

- **The National Institutes of Health** (NIH)[7]
- **The National Council on Disabilities** (NCD)[8]

Court:

- "**Brown v. LAUSD establishes that symptoms of 'electromagnetic hypersensitivity' a.k.a. 'Microwave Sickness' could be deemed a 'physical disability' under the FEHA**"[9] ("The Court of Appeal held that Brown sufficiently alleged that she suffered from a physical disability under the FEHA [California Fair Employment and Housing Act] and that she sufficiently stated a cause of action for failure to accommodate..."[10])

- **Environmental Health Trust v. the Federal Communications Commission**[11]

Vote NO on the proposed title 16 and 22 amendments, and reverse the categorical CEQA exemption that relates to them. You must have consent of the governed. You must protect the most vulnerable who cannot protect themselves,

7 Magda Havas talks at NIEHS May 9, 2016 on Electrosmog and Electrohypersensitivity. - YouTube

8 National Council on Disability (NCD) EHS/CS Presentation May 12, 2022 – The Electrosensitive Society. An important history of government actions related to the electromagnetic disabled is at the end of this page.

9 JML Law Wins Appeal in 'Unprecedented' Disability Case Against LAUSD For Failure to Accommodate Teacher With Electromagnetic Hypersensitivity

10 2021-b294240 LAURIE BROWN V. LA UNIFIED SCHOOL DISTRICT.pdf

11 EHT/CHD et al v. FCC decision

Government has been aware of the biological harm from non-ionizing radiation for over 50 years, which means not spraying unlimited amounts anywhere over the public. nvisible does not mean harmless:

- (Text - H.R.10790 - 90th Congress (1967-1968): An Act to amend the Public Health Service Act to provide for the protection of the public health from radiation emissions from electronic products | Congress.gov | Library of Congress

- Biological Effects and Health Implications of Microwave Radiation | Dr. Zory Glaser

- A Comprehensive Review of the Research on Biological Effects of Pulsed Radiofrequency Radiation in Russia and the Former Soviet Union | SpringerLink

This document shows that the Federal Government also knew that even all of the RF for which they do not have data of its specific effects still have ("good, bad, and benign") effects that have not been observed or documented. If you approve the amendments, this is what you are leveling on the public with ZERO oversight, studies, or accommodation for the disabled.

16. Abstract Mankind has been immersed in electromagnetic (EM) fields since his appearance on the earth. Only relatively recently has his environment included more or less coherent EM fields (from electric power lines, radio and television broadcasting, radar, lasers, etc.). Most previous studies have involved effects of "ionizing" radiation on the human body. Significantly less has been done with "non-ionizing" EM fields. This report attempts to summarise the state of published knowledge about the effects of non-ionizing EM fields on humans. Information has been collected from a variety of sources. The written sources (over 1000) included a wide variety running from journals to news articles. Other types of sources included in-person meetings, telephone interviews and lecture tapes. Of the reported 5000 pertinent documents and items that exist on the subject, it is believed that the report represents an accurate sampling of existing relevant subject matter. A major purpose of the report is to indicate that there are good, bad and benign effects to be expected from non-ionizing EM fields and much more knowledge appears necessary to properly categorize and qualify EM field characteristics. Knowledge of the boundary between categories, perhaps largely dependent on field intensity, is vital to proper future use of EM radiation for any purpose and the protection of the individual citizen from hazard. It is hoped that the report will stimulate discussion about priority and direction for the needed future work.

17. Key Words (Selected by Author(s)) | 18. Distribution Statement

NASA-EMR-Effects-Human-Body-1981.pdf .

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Toxicology and **carcinogenesis** studies in B6C3F1/N **mice** exposed to whole-body radio frequency radiation at a frequency (1,900 MHz) and modulations (GSM and CDMA) used by cell phones
https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr596_508.pdf
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Toxicology and **carcinogenesis** studies in Sprague Dawley SD **rats** exposed to whole-body radio frequency radiation at a frequency (900 MHz) and modulations (GSM and CDMA) used by cell phones
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4G-5G-Microwaves_Favorite Peer-Reviewed and Government Studies (of 25,000) and Links_3.pdf - Google Drive

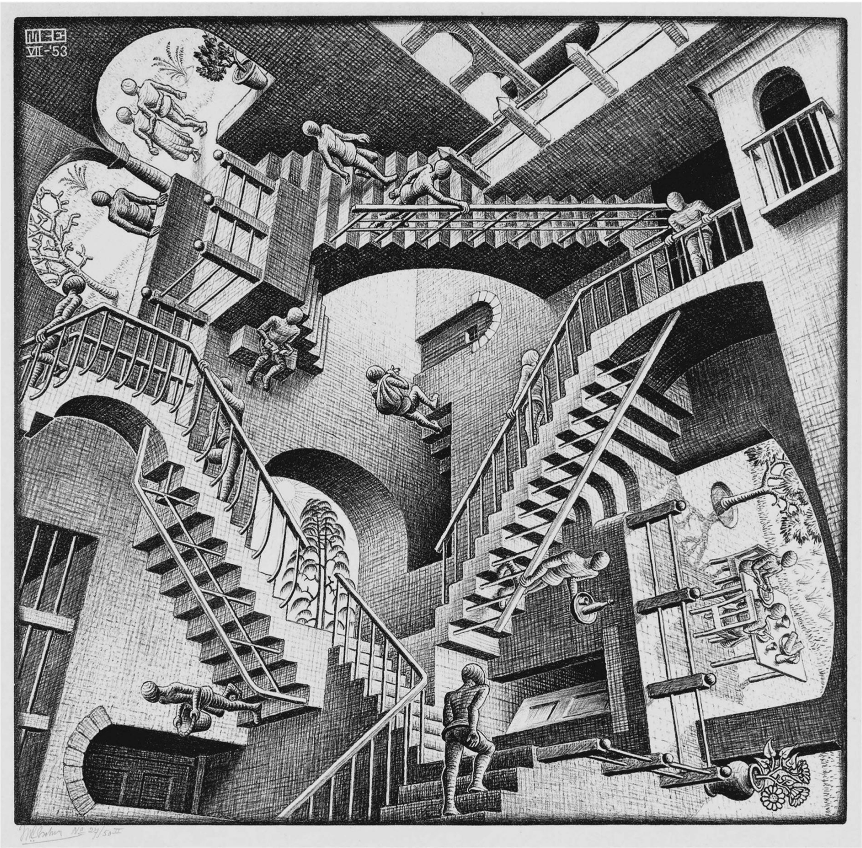
The Occupational Safety and Health Act of 1970 emphasizes the need for standards to protect the health and safety of workers exposed to an ever-increasing number of potential hazards at their workplace. To provide relevant data from which valid criteria and effective standards can be deduced, the Division of Biomedical and Behavioral Science of the National Institute for Occupational Safety and Health conducts a formal program of research and information dissemination. The users of this information include basic and clinical researchers, legislators, research and biohazards administrators, occupational safety and health professionals, teachers, and students.

In keeping with its mandate, the Division of Biomedical and Behavioral Science requested The Franklin Institute Research Laboratories' Science Information Services to review the world's biomedical literature and to prepare a general reference document on the known or potential carcinogenic hazards of occupational exposure to ionizing and non-ionizing radiation. The purpose of the study was 4-fold:

1. to identify and document radiation types which have been shown to be actual or potential carcinogens;
2. to review recent findings, regarding (a) current substantive issues and (b) impressions of distinguished investigators regarding the types of cancer induced by radiation, carcinogenic dose-response relationships, radiocarcinogenic mechanisms, and synergistic (co-carcinogenic) effects;
3. to predict the expected excess of cancers (or, for potentially carcinogenic types of radiation, the potential risk of cancer) either under commonly encountered conditions of occupational exposure or at the currently accepted maximum permissible dose limits; and
4. to identify specific gaps in the present knowledge of radiation carcinogenesis, and to recommend specific areas in need of further investigation.

In the course of the Franklin Institute study, five types of radiation were examined: ionizing, ultraviolet, visible, infrared, and microwave/radiofrequency radiation. The range of energies, frequencies, and wavelengths for each of these is as follows:

CARCINOGENIC-PROPERTIES-OF-IONIZING-AND-NON-IONIZING-RADIATION-VOL-II-MICROWAVE-AND-RADIOFREQUENCY-RADIATION.pdf



5G is for the Electromagnetic Sensitive Disabled as an M C Escher stairscape hell over all the land is for the wheelchair bound.

Stop Fundamentally Altering society.

Protect the vulnerable.

Stop 5G

https://www.ada.gov/law-and-regs/ada/

Why EHS is no Fairy Tale - YouTube

https://signstop5g.eu/

HUD CONSIDERS CELL TOWERS HAZARDS AND NUISANCES

U.S. Department of Housing and Urban Development

Archives

HUD HOC Reference Guide

Hazards & Nuisances: Overhead High Voltage Transmission Towers and Lines

Chapter 1
Appraisal & Property Requirements
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The appraiser must indicate whether the dwelling or related property improvements is located within the easement serving a high-voltage transmission line, radio/TV transmission tower, cell phone tower, microwave relay dish or tower, or satellite dish (radio, TV cable, etc).

1. If the dwelling or related property improvement is located within such an easement, the DE Underwriter must obtain a letter from the owner or operator of the tower indicating that the dwelling and its related property improvements are not located within the tower?s (engineered) fall distance in order to waive this requirement.
2. If the dwelling and related property improvements are located outside the easement, the property is considered eligible and no further action is necessary. The appraiser, however, is instructed to note and comment on the effect on marketability resulting from the proximity to such site hazards and nuisances.

- Airports
- Railroad tracks and other high noise sources
- Flood zones and insurance
- Lead based paint
- Radon
- Overhead high voltage transmission towers and lines
- Operating and abandoned oil and gas wells, tanks and pressure lines
- Insulation materials
- Lava zones
- Avalanche hazards

Content Archived: October 25, 2012

HUD Archives: HOC Reference Guide -- Hazards & Nuisances: Overhead High Voltage Transmission Towers and Lines (Page 1-18f)

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January 6, 2023

Los Angeles Board of Supervisors
Honorable Janice Hahn, Chair
Honorable Board Members: Hilda Solis,
Holly J. Mitchell, Lindsey Horvath & Kathryn Barger

Re: Agenda Item 59- County Code, Title 16 - Highways and Title 22 - Planning and Zoning Amendments

Dear Members of the LA Board of Supervisors:

Thank you for your careful foresight in postponing your vote on Titles 16 and 22 of the LA County Code on December 6th. However, on Tuesday, January10th, please DO NOT APPROVE the "revised" language of Titles 16 and 22 that was added in the last few weeks. Here's why: Protective language that the people of LA County need to keep them safe from the explosive expansion of wireless infrastructure has not been incorporated into these revised Titles.

We know that Verizon "*has been working proactively with cities across the county to update ordinances and design standards to better align with Federal Communication Commission (FCC) regulations."*

Although the FCC does mandate certain requirements for local governments regarding telecom permit applications, such as shot clocks (where local planning and zoning departments must act within a prescribed time period), and radio frequency (RF) emissions guidelines (assuming that the provider is in compliance with the Commission's RF rules), there are still a number of actions that local governments can take to ensure maximum safety for their populous.

Fiber First LA has prepared comprehensive "redline" drafts of Titles 16 and 22 to give LA County the maximum amount of control over the siting of telecommunication infrastructure. It appears that the revised versions of 16 and 22 did not take these suggested control measures into consideration. Why is that? It appears Verizon certainly had their say with County staff.

Verizon's public comment letter specifically states, "*By separate letter, Verizon has previously provided technical comments to the proposed ordinance. The Verizon legal team greatly appreciates the ongoing engagement with County staff to develop strategies to accelerate the deployment of broadband infrastructure and delete the digital divide."*

Of course, companies such as Verizon would want to accelerate the deployment of their infrastructure because that is their business model and they have stockholders to satisfy. Verizon, AT&T, T-Mobile and others are all competing for market share. Can't blame them for trying to make a buck, or a few billion bucks. They want you to think that their product is the only way to eliminate the digital divide.

What does this all this mean? Who has actually written these amendments to the County code titles? Is it Verizon? Why hasn't Fiber First LA been consulted? Their redline drafts of Titles 16 and 22 have been prepared by a top notch legal team NOT connected to Telecom, so there is no conflict of interest. Their only motivation is to give the County maximum control and the people maximum protection of rights. Can't argue with that!

There is something very wrong with this picture.

No one is saying that the County must prohibit wireless service or not take important steps to "bridge the digital divide." We are simply advocating for the County to employ a balanced approach. (1) Maximize protective measures in the permitting of wireless infrastructure, (2) Take proactive steps to develop comprehensive fiber networks to give people more choice in connectivity (taking advantage of billions of federal dollars for developing low cost wired networks) and (3) Work with local city governments and county residents to ensure that ALL have the right to fair hearings in the placement of telecom infrastructure with maximum protection so they can be safe in their communities.

Please don't allow Verizon, or any other wireless company to cloud your judgment. The future of LA County is at stake here. This is not an exaggeration. The decision you make on Tuesday could be the biggest one that you will ever make as Supervisor.

Thank you for your consideration.

Sincerely,

Sidnee Cox

Sidnee Cox
Director, EMF Safety Network
Consultant, Safetech4SantaRosa

101 South Topanga Canyon Blvd. #1705, Topanga, CA 90290
www.FiberFirstLA.org • info@FiberFirstLA.org

MEMORANDUM

To: Los Angeles County Board of Supervisors/Department of Regional Planning
From: Fiber First Los Angeles County
Re: **Legal Issues Under CEQA, NEPA, and NHPA Presented by Proposed Amendments to Title 16 and 22 Ordinances**
Date: September 23, 2022

The following is an analysis of various legal issues under the California Environmental Quality Act (CEQA), the National Historic Preservation Act (NHPA) and related California state laws, and the National Environmental Policy Act (NEPA) arising from proposed wireless facilities ordinances (amending County Code Titles 16 and 22) now before the Los Angeles Board of Supervisors (BOS) as a result of recommendations by the Department of Regional Planning (LACDRP).

Fiber First Los Angeles (FFLA) contests the Proposed Environmental Determination, which states:

PROPOSED ENVIRONMENTAL DETERMINATION

DETERMINATION DATE:	*March 23, 2022*
PROJECT NUMBER:	*2021-002931*
PERMIT NUMBER(S):	*RPPL2021007939 Permit Number*
SUPERVISORIAL DISTRICT:	*1-5*
PROJECT LOCATION:	*Countywide*
OWNER:	*N/A*
APPLICANT:	*Los Angeles County*
CASE PLANNER:	*Alyson Stewart, Senior Regional Planner, ordinance@planning.lacounty.gov*

Los Angeles County ("County") completed an initial review for the above-mentioned project. Based on examination of the project proposal and the supporting information included for the project, the County proposes that an Exemption is the appropriate environmental documentation under the California Environmental Quality Act (CEQA). This project (Ordinance) qualifies for a Categorical Exemption, (Class 1 – Existing Facilities, and Class 3 – New Construction or Conversion of Small Structures) under the California Environmental Quality Act (CEQA) and County environmental guidelines. The project includes authorization for modifications to existing facilities as well as for *minor alterations to land with the construction or conversion of small structures. Both actions will not have a significant effect on the environment.*

I. Executive Summary

The county staff recommends that the Board find that the action on wireless-related provisions through Amendments to County Codes Titles 16 and 22 is exempt from any environmental or historical evaluation based on a purported Categorical Exemption, (Class 1 – Existing Facilities, and Class 3 – New Construction or Conversion of Small Structures) under the California Environmental Quality Act (CEQA) and County environmental guidelines. We disagree.

1. There will be massive and irreversible adverse environmental consequences if the staff-recommended amendments are adopted.
2. The claimed Categorical Exemptions do not apply for any purpose.
3. Even if the Categorical Exemptions do apply generally, the BOS action will fall within specific Exceptions to the Exemptions, specifically, CEQA Guidelines Section 15300.2[1]:
   (a) Location. Classes 3, 4, 5, 6, and 11 involving significant impacts on particularly sensitive environments
   (b) Cumulative Impacts.
   (c) Significant Effects. Arising from unusual circumstances
   (f) Historical Resources. Substantial adverse change to a historic resource.
4. The extensive federal involvement in Los Angeles Country triggers NEPA's "small handle doctrine," which will necessitate a separate NEPA compliant Environmental Impact Statement (EIS). The BOS is the "co-lead agency," as this term is interpreted under NEPA, in close consultation and collaboration with several federal agencies that are most engaged in providing funding to Los Angeles County.
5. There are a substantial number of registered and otherwise recognized historical sites and places located in Los Angeles County that are specially protected, and subject to Section 15300.2 Exceptions as well as provisions of NHPA and court decisions.
6. To the extent staff claims CEQA is preempted in whole or in part by the Communications Act (47 U.S.C.) Title III they are incorrect. Nothing in that statute or any FCC rule promulgated thereunder preempts the Board's duty to perform a compliant programmatic Environmental Impact Report (EIR) for both proposed ordinances and the individual projects they countenance.
7. The FCC's shot clock rules have no relevance to the ordinance drafting process for Titles 16 and 22. They apply only to decisions involving individual applications. The shot clock rules do not pre-empt state or local due process notice and hearing requirements, although they do compress the available time for final disposition.

[1] https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-6-resources-agency/chapter-3-guidelines-for-implementation-of-the-california-environmental-quality-act/article-19-categorical-exemptions/section-153002-exceptions.

8. The BOS cannot avoid its heavy environmental responsibilities under CEQA, NEPA, and NHPA by pushing the process into Ministerial Site Review. All permits must remain subject to traditional Conditional Use Permit review.

II. Legal Analysis

The LACDRP's proposed Environmental Determination recommendation is fatally defective as a matter of CEQA law in two fundamental respects. First, the staff asserts that the proposed Code Amendments to Titles 16 and 22 are Categorically Exempt, which in CEQA language means that their environmental impacts are so negligible as not to justify even preparing an Initial Environmental Review, much less a Negative Declaration. The staff ignores, however, that categorical exemptions are construed narrowly. Aptos Residents Ass'n v. Cty. of Santa Cruz, (2018) 20 Cal. App. 5th 1039, 1046, 229 Cal. Rptr. 3d 605, 612. The county must determine the cumulative impact of all reasonably expected wireless facilities that will be authorized pursuant to the ordinances. Id. The extensive evidence of serious environmental impacts presented below belies any notion the operation of the contemplated ordinances could not possibly have a significant effect on the environment.

Union of Med. Marijuana Patients, Inc. v. City of San Diego, (2019) 7 Cal. 5th 1171, 1184-87, 250 Cal. Rptr. 3d 818, 825-27, 446 P.3d 317, 323-25 (quotation marks, citations and footnotes omitted) provides a good overview of the statutory regime:

2. CEQA generally

> CEQA was enacted to advance four related purposes: to (1) inform the government and public about a proposed activity's potential environmental impacts; (2) identify ways to reduce, or avoid, environmental damage; (3) prevent environmental damage by requiring project changes via alternatives or mitigation measures when feasible; and (4) disclose to the public the rationale for governmental approval of a project that may significantly impact the environment. CEQA embodies a central state policy to require state and local governmental entities to perform their duties so that major consideration is given to preventing environmental damage. CEQA prescribes how governmental decisions will be made when public entities, including the state itself, are charged with approving, funding – or themselves undertaking – a project with significant effects on the environment.
>
> CEQA review is undertaken by a lead agency, defined as the public agency which has the principal responsibility for carrying out or approving a project which may have a significant effect upon the environment. A putative lead agency's implementation of CEQA proceeds by way of a multistep decision tree, which has been characterized as having three tiers. First, the agency must determine whether the proposed activity is subject to CEQA at all. Second, assuming CEQA is found to apply, the agency must decide whether the activity qualifies for one of the many exemptions that excuse otherwise covered activities from CEQA's environmental review. Finally, assuming no applicable exemption, the agency must undertake environmental review of the activity, the third tier. We examine the three-tier process in more detail below.

CEQA's applicability: When a public agency is asked to grant regulatory approval of a private activity or proposes to fund or undertake an activity on its own, the agency must first decide whether the proposed activity is subject to CEQA. In practice, this requires the agency to conduct a preliminary review to determine whether the proposed activity constitutes a "project" for purposes of CEQA. If the proposed activity is found not to be a project, the agency may proceed without further regard to CEQA.

Exemption from environmental review: If the lead agency concludes it is faced with a project, it must then decide whether the project is exempt from the CEQA review process under either a statutory exemption or a categorical exemption set forth in the CEQA Guidelines. The statutory exemptions, created by the Legislature, are found in section 21080, subdivision (b). Among the most important exemptions is the first, for "[m]inisterial" projects, which are defined generally as projects whose approval does not require an agency to exercise discretion. The categorical exemptions in Guidelines sections 15300 through 15333 were promulgated by the Secretary for the Natural Resources Agency in response to the Legislature's directive to develop "a list of classes of projects that have been determined not to have a significant effect on the environment." If the lead agency concludes a project is exempt from review, it must issue a notice of exemption citing the evidence on which it relied in reaching that conclusion. The agency may thereafter proceed without further consideration of CEQA.

Environmental review: Environmental review is required under CEQA only if a public agency concludes that a proposed activity is a project and does not qualify for an exemption. In that case, the agency must first undertake an initial study to determine whether the project may have a significant effect on the environment." If the initial study finds no substantial evidence that the project may have a significant environmental effect, the lead agency must prepare a negative declaration, and environmental review ends. If the initial study identifies potentially significant environmental effects but (1) those effects can be fully mitigated by changes in the project and (2) the project applicant agrees to incorporate those changes, the agency must prepare a *mitigated* negative declaration. This too ends CEQA review. Finally, if the initial study finds substantial evidence that the project may have a significant environmental impact and a mitigated negative declaration is inappropriate, the lead agency must prepare and certify a full and complete EIR before approving or proceeding with the project.

In Farmland Protection Alliance v. County of Yolo, 71 Cal. App 5th 300 (2021) the Appellate Court held that if **any** aspect of a project entails a significant environmental impact, a Negative Declaration, or Mitigated Negative Declaration cannot cure this fundamental deficiency and a full EIR is thereby required. As explained below, in addition to qualifying for a Cumulative Impacts Exception, proposed Titles 16 and 22 also effectively meet the requirements of the Historic Resource Exception, which like Cumulative Impacts does not require the analysis of the "unusual circumstances" test of the Supreme Court in Berkeley. Historic Resources are considered so important that if a single historic resource is seriously threatened the entire asserted Exemption collapses.

A. Ministerial Exemption

Proposed Titles 16 and 22 contemplate a comprehensive Ministerial Site Review that is inappropriate as a general matter. This Ministerial Site Review does not comply with CEQA. It allows unfettered discretion by the LACRPD and fails to apply strict criteria for each permit application. Further, it presumes there will always be an insignificant environmental impact, when it is highly likely many individual wireless facilities subject to the process will, in fact, have a significant impact.

CEQA Guidelines 14 CCR § 15369 defines "Ministerial":

> "Ministerial" describes a governmental decision involving little or no personal judgment by the public official as to the wisdom or manner of carrying out the project. The public official merely applies the law to the facts as presented but uses no special discretion or judgment in reaching a decision. A ministerial decision involves only the use of fixed standards or objective measurements, and the public official cannot use personal, subjective judgment in deciding whether or how the project should be carried out. Common examples of ministerial permits include automobile registrations, dog licenses, and marriage licenses. A building permit is ministerial if the ordinance requiring the permit limits the public official to determining whether the zoning allows the structure to be built in the requested location, the structure would meet the strength requirements in the Uniform Building Code, and the applicant has paid his fee.

CEQA Guidelines 14 CCR §15002(i) states:

> (i) Discretionary Action. CEQA applies in situations where a governmental agency can use its judgment in deciding whether and how to carry out or approve a project. A project subject to such judgmental controls is called a "discretionary project." See Section 15357.
>
> (1) Where the law requires a governmental agency to act on a project in a set way without allowing the agency to use its own judgment, the project is called "ministerial," and CEQA does not apply. See Section15369.
>
> (2) Whether an agency has discretionary or ministerial controls over a project depends on the authority granted by the law providing the controls over the activity. Similar projects may be subject to discretionary controls in one city or county and only ministerial controls in another. See Section 15268.

CEQA Guidelines 14 CCR § 15300.1 provides:

> § 15300.1. Relation to Ministerial Projects.
>
> Section 21080 of the Public Resources Code exempts from the application of CEQA those projects over which public agencies exercise only ministerial authority. Since ministerial projects are already exempt, Categorical Exemptions should be applied only where a project is not ministerial under a public agency's statutes and ordinances. The inclusion of activities which may be ministerial within the classes and examples contained in this article shall not be construed as a finding by the Secretary for resources that such an activity is discretionary.

The draft ordinances' contemplated "Ministerial" review process does not meet the applicable definitions and treatment that are required before a project is exempt from CEQA review.

B. The claimed Categorical Exemptions do not apply

The LACDRP proposed Environmental Determination implicitly accepts that the ordinance drafting process here is a "project" for purposes of CEQA (step 1) because it undertakes step 2. We expressly agree that this ordinance exercise is a CEQA project. Staff, however, manifestly errs at step 2.

We first note that the draft Environmental Determination is defective because it does not "cit[e] the evidence on which [the lead agency, here presumably the County] relie[s] in reaching that Conclusion." Union of Med. Marijuana Patients, supra, 7 Cal. 5th at 1186, *citing* Muzzy Ranch Co. v. Solano County Airport Land Use Com. (2007) 41 Cal.4th 372, 380, 386-387, 60 Cal. Rptr. 3d 247, 160 P.3d 116. "The exemption can be relied on only if a factual evaluation of the agency's proposed activity reveals that it applies… whether a particular activity qualifies for the commonsense exemption presents an issue of fact, and [] the agency invoking the exemption has the burden of demonstrating it applies." Muzzy, 41 Cal. 4th at 386. An agency's duty to provide such factual support "is all the more important where the record shows, as it does here, that opponents of the project have raised arguments regarding possible significant environmental impacts." Id. This alone is fatal to the proposed Environmental Determination. But there are additional issues.

Exemption Class 1 pertains to "existing facilities" when the project involves negligible or no expansion of an existing use. Every type of wireless facility (other than exempt facilities covered by Section 6409 of the federal Spectrum Act, 47 U.S.C. Section 1455 and its implementing regulations at 47 C.F.R. Section 1.6100) that will be authorized under the proposed ordinance will either involve a new facility or a new use on an existing facility.

The Title 22 changes address, for example, new towers on public property other than highways or on private property. *See, e.g.*, proposed 22.140.E.b.i,[2] d. The Title 16 amendments contemplate the leasing of public infrastructure and allow for new or replacement poles to which new facilities will be attached. *E.g.*, proposed 16.25.030.E.3.d., 16.25.050.E. New poles or structures are not existing facilities.[3] Even when existing county infrastructure is used the wireless facility will be a non-negligible "new use."

Exemption Class 3 consists of construction and location of limited numbers of new, small facilities or structures; installation of small new equipment and facilities in small structures; and the conversion of existing small structures from one use to another where only minor modifications are made in the exterior of the structure. This exemption does not apply because the ordinances will allow for construction and location of thousands of facilities. It is foreseeable that there may be many more applications than the 700 "small cabinets" involved in S.F.

[2] This provision addresses potential towers on the grounds of historical properties, a matter clearly not within any categorical exemption.

[3] The staff does not rely on Class 2 for an exemption, but this also does not apply because the replacement structure will not have the same purpose or capacity.

Beautiful v. City & Cty. of S.F., (2014) 226 Cal. App. 4th 1012, 172 Cal. Rptr. 3d 134[4] or the "transformer boxes" in McCann v. City of San Diego, (2021) 70 Cal. App. 5th 51, 89, 285 Cal. Rptr. 3d 175.[5] More than minor modifications will be required. The draft ordinances provide for ministerial approval of thousands of wireless projects, so the scope is much greater than the 13 microcell sites addressed in Aptos. The ordinances expressly contemplate that facilities will be placed in scenic rural areas – not just neighborhoods or the urban core. They also expressly allow facilities on, in or near to historical resources. Los Angeles County General Plan Goal C/NR 14[6] requires mitigation of impacts to historic resources, inter-jurisdictional collaboration, preservation of historic resources and it mandates that "proper notification and recovery processes are carried out for development on or near historic … resources." Exemption Class 3 does not apply.

C. Applicable California Judicial Standards

Even if the exemptions apply this is an unusual circumstance, and there is a reasonable possibility of a significant effect due to this circumstance. The significant effect is so substantial that the effect itself is an unusual circumstance. There are therefore applicable exceptions to the exemptions.

CEQA Guidelines Section 15300.2[7] provides explicit exceptions to the exemptions section upon which the staff relies. The most relevant sections are:

> (a) Location. Classes 3, 4, 5, 6, and 11 are qualified by consideration of where the project is to be located -a project that is ordinarily insignificant in its impact on the environment may in a particularly sensitive environment be significant.
>
> (b) Cumulative Impact. All exemptions for these classes are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time is significant.
>
> (c) Significant Effect. A categorical exemption shall not be used for an activity where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances…

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[4] These projects will involve more obtrusive antennas, wiring and associated equipment on various structures more than 10 feet above the ground and sometimes equipment on the ground.

[5] McCann involved a "mitigated negative declaration" not a claimed categorical exemption. Notably, the McCann court found that San Diego did not adequately address whether the project would have a significant impact due to greenhouse gas emissions. 70 Cal. App. 5th 51, 91. The staff recommendation here suffers the same defect. As explained below, the projects contemplated by the ordinances will lead to more electric utility consumption that will, in turn, generate additional greenhouse gas emissions.

[6] https://planning.lacounty.gov/assets/upl/project/gp_final-general-plan.pdf#page=163.

[7] https://casetext.com/regulation/california-code-of-regulations/title-14-natural-resources/division-6-resources-agency/chapter-3-guidelines-for-implementation-of-the-california-environmental-quality-act/article-19-categorical-exemptions/section-153002-exceptions.

> (f) Historical Resources. A categorical exemption shall not be used for a project which may cause a substantial adverse change in the significance of a historical resource.[8]

As explained above and in more detail below, the proposed action falls well within exceptions (a), (b) and (f) and easily meets the "unusual circumstances" test in (c), as established by the California Supreme Court. Historical resources are involved so (f) applies as well.

In Berkeley Hillside Pres. v. City of Berkeley, (2015) 60 Cal. 4th 1086, 184 Cal. Rptr. 3d 643, 343 P.3d 834 the California Supreme Court addressed the scope of exceptions under the "unusual circumstances test" under Exception (c):

> A party invoking the exception may establish an unusual circumstance without evidence of an environmental effect, by showing that the project has some feature that distinguishes it from others in the exempt class, such as its size or location. In such a case, to render the exception applicable, the party need **only** show a reasonable possibility of a significant effect due to that unusual circumstance. Alternatively, … a party may establish an unusual circumstance with evidence that the project will have a significant environmental impact. That evidence, if convincing, necessarily also establishes "a reasonable possibility that the activity will have a significant effect … due to unusual circumstances.

60 Cal. 4th at 1105.[9]

Berkeley applies only to Exception (c). The other listed Exceptions are more liberally interpreted and applied. As explained below, the cumulative impacts even in a single location, which could be a neighborhood where permitted towers under Title 22 are densified will be significant. This distinguishes the present situation from prior situations where the environmental risks were clearly limited. The proposed Titles 16 and 22 propose to use Ministerial Site Review for a huge number of specific sites under comprehensive plans written by the telecom providers.[10] As explained below, FFLA will be able to present overwhelming evidence that there is more than a reasonable probability, indeed an almost certain likelihood, that there will be a massive environmental impact.

D. Proper Application CEQA Exemptions and Exceptions

Statutory interpretation requires harmonization of different statutes and multiple parts of the same statute to reconcile potential conflicts and give optimal effect to legislative intent. In the present instance, the staff is asking the Board to ignore the framework California courts have developed to constrain arbitrary overuse of claimed Categorical Exemptions and Negative

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[8] *See* Committee to Save the Hollywoodland Specific Plan v. City of Los Angeles (2008) 161 Cal.App.4th 1168, 1186 ["a categorical exemption is not applied to projects that may cause a substantial adverse change in the significance of a historic resource."]

[9] The majority deemed the above analysis consistent with the concurring opinion's "central proposition" that the exception applies where there is evidence that a project *will* have a significant effect." 60 Cal. 4th at 1106.

[10] There are already thousands of sites in the incorporated and unincorporated parts of Los Angeles County, and one provider alone wants to install more than 1,300 new facilities. *See* https://pw.lacounty.gov/tnl/streetlights/?action=small-cell; https://data.lacity.org/City-Infrastructure-Service-Requests/Small-Cell-Locations/3nrm-mq6k; https://www.crowncastle.com/communities/los-angeles-ca.

Declarations. Here, staff does not even get to the point of a Negative Declaration analysis – which makes the error even more egregious.

The Third District Court of Appeal (in a unanimous opinion authored by Justice Robie) recently reaffirmed that Cal. Pub. Res. Code § 21151 requires a "full EIR" whenever a project may have any significant environmental effect; it thus reversed the trial court's judgment that had allowed a deficient revised Mitigated Negative Declaration (MND) and its mitigation measures to remain intact while ordering Yolo County to also prepare an EIR limited to addressing only the project's impacts on three species of concern (tricolored blackbird, valley elderberry longhorn beetle, and golden eagle). The court reversed and remanded with instructions to issue a peremptory writ directing the County to set aside its MND approval and to prepare a full EIR. Farmland Protection Alliance v. County of Yolo, (2021) 71 Cal. App. 5th 300, 286 Cal. Rptr. 3d 227.

Boiled down to the essentials, the Court of Appeal held that neither CEQA nor its interpretive case law authorize a "limited EIR" at the "third tier" of the CEQA review process, nor do they provide any authority for "an order splitting the analysis of a project's environmental impacts across two types of environmental review documents," such as the deficient MND and the "limited EIR" ordered by the trial court in that case. Rather, once substantial evidence is presented that a project might have a significant environmental impact in any area, a negative declaration is inappropriate and a "full EIR" is required. While the CEQA remedies statute (Public Resources Code, §21168.9[11]) is intended to provide flexibility in facilitating compliance with CEQA, judicial remedies cannot avoid "the heart of the Act – the preparation of an environmental impact report for the project." Yolo involved an MDR but the principles articulated in that case still directly and forcefully guide the unusual circumstances test to the proposed "Project" – here the two ordinances at hand.

The Court held that "if *any* aspect of the project triggers preparation of an environmental impact report, a full environmental impact report must be prepared in accordance with the definition of [an EIR in Public Resources Code] section 21061." (*Citing* San Bernardino Valley Audubon Society v. Metropolitan Water Dist. *(*1999) 71 Cal.App.4th 382, 402 & fn. 11; Muzzy, supra at 381.

E. Unassessed Environmental Impacts

The proposed amendments to Code Titles 16 and 22 (henceforth, "Project") and the associated Facility Design Guidelines raise a wide range of unaddressed but substantiated grave environmental risks that meet the unusual circumstances test. Further, since there are historical resources in issue there can be no exemption. These risks are:

- Human Health;
- Wildlife—fauna and plants;
- Historic sites;
- Wildfires, earthquakes, floods leading to lack of resilience;
- Plastic faux trees (including monopines) and other plastic faux products;
- Energy use and wasteful consumption;
- Especially sensitive environmental areas.

[11] https://codes.findlaw.com/ca/public-resources-code/prc-sect-21168-9/.

The Project, if approved, represents a massive, unprecedented assault on human populations and the environment which distinguishes it from individual applications or locations covered by the CEQA Exceptions.

1. **Human Health Effects**

There is already an extensive and mounting body of peer reviewed studies from many countries on the health effects of exposing densified human populations from continuous cumulative RF/EMF radiation exposure from small cell and macro towers in addition to other RF radiation emitting devices. The present regulatory environment, especially as it relates to "microwave illness" or Electromagnetic Hypersensitivity (EHS), is uncertain. The bottom line is that harm to humans from radiofrequency radiation exposure is clearly foreseeable and the BOS has a high duty to proceed with precaution and heightened vigilance—the very opposite of the position taken by relying on a Category 3 Exemption and the attempt to blanket the unincorporated portions of the county using a Ministerial Exemption. A compendium of abstracts of the published scientific papers on radiofrequency and other non-ionizing magnetic fields is available at https://bit.ly/EMF08102022. The great majority of those published by independent (non-telecom funded) researchers shows significant risk.

2. **Wildlife—Fauna and Plants**

The effects of RF/EMF radiation exposure of fauna and plants is at present a regulatory no-man's land. The FCC's maximum radiation exposure rules do not address wildlife or plants. Bats and bees and other airborne species occupy air space in close proximity to transmitting cell tower antennas. Wireless network densification increases RFR levels (El-Hajj & Naous, 2020[12]) and with over 800,000 new cell sites[13] projected for the 5G buildout nationwide, environmental effects need to be properly examined, because ambient RFR is increasing in wildlife habitat.

A landmark three-part research review on effects to wildlife was published in R*eviews on Environmental Health in 2021* by U.S. experts, including former U.S. Fish and Wildlife senior biologist Albert Manville. The authors reviewed and cited more than 1,200 scientific references. These experts concluded that the evidence was adequate to trigger urgent regulatory action. The review found adverse biological effects to wildlife from even very low intensity non-ionizing radiation emissions at multiple orders of magnitude below current FCC-allowed levels (Levitt et al., 2021a[14], Levitt et al., 2021b[15], Levitt et al., 2021c[16]).

Comprehensive documentation of the biological effects of non-ionizing electromagnetic radiation to flora and fauna has never before been undertaken to this degree in any previous publication. These three experts divide their science and findings with urgent warnings into three parts: Part 1 identifies ambient EMF adverse effects on wildlife and notes a particular urgency regarding millimeter wave emissions and the pulsation/modulation used in 5G technologies. Part 2 explores natural and man-made fields, animal magnetoreception mechanisms, and pertinent studies to all wildlife kingdoms. Part 3 examines current exposure standards, applicable laws, and future directions. Their conclusions after this expansive review of the science are neither

[12] https://ieeexplore.ieee.org/document/9221314.

[13] https://docs.fcc.gov/public/attachments/DOC-354323A1.pdf.

[14] https://pubmed.ncbi.nlm.nih.gov/34047144/.

[15] https://pubmed.ncbi.nlm.nih.gov/34243228/.

[16] https://doi.org/10.1515/reveh-2021-0083.

equivocal nor speculative. This environmental research review is a clarion call to develop regulations that ensure wildlife and its habitat are protected. The abstract summarizes the findings:

- Numerous studies across all frequencies and taxa indicate that low-level EMF exposures have numerous adverse effects, including on orientation, migration, food finding, reproduction, mating, nest and den building, territorial maintenance, defense, vitality, longevity, and survivorship. Cyto-toxic and geno-toxic effects have long been observed. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as 'habitat' so EMF can be regulated like other pollutants. Wildlife loss is often unseen and undocumented until tipping points are reached. A robust dialog regarding technology's high-impact role in the nascent field of electroecology needs to commence. Long-term chronic low-level EMF exposure standards should be set accordingly for wildlife, including, but not limited to, the redesign of wireless devices, as well as infrastructure, in order to reduce the rising ambient levels.
- Numerous individual studies on impacts to flora and fauna have been published over the last two years, notably several on pollinators and insects.
- Two studies used scientific simulations to quantify the amount of power absorbed into the bodies of various insects for different RFR frequencies. In January 2020 researchers published "Radio-frequency electromagnetic field exposure of Western Honey Bees" in Scientific Reports on the absorption of RFR into honey bees at different developmental stages with phantoms simulating worker bees, a drone, a larva, and a queen (Thielens et al., 2020). The simulations were combined with measurements of environmental RF-EMF exposure near beehives in Belgium in order to estimate realistic exposures. They found absorbed RF-EMF power increases by factors of up to 16 to 121 when the frequency is increased from 0.6 GHz to 6 GHz for a fixed incident electric field strength. The implications of the impacts to bees – an ecologically and economically important insect species – are widespread and consequential.
- In October 2021 a second simulation study with far-reaching implications "Radio-frequency exposure of the yellow fever mosquito (A. aegypti) from 2 to 240 GHz" published in PLOS Computational Biology simulated the far field exposure of a mosquito between 2 and 240 GHz and found the power absorption into the mosquito is 16 times higher at 60 GHz than at 6 GHz at the same incident field strength. This increase is even larger (by a factor of 21.8) for 120 GHz when compared to 6 GHz. The authors conclude "higher absorption of EMF by yellow fever mosquitoes, which can cause dielectric heating and have an impact on behaviour, development and possibly spread of the insect."
- In 2020, a report by Alain Hill of the biological effects of non-ionizing radiation on insects found that mobile communications was a critical factor in weakening the insect world along with pesticides and habitat loss. (Khan et al., 2021) found the Apis Cerana bee becomes very passive at a certain level of frequencies and power.

- In May 2021, Spanish biologist Alfonso Balmori published “Electromagnetic radiation as an emerging driver factor for the decline of insects” in Science of The Total Environment. Balmori found that electromagnetic radiation threatens insect biodiversity worldwide. He documents the sufficient evidence of effects of non-thermal, non-ionizing radiation on insects, at well below the limits allowed by FCC guidelines, and warns that action must be taken now before significant new deployment of new technologies (like with 5G) is undertaken. He cautions that the loss of insect diversity and abundance will likely provoke cascading effects on food webs and ecosystem services.
- A November 2021 review of the effects of millimeter waves, ultraviolet, and gamma rays on plants found many non-thermal effects specifically from millimeter waves (Zhong et al. 2021). (The paper examined the millimeter range 30 to 300 GHz which overlaps with FCC’s limits 300 kHz to 100 GHz.) Millimeter-wave irradiation stimulated cell division, enzyme synthesis, growth rate, and biomass. The review highlights how different doses and durations provoked dynamic morphophysiological effects in plants. Seed pretreatment with weak microwaves or millimeter wave irradiation altered root physiology. Different effects were observed in different plants and the authors state that, “the discordance of proteomic changes in different plants is reasonable, since different plants have a distinct tolerance to stress. Moreover, the cell tissues from soybeans and chickpeas used for proteomic analysis were different, which implies that tissue-specific or organ-specific responses of plants under millimeter-wave irradiation might exist and require further investigation.” This review adds to the published analysis confirming non thermal effects from RFR. While these frequencies may have beneficial uses in agriculture, the adverse impact to trees and plants in close vicinity to transmitting antennas must be addressed.

There are massive risks to the environment from the heedless deployment of wireless radiation. The proposed ordinances will facilitate even more, without acknowledgement of the science on the subject. These environmental effects within Los Angeles County must be acknowledged and addressed in any Environmental Determination. They cannot be ignored or brushed off in any potential Categorical Exemptions, Negative or Modified Negative Declaration. As a matter of law an Environmental Impact Report is required.

3. Wildfires, earthquakes, floods lead to lack of resilience

a. Wildfire

Four major wildfires have been initiated, in whole or in part, by telecommunications equipment in Southern California in the last 15 years. Cumulatively, these fires have caused over $6 billion in damages, destroyed over 2000 homes, cost 5 lives, severely burned firefighters and civilians and triggered the largest mass evacuation in California history. These fires are:

1) Guejito Fire (2007)[17] in San Diego which became part of the Witch Creek Fire, the worst fire in San Diego history,[18] causing the largest mass evacuation in California's history of nearly 1,000,000 people.[19]
2) The Malibu Canyon Fire (2007)[20]: Three utility poles overloaded with equipment from Sprint (now T-Mobile), AT&T, Verizon and NextG (now owned by Crown Castle) snapped in the wind and ignited the grass below. All four carriers as well as Southern California Edison,[21] the utility that services Los Angeles County, were accused by the CPUC of attempting to mislead fire investigators.
3) Woolsey Fire (2018)[22]: A telecommunications lashing wire came loose igniting at least one of the two ignition points for the $6 billion fire.[23] Southern California Edison (SCE) was cited for 28 violations by the CPUC. One critical violation involved the failure by SCE to mark as a priority the repair of a broken communication line and broken telecommunications lashing wire. The broken equipment was found during a May 2018 telecommunications inspection. Without priority designation for repair, this known electrical hazard remained in disrepair. In November 2018, the broken Edison telecommunications equipment was involved as part of the ignition of the month-long fire.
4) Silverado Fire in Irvine (2020)[24] involved SCE and a T-Mobile lashing wire.[25] Silverado merged with a second fire causing the evacuation of 130,000 people.

RF stimulates combustible terpene production in conifers. In currently ongoing litigation in the Federal Court (Eastern District) Eisenstecken et al. v Tahoe Regional Planning Agency[26], plaintiffs cite several studies confirming that RF radiation stimulates terpene production in conifers. Terpenes are a combustible and flammable compound. They represent a significant fire hazard.

FFLA has already provided evidence of the high but unassessed wildfire risks that would be allowed by the adoption of Titles 16 and 22 amended ordinances. Others have produced evidence

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[17] https://www.supremecourt.gov/DocketPDF/18/18-1368/98044/20190430151930791_18-___petitionforawritofcertiorari.pdf.

[18] https://www.sandiego.gov/fire/about/majorfires/2007witchcreek.

[19] https://www.kpbs.org/news/midday-edition/2017/10/16/2007-firestorms-ravaged-san-diego-county.

[20] https://www.dwt.com/-/media/files/blogs/broadband-advisor/2022/01/jan-20/cpuc-decision-21-10-019.pdfhttps://www.dwt.com/-/media/files/blogs/broadband-advisor/2022/01/jan-20/cpuc-decision-21-10-019.pdf.

[21] https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M077/K126/77126214.PDF.

[22] https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/investigations-wildfires/sed-investigation-report---woolsey-fire---redacted.pdf.

[23] https://timesofsandiego.com/business/2018/11/28/6-billion-is-estimated-damage-from-woolsey-fire-in-la-and-ventura-counties/.

[24] https://www.theepochtimes.com/law-firm-seeks-clients-to-sue-socal-edison-over-silverado-fire_3639317.html.

[25] https://www.wxii12.com/article/power-company-equipment-woolsey-fire-california/34540269#.

[26] https://casetext.com/case/eisenstecken-v-tahoe-regl-planning-agency/.

that the proposed wireless "Resilience Hubs" are the very worst, least resilient technology to be relying upon during power outages or earthquakes.[27]

By relying on the proposed exemption, the staff is basically asserting these concerns are not even worthy of consideration, but there is no evidence that the LACDRP even examined them.[28]

F. Energy use and wasteful consumption

Mobile service is energy intensive. The transition to 5G, whether 5G NR (non-standalone) or 5G Standalone NR, will exacerbate this situation until newer and far more efficient equipment can be designed and deployed, and 5G networks can fully implement use of their emerging "sleep mode" capability.[29] But even with "sleep mode" the energy consumption profile will still be high.

Environmental Heath Trust provides an extensive summary of this and much more evidence on the topic, with citation to recent sources on its website.[30] All this energy consumption will translate into far more greenhouse gas output, thereby contributing to existing climate issues. An EIR is required to assess the additional greenhouse load that will flow from the operation of thousands of wireless facilities these ordinances will permit.

G. Plastic faux trees (including monopines) and other plastic faux products

Monopines and other toxic faux products designed to camouflage macro cell towers produce microplastic waste that is being scattered, and will increasingly be scattered, all over Los Angeles County. The mechanism is straightforward. The faux plastic falls off the towers via weather, wind, etc. onto the ground, then gets washed away into the storm drain system and other discharge channels. It is standard industry practice to replace faux plastic on macro towers every

[27] In April 2022, the BOS voted in favor of a "Safety Upgrade" to the General Plan and included Wireless Resilience Hubs (WRH) as an important component of this Safety Upgrade. The stated purpose of a WRH is to help LA County address more effectively power outages, wildfires, floods, and other public emergencies. However, there is evidence that WRH will actually make Los Angeles County less safe during these emergencies, because intensive use of cell phones and other wireless devices during emergencies will actually further compromise the power grid. The proposed proliferation of cell towers authorized and encouraged by the amendments to Titles 16 and 22 under Ministerial Site Review will "hard wire" the problem, because local ordinances by California law must be "consistent" with the General Plan. An immediately available alternative proposed by Fiber Free Los Angeles and other concerned organizations is to accelerate the deployment of Resilience Hubs based on Optical Fiber to the home and workplace, supported by funding under the BEAD and other federal and state programs. *See* Tim Schoechle, "Reinventing Wires: https://gettingsmarteraboutthesmartgrid.org/pdf/Wires.pdf; https://www.nytimes.com/2019/10/28/business/energy-environment/california-cellular-blackout.html.

[28] The proposed Environmental Determination does not mention any matters of concern. It just baldly states there are two applicable Categorical Exemptions without providing any evidence in support. *But see* Union of Med. Marijuana Patients at 1186; Muzzy, 41 Cal.4th at 380. In addition, faux plastic trees may present an additional fire risk in this respect. https://www.firehouse.com/rescue/article/10544313/plastics-polymerization-what-firefighters-need-to-know.

[29] The 5G Dilemma: More Base Stations, More Antennas—Less Energy? 5G networks will likely consume more energy than 4G, but one expert says the problem may not be as bad as it seems, Dexter Johnson, IEEE Spectrum (Oct. 3, 2018), available at https://spectrum.ieee.org/will-increased-energy-consumption-be-the-achilles-heel-of-5g-networks. For "sleep mode" background see Ericsson, A technical look at 5G energy consumption and performance, Frenger and Tano (Sept. 19, 2019), available at https://www.ericsson.com/en/blog/2019/9/energy-consumption-5g-nr.

[30] https://ehtrust.org/science/reports-on-power-consumption-and-increasing-energy-use-of-wireless-systems-and-digital-ecosystem/.

five years, up to 10,000 pounds per tower. Microplastics on these faux macro towers contain lead and other carcinogenic materials proscribed under Proposition 65. Scientific studies[31] confirm evidence of microplastics in human and animal lungs and blood. There is no evidence that the LACDRP is even familiar with the problem, much less seriously addressed it. The issue is currently being litigated in *Eisenstecken et al. v Tahoe Regional Planning Agency*.[32]

H. Cumulative Impacts

Section 15300.2 of the CEQA Guidelines clearly provides for an Exception to the Exemption for cumulative impacts. It states:

> All exemptions for these classes are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time is significant. Moreover, a strong line of judicial decisions in California[33] recognizes that a valid EIR must include a careful analysis of cumulative impacts. Massive cumulative impacts is another unusually dangerous condition of the proposed Project.

For purposes of 15300.2 in this matter "projects of the same type" means any of the many "wireless facilities" that will be covered by Title 16 or 22. "The same place" means all of Los Angeles County. *See* Aptos, supra (the "same type" was DAS and "same place" was "Day Valley). The Board must assess the cumulative impact of all the individual wireless facility projects the proposed ordinances will authorize. As noted above, these wireless facilities are not being proposed willy-nilly. They are part and parcel of a wireless plan developed by the telecom providers and their installers with a single purpose to blanket all of Los Angeles County without *any* consideration of the cumulative impact of each component segment of this larger plan. This is precisely the kind of "project" that CEQA and its Cumulative Effects Exception intend an agency to carefully scrutinize with heightened environmental awareness and sensitivity of an EIR process.

I. Piecemealing and Segmentation

CEQA Guidelines explicitly prohibit piecemealing[34] as a strategy to circumvent CEQA's EIR requirements. Section 21159.27. PROHIBITION AGAINST PIECEMEALING TO QUALIFY FOR EXEMPTIONS states: "A project may not be divided into smaller projects to qualify for one or more exemptions pursuant to this article." The specific intention of the Project is to encourage piecemealing under an accelerated Ministerial Site Review. The staff's asserted Exemption cannot stand.

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31 https://drive.google.com/file/d/127Ud8b5nTZuT3meINAFj0ngbj2NQyPa0/view?usp=sharing.

32 On September 7, 2022 the Lahontan Regional Water Quality Control Board (LRWQCB) officially opened an investigation of hazardous waste discharges of microplastic and other toxics emitted from monopine cell towers. The LRWQCB issued Requests for Information on six faux plastic macro cell tower sites operated by Verizon and other telecom companies. Currently, there is a Zero Discharge Standard under the Clean Water Act and California Porter-Cologne Act. Discharges of hazardous waste from monopines into Lake Tahoe have been ignored for many years, and at last the LRWQCB is seriously investigating the past practice and proposals for new developments referenced in *Eisenstecken et al. v. TRPA*. Although Lake Tahoe represents a unique national treasure, there are many historic sites and environmentally sensitive areas in Los Angeles County that must be protected from microplastic hazardous waste discharges into the air, land, and water from faux plastic macro cell towers. *See e.g.* https://drive.google.com/file/d/1GycVZ8Uhv8reweII64dnQ4VHIKNiMlcS/view?usp=sharing.

33 https://www.co.shasta.ca.us/docs/libraries/resource-management-docs/eir/hatchet-ridge/ch_4_otheranalyses.pdf.

34 https://resources.ca.gov/CNRALegacyFiles/ceqa/docs/2014_CEQA_Statutes_and_Guidelines.pdf.

J. Especially sensitive environmental areas

Los Angeles County is replete with environmentally sensitive areas, including parts of the Coastal Zone and the Santa Monica Mountains, all of which are identified in the General Plan. Several are expressly mentioned in, for example, proposed 22.26.E.1.b. The Significant Ecological Area (SEA) Program is a component of the Los Angeles County Conservation/Open Space Element.[35] The imposition of Ministerial Site Review will create an unnecessary conflict with these other important State and County policies and programs, which would otherwise be harmonized and balanced under the established Conditional Use Permit framework. One major purpose of the move to "ministerial" is to avoid dealing with such things. But this you cannot do, unless and until the Board addresses the environmental impact as part of the ordinance drafting process. Even then environmental analysis of certain projects will still be required.

K. Unexamined Alternatives

CEQA: CEQA Guidelines § 15126.6 explicitly states: "An EIR need not consider every conceivable alternative to a project. Rather, it must consider a reasonable range of potentially feasible alternatives that will foster informed decision making and public participation." (*See* https://planning.lacity.org/eir/SwanHall/DEIR/Chapters/7_Alternatives.pdf).

Environmentally safe, energy efficient, resilient, climate change friendly optical fiber to the home and workplace is an alternative solution to the Digital Divide. The Board should express the same policy decision as the current federal administration: wireless solutions are a less preferred alternative. Wireless should be deployed only where it is necessary, not everywhere in heedless fashion. CEQA requires that each potentially feasible alternative be examined, but the proposed Environmental Determination completely avoids any such effort.

L. Federal and State Policy

Local government agencies like the Board are constrained by and must respect directly applicable federal statutes.[36]

1. NEPA "Small Handle Doctrine"

There is quite likely more federal funding and engagement in Los Angeles County than any other California county or quite possibly in the U.S. Specifically, the American Rescue Plan Act provides $1.9 billion in federal funding to assist economic recovery. Substantial funding is also forthcoming under the NTIA policy announced in May 2022. Federal funding under the 2021 Infrastructure Investment and Jobs Act is also being directed to support efforts such as a Community Wireless Network in Los Angeles County. Other federal statutes are possibly applicable as well. This extensive federal involvement triggers NEPA's "small handle" application which necessitates a NEPA review in addition to a CEQA review on the revisions of Titles 16 and 22 which will alter forever the health and well-being of Los Angeles County residents and its environment. Moreover, the Council on Environmental Quality strongly encourages close coordination between NEPA and CEQA environmental reviews[37]. This is

[35] https://planning.lacounty.gov/sea/faqs.

[36] The telecoms repeatedly claim the federal laws they like must be obeyed. But other federal laws preclude the permit review process and substance that they and staff champion.

[37] https://opr.ca.gov/docs/NEPA_CEQA_Handbook_Feb2014.pdf.

another unique circumstance of the present Project which precludes BOS' reliance on the Exemption.

References:

- https://ceo.lacounty.gov/recovery/arp/
- https://www.jstor.org/stable/24115016
- https://sprlaw.com/wp-content/uploads/2020/10/CEQ-New-NEPA-Regulations.pdf
- https://opr.ca.gov/docs/NEPA_CEQA_Handbook_Feb2014.pdf

M. Climate Change Impact Assessment

CEQA Guidelines explicitly require climate change impact analyses.[38] As the presumable lead agency, the county must analyze the greenhouse gas emissions of this project. This "project" relates to two ordinances that will govern how wireless facilities are permitted so any environmental inquiry must assess not only the quantity of emissions and how that quantity of emissions compares to statewide or global emissions but also the project's effect on climate change.

The precedent that the staff is recommending encourages the Board to allow massive deployment of wireless macro towers and other RF radiation emitting devices under Ministerial Site Review. This reckless policy will have massive negative environmental repercussions in Los Angeles County. Moreover, other counties in California and possibly in other states will cite this precedent to justify similar actions. The collective adverse impacts of hundreds of such projects throughout the U.S. could very well contribute to an adverse climate change impact. CEQA Guidelines 15064.4, subd (a)-(c) require a full inquiry and conclusion that uses appropriate modeling and reflects evolving scientific knowledge and the state's regulatory regime. A flat assertion of a Categorical Exemption, without any evidentiary support, simply does not suffice.

N. Cost/Benefit Analysis

California courts sometimes look to NEPA and federal decisions for guidance. Friends of Mammoth v. Board of Supervisors (1972) 8 Cal.3d 247, 260–261; Bowman v. City of Berkeley (2004) 122 Cal.App.4th 572, 591 (CEQA is patterned on NEPA; NEPA cases can be persuasive authority for interpreting CEQA). It is therefore noteworthy that NEPA regulations require cost/benefit analyses in assessment of alternatives. 40 C.F.R. § 1502.22 Cost-benefit analysis[39] states:

> If the agency is considering a cost-benefit analysis for the proposed action relevant to the choice among alternatives with different environmental effects, the agency shall incorporate the cost-benefit analysis by reference or append it to the statement.

The present situation of the proposed amendments to Titles 16 and 22 presents an excellent opportunity to coordinate CEQA and NEPA practices. NEPA cases can be persuasive in interpreting CEQA when CEQA is unclear (Wildlife Alive v. Chickering (1976) 18 Cal.3d 190, 202-203). CEQA amplifies NEPA practice but does not rely on it. There are provisions for coordinating CEQA review with NEPA and other types of review (CEQA Guidelines section 15004 (c)) Although CEQA does not explicitly require cost-benefit analysis as does NEPA, the

[38] https://opr.ca.gov/ceqa/ceqa-climate-change.html.

[39] https://www.law.cornell.edu/cfr/text/40/1502.22.

County of Los Angeles can benefit from and rely upon a NEPA cost benefit analysis in reaching an informed decision as part of fulfilling its CEQA obligations.

Moreover, the staff's claimed Exemption blindly relies on a plethora of unchallenged false claims advanced by the telecom providers. These false claims include:

- The environmental impacts are trivial;
- Radiation exposure levels of children in schools, disabled persons, elderly, and pregnant women are safe;
- Blanketing Los Angeles County, especially underserved communities with macro towers and other radiative emitting devices will close the Digital Divide;
- Wireless devices are energy saving;
- Wireless hubs will promote community network resilience during power outages.

Each such claim is incorrect. At least one federal court has rejected a NEPA EIS on the grounds that the EIS included false statements.[40]

O. Other Applicable Federal Laws

The staff's abuse of claimed Exemptions will place the BOS in direct violation of other important federal statutes. Here are two examples.

1. **National Historic Preservation Act (NHPA).**

The proposed Wireless Facility Design Guidelines address the incursion of small cell and macro towers on historic sites and related properties. For example:

Historic resources and landmarks.

- No new facilities shall be permitted on or within historic resources or structures listed or eligible for listing on the national, state, or county historic registers.
- Existing facilities located on or within historic resources or structures listed or eligible for listing in any historic registers shall be located and designed to eliminate impacts on the historic resource.
- A Historic Resource Assessment, prepared to the satisfaction of the Director, may be required for a facility to be located on a site containing an eligible resource to identify impacts to historic resources, and identify mitigation to minimize impacts.[41]

The Title 22 Wireless Ordinance Summary states:

Development Standards for All Facilities (except small cell facilities).

[40] *See Natural Res. Def. Council v. U.S. Forest Serv.*, 421 F.3d 797, 811–13 (9th Cir. 2005) (finding that the agency's use of inflated, inaccurate, and misleading data violated NEPA).

[41] Proposed Section 22.140.700.E.1.b.v allows the Director to use individual judgment on whether to require more information and/or impose mitigation measures as a condition of the permit. Despite the staff's desire to move to a "ministerial" review, this is a discretionary act for CEQA purposes. *See* Protecting Our Water & Envtl. Res. v. Cty. of Stanislaus, (2020) 10 Cal. 5th 479, 489, 268 Cal. Rptr. 3d 148, 153, 472 P.3d 459, 464.

> Facilities may not be placed on historically significant buildings or structures. They may be placed elsewhere on the property containing historic buildings or structures, provided a Historic Resource Assessment is prepared and submitted.

The Project, however, sets up an accelerated process under Ministerial Site Review that still does not fully implement federal and state law regarding historical resources.

2. **Identification of Historic Sites in Los Angeles County**

The recognized historic sites in Los Angeles County can be found at:

https://ohp.parks.ca.gov/?page_id=21427 and https://hlrc.lacounty.gov/.

Existing County Code Ch. 22.124 recognizes and protects some "historic districts." The proposed Tit. 22 revisions do provide mitigating measures for those districts, but there are several state and nationally recognized historic districts that have not gone through the county 22.124 process. The View Park site in Angela Sherick-Bright v. Los Angeles County[42] is one of these. To be consistent with how the current and proposed amended Titles 16 and 22 apply, we must recognize that some nationally or state recognized places (landmarks or districts) are not accepted for full protection under Chapter 22.124 (Historic Preservation), but are still protected (by way of an exception to any exemption) under state and federal law. There are "historic resources (as defined in current 22.14) that are not, for example, an "historic district" as defined in 22.14 because they have not been recognized by the Board under 22.124, and thus covered by Ch. 22.82.

It appears the drafters of the proposed wireless ordinances are aware of this. *See* proposed Section 22.140.E.1.b.v. which uses "historic resources," the broader term. But what the draft ordinance fails to deal with is existing Section 22.82.030.B:

> Notwithstanding Section 22.300.020 (Application of Community Standards Districts to Property), where an ordinance establishing or amending a historic district imposes development standards, limitations, conditions or regulations which are inconsistent with those otherwise imposed by this Title 22, the development standards, limitations, conditions, and regulations set forth in the ordinance establishing or amending the historic district shall supersede any inconsistent provisions in this Title 22.

A specific provision on development for a particular county 22.124/22.82 district ordinance and preservation plan should prevail over the proposed new provisions. That may or may not be the drafter's intent, however. The proposed language is ambiguous. If the intent is to preserve the specific provisions for existing 22.124/22.82 districts, then it is true there will no impact as to these districts. However, there are many other historic resources not yet recognized in 22.124/22.82, and there will certainly be a significant environmental impact on them. CEQA Guidelines §15300.2(f) provides that any claimed Categorical Exemption does not apply because of the historical resources exception.

More important, the drafters clearly recognize there will be an impact on historical resources, whether part of the 22.124/22.82 regime or not. There are specific draft terms addressing historical resources. It appears the drafters attempted to provide some mitigating provisions, but

[42] https://drive.google.com/file/d/1pfnYIhHB2IbhmYh59nJUTR8y9PbhRlnZ/view?usp=sharing.

staff has not provided any facts in support of the proposition there will still be no significant impact on any historical resource. This could, in theory, form the basis of a Modified Negative Declaration, if the mitigating steps are sufficient. But staff did not go that far; it just incorrectly asserts the Categorical Exemption, implying thereby no historic analysis is required.

3. **Federal Clean Water Act/California Porter Cologne Acts.**

As noted, the Project will permit unregulated wide diffusion of toxic faux plastic and micro plastic and related plastic waste, lead, and other toxic and carcinogenic materials listed under Proposition 65. The toxic wastes are being carried by strong winds and deposited on land, in or near lakes, streams, and coastal waters. They will penetrate ground water aquifers used for drinking water. They will expose animals and plants in environmentally sensitive areas. They will enter food chains. The widespread discharge of such toxic materials is subject to a Zero Discharge Standard as implemented in California through State, Regional, and Local Water Quality Boards, which are governed by California's Porter Cologne Act. The BOS Project completely ignores this unique and imminent environmental hazard.

P. Federal and State Shot Clock Regulations.

An unstated but obvious reason for the staff's effort to "streamline" the process through ministerial treatment instead of the currently-required Conditional Use process is that the FCC and state legislatively imposed "shot clock" rules require strict deadlines for a final decision. If the deadline is not met, the status for many wireless facility categories will be "deemed approved." FFLA acknowledges this practical problem.

It is important to understand that **the "shot clock" rules *do not apply* to the ordinance drafting process.** They pertain only to individual (or bundled) permit applications seeking land use approval.

The environmental rules FCC establishes when it is complying with NEPA are qualitatively different than the rules FCC promulgates under its Title III authority. The "preemption" in 47 U.S.C. 332(c)(7)(B)(iv) is in Title III. It provides that a state or local government may not "regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions." This provision speaks only to "radio frequency emissions" and does not in any way inhibit inquiry into the other environmental effects of the facilities – visual effects, greenhouse gas emissions, camouflage shedding of microplastics, lead and other carcinogenic materials. The FCC's NEPA rules are in 47 C.F.R. Part 1, Subpart I and do not derive from Title III. Instead these rules are mandated by NEPA, which is an entirely different statute. That is why the FCC has directly held that its NEPA related rules do not preempt state law equivalents like CEQA. *See In re Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Inv.*, 33 FCC Rcd 3102, 3132 ¶77 (March 30, 2018), *rev'd other grnds United Keetoowah Band of Cherokee Indians in Oklahoma*, 933 F.3d 728, 744 (D.C. Cir. 2019):

> …Finally, nothing we do in this order precludes any review conducted by other authorities—such as state and local authorities—insofar as they have review processes encompassing small wireless facility deployments.[152] The existence of state and local review procedures, adopted and implemented by regulators with more intimate knowledge of local geography and history, reduces the

likelihood that small wireless facilities will be deployed in ways that will have adverse environmental and historic preservation effects.[153]

n.152 The record refers to a range of such requirements that exist under state or local law. See, e.g., City of Boston et al. Ex Parte Letter at 8 (stating appreciation that this order "does not intend to preempt state and local environmental and historical review, and thus leaves open the possibility that states and localities may be able to provide protections that had been provided through the Section 106 and NEPA processes" and noting that "many states have their own versions of NEPA and Section 106"); Letter from Scott K. Bergmann, CTIA, to Marlene H. Dortch, FCC, WT Docket No. 17-79, at 3 (filed Mar. 16, 2018) (the actions taken here do not "mean that small wireless facilities can be deployed by private parties without environmental and historic protections; state and local zoning, environmental, and historic preservation requirements will continue to apply"); Letter from Kenneth S. Fellman, counsel for Colorado Communications and Utility Alliance et al., to Marlene H. Dortch, FCC, WT Docket No. 17-79, Attach. At 5 (filed Oct. 19, 2017) (discussing Colorado state rights-of-way and Denver zoning requirements for wireless facilities); National League of Cities Comments, Attach. At 4 (discussing examples of factors that local authorities consider in connection with right-of-way access, including environmental and aesthetic considerations); National League of Cities et al. Request for Extension of Time at 3 (filed July 7, 2017) (observing that several states have enacted small wireless facility siting laws); see also, e.g., 2017 Pole Replacement Order, 32 FCC Rcd 9760, 9769-70, para. 23 (noting state law requirements for the handling of human or burial remains). Although this order does not preclude otherwise-existing review by other authorities, it also does not eliminate otherwise-existing limitations on that review, see, e.g., City of Boston et al. Ex Parte Letter at 8 (discussing limits under 47 U.S.C. § 1455), but instead leaves the preexisting status quo in place at this time.

n.153 We recognize that state and local procedures do not mirror the review required under Section 1.1312 of the Commission's rules in all respects. But these procedures nevertheless act as an independent check and show that our action today will not have the effect of authorizing indiscriminate deployment. To the extent that review provided for under state and local law differs, those differences presumably reflect the judgment of state and local lawmakers as to the type of review required for a particular geographic area. We thus find no basis to ignore the role of state and local procedures based on differences in their scope or application cited by commenters. See, e.g., Missouri SHPO Comments at 4; Texas Historical Commission Comments at 3; City of Boston et al. Mar. 14, 2018 Ex Parte Letter at 8-9.

There is no evidence NEPA or 47 U.S.C. Title III was intended to preempt CEQA. In fact, Congress intended NEPA and CEQA to be closely coordinated and integrated within a larger federal/state environmental framework. So any analysis required by CEQA for this project, or any of the hundreds of wireless facility application projects the draft ordinances contemplate, must still be obtained.

It is true a local jurisdiction cannot "regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions." That is the result of a federal statute (47 USC §332(c)(7), which, again is in Title III), not an agency rule. Even so, that does not mean the local jurisdiction is federally preempted from informing itself of the environmental impact from emissions that will flow from the permits it issues. Information gathering to produce required knowledge is not "regulation." Even if the county cannot "regulate" RF emissions, nothing in any federal or state law prevents the Board from informing itself, and thus also the public, about the emissions that will occur because of the permits the County will grant pursuant to the contemplated ordinances.

CEQA compliance is not "regulation on the basis of environmental effects." While CEQA has a substantive mandate (Public Resources Code section 21081), it is mainly procedural in nature, not substantive like the specifics of a zoning ordinance or design guidelines. A fully compliant CEQA analysis of the substantive ordinance and guideline outcomes is still fully required, and the Board must take a meaningful look at the true environmental impact of the proposed action. This means that any Initial Study must look at the impact of additional RF emissions on humans and the rest of the environment. It must also consider the extent to which the operation of thousands of additional wireless facilities will further increase greenhouse gas emissions and result in other toxins like lead or microplastics going into the environment.

4. **California Shot Clock Rules as Applied to CEQA Exception Analysis**

There are cases that stand for the premise that there must be a CEQA decision prior to commencing the Permit Streamlining Act's (PSA) time limits for acting on a "complete application." Eller Media Co. v. City of Los Angeles (2001) 87 Cal.App.4th 1217, 1221 [noting the Permit Streamlining Act measures all time limits for final approval or disapproval of an application in terms of the environmental review process established by CEQA]; *see also* § 65950, subd. (a); Riverwatch v. County of San Diego (1999) 76 Cal.App.4th 1428, 1440–1441 [discussing exceptions to PSA time limits, stating "CEQA itself contains no automatic approval provisions and its time limits are directory rather than mandatory."] However, unfortunately, AB 57 enacted shot clocks that do not have the same provisions that allow CEQA review to be completed as the Permit Streamlining Act does.[43] Therefore, the new rules might- and likely do- override the directory nature of CEQA-based time limits. Even so, as the article at this link indicates it is unclear what happens when a permit is deemed approved in this context. Nonetheless any CEQA-required process must be completed, even if under a compressed schedule.

In sum, the federal and state shock clock rules raise complex legal questions, but they will only arise in individual permit applications. The FCC rules defer to the state; some California cases recognize that a CEQA analysis must precede the initiation of the shot clock, but the PSA appears to supersede these cases. At the same time, NEPA is the superior federal statute and CEQA was enacted to extend Congress' intention to foster "little NEPAs." The Board cannot frustrate or undermine the federal and state policies that check against the abuse of Exemptions.

[43] *See* https://www.westerncity.com/article/brave-new-world-cell-antennas-california-what-you-need-know-about-ab-57.

To be sure, the ordinance provisions must be constructed to allow, indeed assure, any applicable shot clock is met because there are negative consequences when they are not. But nothing in federal law or any state law allows or requires that fundamental procedural due process or property rights and the environment be sacrificed at the shot clock altar. Notice and an opportunity for hearing must be provided, so ministerial treatment is not allowed.

III. Conclusion

The proposed amendments to Titles 16 and 22 will inevitably result in the blanketing of Los Angeles County with small cell and macro towers installed in high densified residential communities, rural areas and many environmentally sensitive and vulnerable historic sites. This ill-conceived, wireless industry promoted project will have massive human health and environmental consequences and threaten over 1,000 historic sites and resources in Los Angeles County. The staff failed even to consider, much less evaluate, any of these risks and wrongly contends that it has no legal obligation to do so. There is not a shred of evidence the Planning Division has consulted with the California state authorities that are responsible for the protection and stewardship of historical resources. Rather, by a flick of the administrative finger, the entire wireless enterprise – or at least that which is most urgent for humans and the environment – is careless and wrongly gifted over to “ministerial” treatment and thus exempted from meaningful evaluation.

The staff also asserts a Category 3 Exemption under the CEQA Guidelines. This memo explains why that Exemption does not contemplate or allow the wholescale environmental destruction that will result from the amended Titles 16 and 22. The staff’s reliance on this section is refuted by the extremely unusual circumstances that attend the project, which will disqualify any reliance on this Exemption.

Any potentially applicable Exemption is overridden as this memorandum documents by two Exceptions to the Exemption: the Exception for Historic Resources, and Cumulative Effects. Because the documented environmental and health risks are so grave, a Negative Declaration or Mitigated Negative Declaration will not suffice. The BOS must prepare a Comprehensive Programmatic Environmental Impact Report as required by CEQA. This EIR should also require ongoing monitoring and mitigation of identified impacts.

The BOS must also recognize that the proposed Project is not a small and insignificant County initiative. Because of the extensive federal involvement, including significant funding and services in Los Angeles County like airports, roads, crime prevention, weather forecasting and other basic functions, various federal laws are immediately applicable. The most directly relevant of these is NEPA. The BOS is legally required as the co-lead agency to consult and collaborate closely with a lead federal agency (or agencies), most prominently in this instance the Department of Transportation, FAA, and/or other concerned federal agencies in preparing a Comprehensive Environmental Impact Assessment.

The rigorous environmental review required for the Project is not preempted by federal law, in particular the 1996 Telecommunications Act (“Communications Act”) for several reasons. First, nothing in that statute indicates that states are preempted from informing themselves of the environmental and health effects, even if they are preempted from regulating the facilities causing these harms. Second, the Communications Act does not preempt or supersede other federal statutes, including most relevant here NEPA, NHPA, Americans with Disabilities Act and the Clean Water Act, all of which are triggered by the extensive federal presence. Third, it is a core principle of American jurisprudence that whenever possible, any statutes in apparent conflict must be “harmonized.” If CEQA, NEPA and Communications Act mandates are effectively harmonized, the result will be a fair and effective solution for balancing broadband infrastructural development, addressing the needs of internet-underserved communities, and protecting Los Angeles County’s living environment.

Kathleen Gildred

January 7, 2023

Dear Supervisors,

I urge you to vote NO on Titles 16 and 22. In the posted revisions, it appears you are attempting to address the problems that I and many of your other constituents have pointed out to you over the past several months. But the changes you've made do not have any enforcement mechanism or specifications. So the issues we've raised are still valid.

Although the Telecommunications Act of 1996 disallows considerations based on environment (which is interpreted as health), as our lawmakers / women / mothers - here is some background I think you should know before allowing the rollout of a technology that will be with us for many decades to come:

In 2018, the National Toxicology Program (NTP) — part of the U.S. Department of Health and Human Services — determined in a $30 million study that there was “clear evidence” that electromagnetic radiation is associated with cancer and DNA damage.
“The $30 million U.S. National Toxicology Program RF [radio frequency] studies and the Italian Ramazzini Institute’s 10-year research project both found clear evidence of malignant tumors. This study confirmed what other studies already showed decades ago including reports and studies by the Navy, Air-Force and NASA, which recognized and documented the profound bio-effects of wireless technology. These studies were for 2G/3G radiation; 5G is up to 100 times stronger, and there has never been a single safety test conducted on 5G

Over 10,000 peer reviewed scientific studies document that electromagnetic field radiation causes biological harm including increased cancer risk, neurological disorders, learning and memory deficits, increased blood pressure and blood glucose, increase in harmful free radicals, cellular stress, structural/functional changes to the reproductive system, and DNA damage. The FCC recently lost a lawsuit on their failure to update their standards and exposure levels in 26 years. The Judge's decision said that the FCC was "arbitrary and capricious" in ignoring the clear evidence of harm, particularly to children.

Firefighters in California have been granted an exemption to cell towers erected on their fire stations because the Firefighter's Unions entered substantial evidence into the public record that cell towers on or near fire stations caused (in every firefighter examined) brain abnormalities, neurological damage, cancer and other illnesses caused by wireless radiation. Is this something we want to expose all of our population to?

So please, don't take this vote lightly. Our health, our children's health, and the health of future generations will be impacted by this. Reject the influence of the telecom lobbiests! Please vote to OPPOSE Titles 16 & 22.

With sincere thanks,
Kathleen Gildred

Kathleen Gildred

We oppose LA County's amendments to Titles 16 and 22 of the LA County Code. Please vote NO!

We do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections. We want fiber instead of G5 or wifi. Fiber is safer, lasts longer, it is more economical in the long run, can use existing infrastructure by just updating it, and it is much faster.

Soft tissue development in humans, ie brains, nervous system, reproductive organs, starts with birth until the age of 22 yrs of age. Children up to that age are most vulnerable to ionizing radiation damage to the soft tissues in their bodies during that period. We oppose the increase of ionizing radiation in our neighborhoods due to the widespread use of G2-G5 cellphones, wifi and communication towers. Los Angeles should follow the example of several European Countries that have already started limiting/banning the use of wifi in schools, in favor of fiber.

We want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully with CEQA.

We also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

We are requesting you respect the rights of the disenfranchised segregated unincorporated areas in Los Angeles. They have yet to receive equal access and protection for build outs, maintenance, upgrades, or adequate remediation for past fires and the current fire risks that remain. These fire risks will be exacerbated by the complications resulting from the reckless changes to Titles 16 & 22.

We support fiber first, for it is less harmful to our health and environment. It is more secure and sustainable which will lessen our carbon foot print. Fiber First will not leave future generations left behind as it's life span goes far beyond 5G. Fiber First will provide many jobs. 5G wireless communication poses national security risks. It is easier to hack which is a threat to our privacy. It allows private corporations to mind all our data.

Prof. Dr. Tony Pereira, UCLA PhD, Fulbright Scholar
1501 E Carsons St 15
Carson, CA 90745
(310) 549-3077
apereira@ucla.edu

From: Michael Patti
To: PublicComments; Barger, Kathryn; Supervisor Janice Hahn (Fourth District); Sheila; holly.jmitchell@bos.lacounty.gov; firstdistract@bos.lacounty.gov
Subject: No to 75foot or 95foot at&t cell tower in Stevenson Ranch community
Date: Sunday, January 8, 2023 7:22:30 PM

CAUTION: External Email. Proceed Responsibly.

To Los Angeles County Board Of Supervisors
publiccomments@bos.lacounty.gov,kathryn@bos.lacounty.gov,fourthdistrict@bos.lacounty.gov,sheila@bos.lacounty.gov,holly.jmitchell@bos.lacounty.gov,firstdistrict@bos.lacounty.gov
RE: Project No. PRJ2021-000295/CUP No. RPPL.2021000766, Hearing 01/10/23 and 01/31/23

My wife and I are long time residents of Stevenson Ranch community. We are not in favor of this steel tree in this wonderful community.
We are not saying that there is not a problem with the cell service. Although we have great service at our home and outside of our home. Everywhere I walk I have great reception. I walk every morning rain or shine throughout this community.
Are you aware that this tower was proposed 8 or 9 years ago. The residents at the top of the development had and still have a problem with their cell service. And the same tower was proposed 75 to 95 foot tower. But the residents didn't want this tower up at that part of the community.
AT&T and our H.O.A kept in touch both looking to make a profit from this project. When asked about the amount of the lease the HOA said that didn't have any idea. But AT&T would have to lease the land from the HOA. And sell tower space to other cellular providers. They choose this site no prep work. Each looking to make a profit from this project at our expense.
Two signs were put up, one was on a short dead end street, that was most affected by the emergency generator and the 95foot tower with only ten homes. The other sign on a street that is only traveled by less then 10% of the nearby residents. There are people affected in other areas, for instance, by the elementary school and people that frequent Rioux Park that were not made aware of the tower. The placement of the signs were meant to keep people in the dark, why was it such a secret.
There are no other towers like this in the Santa Clarita Valley or in neighborhoods of the San Fernando Valley, because there are other alternatives, like boosters on street lights. Thank you
Michael J Patti 26005 O'Hara Lane, Stevenson Ranch, CA 91381

From:	Michael Patti
To:	PublicComments
Cc:	Barger, Kathryn; Sheila; holly.jmitchell@bos.lacounty.gov; firstdistract@bos.lacounty.gov; Supervisor Janice Hahn (Fourth District)
Subject:	NO to 95 Foot AT&T Cell Tower in the Middle of Stevenson Ranch Residency
Date:	Sunday, January 8, 2023 8:28:58 PM

CAUTION: External Email. Proceed Responsibly.

Cell tower in Stevenson Ranch. We my husband and I are not in favor of the tower. We the residents have been continuously let down and sold out by our association and the planning commission. It is mind boggling that the modern county of Los Angeles with a population of over 10 million has a planning committee who stated that they didn't understand the AT&T proposal and didn't have the common sense to say, we would like to take this matter under advisement. After that just to rubber stamp it again. Well I just don't have the words to describe how incompetent that was.

The cell tower doesn't have to be placed here in the middle of a residential community, school and park surrounded by houses. I have lived here for over 25 years and purchased our home new. We were the first one on our street and want to stay here. This is a community we know and love. Our neighbors up and down our street and other streets are our friends. At the second meeting of the planning commission, there was a comment made by AT&T that the first responders need this cell service in case of an emergency. That is not true, after the 94 earthquake a resolution was made to have a radio frequency that is inter departmental for emergencies that is just for their use.

Stevenson Ranch is our home. Do us all a favor and take this matter under advisement. To have a tower that big it should be placed on the edge of our community, not in the center of it where children play. I believe that another location was considered but there would more costs to AT&T as it would need an access road. There is also a area near the water tank at the north end outside of our community.

Thank you, Patricia Patti 26005 O'Hara Lane, Stevenson Ranch CA 91381

From:	Charlett Albert
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	Please enter into public record for changes to Titles 16 and 22
Date:	Saturday, January 7, 2023 7:15:06 PM

CAUTION: External Email. Proceed Responsibly.

Dear Supervisor;

“The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.”

Here is a link to a **CBS news report of multiple children getting cancer from a cell tower placed on their school property,** according to the parents interviewed.
https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the **lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling.**
https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you and sincerely,

Charlett Albert

From: Frank Gonzales Jr.
To: ExecutiveOffice; First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn
Subject: Please enter into public record for changes to Titles 16 and 22. Thank you.
Date: Saturday, January 7, 2023 6:26:26 PM

CAUTION: External Email. Proceed Responsibly.

Dear Supervisor,

“The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.”

Here is a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed.
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FCC Lawsuit 2020 RF Standards

We Won! FCC RF Standards Ruling In this historic win, the court ruled the FCC ignored complaints of health effec...

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you and sincerely,

From:	Jessica Isles
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	Please enter into public record for changes to Titles 16 and 22
Date:	Saturday, January 7, 2023 6:13:34 PM

CAUTION: External Email. Proceed Responsibly.

Dear Supervisor;

"The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children."

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https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you and sincerely,
Jessica Isles

From:	Paul Statman
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	Please enter into public record for changes to Titles 16 and 22
Date:	Saturday, January 7, 2023 7:29:06 PM

CAUTION: External Email. Proceed Responsibly.

Dear Supervisor,

The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.

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And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling. https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you.

Sincerely,
Paul Statman

From:	John Star
To:	First District; Barger, Kathryn; ExecutiveOffice; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District)
Subject:	Please enter into public record for changes to Titles 16 and 22
Date:	Saturday, January 7, 2023 10:36:32 PM

Dear Supervisor,

This is the time to fully acknowledge and act in accordance with the scientifically proven fact that 5G radiation has serious deleterious biological effects on human beings.

The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.

Here is a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed. https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling. https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Seriously and Sincerely Yours,

John Star

From: Sherri Andrade
To: First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject: Please enter into public record for changes to Titles 16 and 22
Date: Saturday, January 7, 2023 10:00:15 PM

CAUTION: External Email. Proceed Responsibly.

Dear Supervisor;

"The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children."

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https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling.

https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you and sincerely,

Sherri Andrade

From:	Amy Harlib
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.
Date:	Saturday, January 7, 2023 8:17:42 PM

Dear Supervisor;

STOP DANGEROUS MICROWAVE RADIATION FROM POISONING WE THE PEOPLE!

“The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.”

Here is a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed.
https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling.
https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you and sincerely,

Amy Harlib
Citizen, USA

From:	Kelly McMenimen
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	Please enter into public record for changes to Titles 16 and 22
Date:	Saturday, January 7, 2023 8:05:51 PM

Dear L.A. Supervisors,

I am writing to urge you not to give away our private property rights and rights to maintain a healthy environment around our homes to big corporations.

I do not live in L.A., but what you decide matters for all of California, not only for L.A. So I am writing to you because your decision will affect all of us.

I imagine you may be getting pressure from representatives of industry. Perhaps they are using carrots, perhaps sticks. Please remember that for them, it's all about money. They are willfully turning a blind eye to the harms of their technology because all they see are dollar signs.

Please don't fall for it. Vote NO ON CHANGES TO TITLES 16 AND 22, item # 59 on Jan. 10. The changes would strip citizens of our rights to a healthy environment around our homes, self-determination on our own private property, and so much more, all in favor of corporate profit. Please don't do it. You are all that stands between the communications industry and a huge health problem for the children and all people in your county and in the state and beyond.

Here is a link to the lawsuit the FCC just lost in regard to children getting cancer from such cell towers, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling.

https://thepeoplesinitiative.org/wp-content/uploads/2022/11/FCC-Ruling-RF-Standards.pdf

Thank you for doing the right thing. A whole lot of us are going to have to be even more courageous and determined to the do the right thing if we are going to ensure that our children have a future worth living.

Regards,
Kelly McMenimen

Kelly McMenimen
Director and Lead Teacher
Earthwise Education
(415) 488-4682
www.earthwiseeducation.org

From:	contact thepeoplesinitiative.org
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	VOTE NO on Titles 16 and 22, For Entry Into Public Record
Date:	Saturday, January 7, 2023 7:55:46 PM

Dear BOS,

My name is Liz Barris, I am in District 3 and beseech you to vote NO on Item # 59, proposed changes to titles 16 and 22.

Recently, I was a plaintiff in a case against the FCC for failure to protect public health from health effects in the "safety standards" of wireless radiation. We prevailed in that case which is bad news for the industry, good news for those suffering from microwave radiation poisoning aka electrosensitivity, like myself and many others in our non profit and other EMF activist groups.

There tens of thousands of studies in existence showing harm from wireless radiation. The industry and Regional Planning are probably telling you it is not legal for you to block these proposed changes from being enacted. If they are saying this, it is not true and in fact, the county is going to be sued by numerous people, starting with our non profit and I am not saying that to threaten, I am just stating a fact. This is a life and death situation for those who already have had cancer or other pre-existing conditions, myself and others in our group included. Here is a link from our website with drop downs for different illnesses and studies of wireless radiation and the associated illness...

https://thepeoplesinitiative.org/wireless-radiation-and-health-effects/

This link contains 11,000 pages of evidence from our winning FCC suit plus 4 amicus briefs...

https://thepeoplesinitiative.org/lawsuits/

Here is a link to a CBS story from a school in CA where 4 children and 3 teachers all got cancer after a cell tower was placed on campus...

https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

I will follow this email up with the true reason why the NWO wants 5G transmitters near every home.

Thank you for voting NO on Titles 16 and 22.

Sincerely,

Liz Barris

United Keetoowah Band of Cherokee Indians in Oklahoma

P.O. Box 746 • Tahlequah, OK 74465
18263 W. Keetoowah Circle • Tahlequah, OK 74464
Phone: (918) 871-2800 • Fax: (918) 414-4000
Toll Free: 1-877-431-1818
www.ukb-nsn.gov

January 9, 2023

Federally Recognized
October 3, 1950

OFFICE OF THE
ATTORNEY GENERAL

Klint A. Cowan
Attorney General
c/o FELLERS SNIDER
100 N. Broadway, Suite 1700
Oklahoma City, OK 73102
(405) 232-0621
KCowan@FellersSnider.com

Supervisor Janice Hahn – FourthDistrict@bos.lacounty.gov
Supervisor Holly J. Mitchell – HollyJMitchell@bos.lacounty.gov
Supervisor Hilda Solis – firstdistrict@bos.lacounty.gov
Supervisor Kathryn Barger – Kathryn@bos.lacounty.gov
Supervisor Lindsey Horvath – Lindsey@bos.lacounty.gov
Los Angeles County Board of Supervisors –
executiveoffice@bos.lacounty.gov

Dear Hon. Sup. Hahn and Members of the Board:

I am writing in opposition to Agenda Item 59, Titles 16 and 22, which will fast-track cell towers throughout Los Angeles County. The Los Angeles County Board of Supervisors has already passed a categorical exemption to California state environmental law, CEQA.

We are opposed to any exemption of environmental review when it comes to the placement of cell towers. The United Band of Keetoowah Cherokee Indians sued the FCC, asking the federal courts to halt the FCC's Wireless Infrastructure Streamlining Order which was passed in September 2018. The FCC had ruled it could deploy thousands of wireless antennae for 5G capabilities across the United States without meeting tribal consultation review requirements because the projects were not defined as "undertakings" under the National Historic Preservation Act or "major Federal actions" under the National Environmental Policy Act.

The United Band of Keetoowah Cherokee Indians was victorious in that lawsuit against the FCC.

NHPA was enacted in 1966 to preserve historical and archaeological sites in the U.S. if they were located in construction sites. NEPA was enacted in 1970 and requires federal agencies to determine any environmental effects that could happen as a result of a proposed project.

The FCC argued these types of reviews by tribes, commonly known as Section 106 reviews, "would impede the advance of 5G networks and that its costs outweighed any benefits."

It also justified bypassing NHPA and NEPA regulations because 5G antennae are less than 200 feet in height, won't be located near an airport and their construction is not subject to the agency's "limited approval authority." The agency cited that the "small" nature of the projects "appears to render them inherently unlikely to trigger environmental and historic preservation concerns."

The appeals court did not agree, calling the deregulation "arbitrary and capricious" because it "did not adequately address the harms of deregulation or justify its portrayal of those harms as negligible." Instead, the FCC "failed to justify its confidence that small cell deployments pose little to no cognizable religious, cultural, or environmental risk, particularly given the vast number of proposed deployments."

The opinion states that "tribes' views must be taken into account where the agreement has the potential to affect historic properties on tribal lands or historic properties of religious and cultural significance to an Indian tribe."

NEPA is the National Environmental Protection Act and as you know, CEQA is the California state environmental law. We believe there is an environmental impact to building out thousands of cell towers in Los Angeles County. You have a duty to protect the environment and as you protect the environment, you are protecting the residents of Los Angeles County. You would be failing to take into account location in sensitive areas, the overall environmental, radiation, and energy usage of 5G antennae, and you would be ignoring the fire risks in a state that cannot afford more fires.

Los Angeles County has more Native Americans than any other County in the country. Fire can damage Native American homes, lands, and artifacts that are irreplaceable.

The United Band of Keetoowah Cherokee Indians therefore stands in opposition to the passage of Titles 16 & 22 and urges the Los Angeles County Board of Supervisors to reverse their categorical exemption of California's environmental law.

Respectfully,

Klint A. Cowan
Attorney General
United Keetoowah Band of
Cherokee Indians in Oklahoma

KAC/sah
899483.1/80729

Mothers of East Los Angeles

MELA

January 9, 2023

To: Los Angeles County ("LAC") Board of Supervisors Members:
Hilda L. Solis, Holly J. Mitchell, Janice Hahn, Kathryn Barger, Lindsay Horvath
Cc: Chair LA County Regional Planning Department ("LACRPD"): Yolanda Duarte-White,
Director of Public Works: Mark Pestrella, Dawyn R. Harrison, Acting County Counsel

Re: Petition Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage Scheduled for January 10, 2023)

Dear LAC Board of Supervisors Members (and Other Concerned with the above captioned matter):

The Mothers of East LA have struggled for a better condition of life for the community of East Los Angeles over the last 37 years. Our most recent struggle has been against the Exide battery recycling plant that has been poisoning our community for decades.

Over the last 37 years we have dedicated our lives to give the people a voice against environmental injustices. This voice has been heard in the past in which we were successful in opposing the proposed state prison facility in Boyle Heights.

We feel that the introduction of a wireless system would be another case in which the community of Boyle Heights is used for the benefit of everyone else. Further this system would negatively impact the children of East Los Angeles. This project, the Title 16 and Title 22 Amendments, proposes to put an antenna adjacent to the East Los Angeles interchange, a freeway interchange of 5 different freeways where over 500,000 cars travel daily to Downtown Los Angeles and back. The addition of the invisible radiation system will only amplify the current negative impacts of the freeway system.

We urge the Board to vote "No" on this measure because of the impact and lack of social concern for the people of Boyle Heights and East Los Angeles.

Sincerely,
Teresa Griffin, Secretary

Mother of East Los Angeles | 3324 Opal St. Los Angeles, CA 90023

Supervisors, Hilda Solis, Janice, Hah, Kathryn Barger, Holly J. Mitchel, Lindsey Horvath,

The digital divide has been caused by a partisan divide that in recent years has perpetuated an agenda that has exposed the bigotry and a financial theocracy practiced by both both the extreme right and fascist neo liberals.

This partisan divide has blocked and stalled President Joseph Biden's appointment of Gigi Sohn’s to the Federal Communications Commission. The previous administration promoted privatization and the satellite, cable, and telecommunications industry seized that opportunity to engage in a very well funded campaign to push through legislation that served their multinational corporate agendas at the expense of our constitutional rights, our health and well being, the ecocide of our environment caused by radiation, and the massive hyste of public funds.

Therefore, we oppose the Amendments to Titles 16 & 22 of the LA County Code. Do not take away our rights and protections. Please vote no on agenda item # 56.

We do not want a cell tower or small cell facility installed right outside our homes or in our neighborhoods without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

We want a reversal of the Categorical Exemptions to California Environmental Quality Act in Titles 16 & 22, so the County Code complies fully with the California Environmental Quality Act.

We also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

We are also requesting that you respect the rights of the disenfranchised segregated unincorporated areas in Los Angeles and other areas of the county. That have yet to receive equal access and protection for build outs, maintenance, upgrades, or adequate remediation for past fires and the current fire risks that remain. In our areas we have died, we are chronically sick and our future generations will forever be negatively impacted due to the environmental racism we continue suffering from. Those who are born with congenital issues or suffer from preexisting conditions will only suffer more from this radiation exposure and know our life spans will be shortened due to the radiation exposure and due to the current deplorable environmental situation that plagues our segregated areas.

In addition, we can't discuss the digital divide and attempt to address it without integrating the electrical grid into the equation in order to make informed decisions regarding these serious topics.

Cell tower explosions have caused the loss of human lives, as well as other life forms. They have devastated entire communities and have caused unimaginable heart ache and financial hardships to families and our economy. These fire risks will be exasperated by the complications resulting from the reckless changes to Titles 16 & 22.

We support fiber first, for it is less harmful to our health and our environment. It is more secure and sustainable which will lessen our carbon footprint. Fiber First is essential for businesses and academic institutions and to our government and our republic as a whole.

Fiber First will not leave future generations left behind as it's life span goes far beyond 5G.

5G towers are an eye sore and are designed differently with no community input in minority communities or within areas that have a lower S.E.S. Social Economic Status. Fiber First will provide many much needed jobs all across the county.

Furthermore, 5G wireless communication poses national security risks. It is easier to hack which is a threat to our privacy. It allows private corporations to mind all our data. We request that you vote no on agenda item # 59.

For your review please access the following link that provides the scientific data that documents the rational for biological based exposure standards for harmful low-intensity Electromagnetic Radiation and Radio Frequencies Radiation.

The BioInitiative 2012 Report has been prepared by 29 authors from ten countries, ten holding medical degrees (MDs), 21 PhDs, and three MsC, MA or MPHs. Among the authors are three former presidents of the Bioelectromagnetics Society, and five full members of BEMS.

https://bioinitiative.org/

Por Mi Raza Habla Mi Espíritu!

Sofía G. Quinones
East Los Angeles
Boyle Heights Coalition
(323)494-6005

Dale Conklin
7516 W 80th St
Los Angeles, CA 90045

Re: Vote NO to change to Titles 16 and 22 (Agenda item 59)

LA Board of Supervisors

Please Safeguard Due Process Rights: _The radiation emitted from cell towers is not safe._ Placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.

Please adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Please expand use of fiber optic broad connections not wireless.

New small cell antennas will not help 911 calls when power is out since they will not be on emergency backup power. The claim that these will be helpful is false and not an argument in favor of amendment.

Thanks for your consideration.

Dale Conklin

Homeowner

From: Gabriel Chrislock
To: First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject: Please enter into public record for changes to Titles 16 and 22
Date: Sunday, January 8, 2023 12:46:52 PM

CAUTION: External Email. Proceed Responsibly.

Dear Supervisor;

“The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.”

Sincerely, G

abriel Chrislock

From: Suzanne Pelletier
To: First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject: Please enter into public record for changes to Titles 16 and 22
Date: Sunday, January 8, 2023 12:37:10 PM

CAUTION: External Email. Proceed Responsibly.

Dear Supervisor;

"The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children."

Here is a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed.
https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling.
https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you and sincerely,

Suzanne Pelletier
Montgomery, VT

From: 5GFree California
To: First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject: Please Vote No on Jan 10th on Agenda Item 59 - Titles 16 and 22
Date: Sunday, January 8, 2023 11:37:31 AM

CAUTION: External Email. Proceed Responsibly.

image.png

January 8, 2023

Los Angeles Board of Supervisors
Honorable Janice Hahn, Chair
Honorable Board Members: Hilda Solis,
Holly J. Mitchell, Lindsey Horvath & Kathryn Barger

Re: Agenda Item 59- County Code, Title 16 - Highways and Title 22 - Planning and Zoning Amendments

Dear Members of the LA Board of Supervisors:

We appreciate your delaying your vote on Titles 16 and 22 of the LA County Code on December 6th. We urge you not to approve the recently "revised" language of Titles 16. because protective language that the people of LA County need to keep them safe from the explosive expansion of wireless infrastructure has not been incorporated into these revised Titles.

We know that Verizon "*has been working proactively with cities across the county to update ordinances and design standards to better align with Federal Communication Commission (FCC) regulations.*"

Although the FCC does mandate certain requirements for local governments regarding telecom permit applications, such as shot clocks (where local planning and zoning departments must act within a prescribed time period), and radio frequency (RF) emissions guidelines (assuming that the provider is in compliance with the Commission's RF rules), there are still a number of actions that local governments can take to ensure maximum safety for their populous.

Fiber First LA has prepared comprehensive "redline" drafts of Titles 16 and 22 to give LA County the maximum amount of control over the siting of telecommunication infrastructure. It appears that the revised versions of 16 and 22 did not take these suggested control measures into consideration. Why is that? It appears Verizon certainly had their say with County staff.

Verizon's public comment letter specifically states, "*By separate letter, Verizon has previously provided technical comments to the proposed ordinance. The Verizon legal team greatly appreciates the ongoing engagement with County staff to develop strategies to accelerate the deployment of broadband infrastructure and delete the digital divide."*

Of course, companies such as Verizon would want to accelerate the deployment of their infrastructure because that is their business model and they have stockholders to satisfy. Verizon, AT&T, T-Mobile and others are all competing for market share. Can't blame them for trying to make a buck, or a few billion bucks. They want you to think that their product is the only way to eliminate the digital divide.

What does this mean? Who has actually written these amendments to the County code titles? Is it Verizon? Why hasn't Fiber First LA been consulted? Their redline drafts of Titles 16 and 22 have been prepared by a top notch legal team NOT connected to Telecom, so there is no conflict of interest. Their only motivation is to give the County maximum control and the people maximum protection of rights. Can't argue with that!

There is something very wrong with this picture.

No one is saying that the County must prohibit wireless service or not take important steps to "bridge the digital divide." We are simply advocating for the County to employ a balanced approach. (1) Maximize protective measures in the permitting of wireless infrastructure, (2) Take proactive steps to develop comprehensive fiber networks to give people more choice in connectivity (taking advantage of billions of federal dollars for developing low cost <u>wired</u> networks) and (3) Work with local city governments and county residents to ensure that ALL have the right to fair hearings in the placement of telecom infrastructure with maximum protection so they can be safe in their communities.

Please don't allow Verizon, or any other wireless company to cloud your judgment. The future of LA County is at stake here. This is not an exaggeration. The decision you make on Tuesday could be the biggest one that you will ever make as Supervisor.

Thank you for your consideration.

Sincerely,

Julie Levine, Executive Director

5G Free California

From:	mwchrislock@redshift.com
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	Please enter into public record for changes to Titles 16 and 22
Date:	Sunday, January 8, 2023 10:13:27 AM

Dear Supervisor,

Please do not expose my children and grandchildren to 5G technology. It has not been proven safe.

“The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.”

Here is a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed.

https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling.

https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you,

Melodie Chrislock

From:	contact thepeoplesinitiative.org
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	How 5G Interacts with Vaccinated People, VOTE NO on Titles 16 and 22, For Entry Into Public Record
Date:	Sunday, January 8, 2023 6:49:37 AM

Dear BOS,

My name is Liz Barris and am following up on the email I just sent asking you vote NO on changes to titles 16 and 22. The below links are videos, papers and articles on how 5G will interact with people who have been vaccinated with the Covid 19 vaccine or other recent flu vaccines that contain nano tech and graphene oxide (only a couple of the harmful ingredients that have nothing to do with helping people not catch the flu or other illness).

Here is evidence of nano tech in the vaccines and how 5G will work with the nano tech that has is contained in the vaccines...

https://www.brighteon.com/cf03d0b1-a6ca-4741-b484-9ed90d818d23

Here is a very timid example of how easily wireless radiation can be weaponized with AI

https://www.brighteon.com/29ed130f-ff5b-4ac2-9c3f-f1ef3475de22

More on nano tech in the vaccines...

https://expose-news.com/2021/12/24/nano-technology-in-covid-injections-its-for-communications-its-technological-parasitism/

5G in front of peoples houses will be used to hook everyone up to the IoB (Internet of bodies.

https://www.rand.org/about/nextgen/art-plus-data/giorgia-lupi/internet-of-bodies-our-connected-future.html

5G will just be one more intrusive surveillance infrastructure, however the difference here is it can also be used as a weapon due to the focused beam, extremely high frequencies and power densities.

PLEASE VOTE NO TO CHANGES TO TITLES 16 and 22.

Thank you and sincerely

Liz Barris

From:	Ken
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice
Subject:	Please vote NO on changes to titles 16 and 22.
Date:	Sunday, January 8, 2023 6:38:35 AM

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you,
Ken Marino
1112 Montana Ave.
Santa Monica, CA 90403

From:	J Petzold
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn; ExecutiveOffice; Sheila
Subject:	Opposition to the Board"s Intent to Make changes to Titles 16 and 22 Re proliferation of 5G towers. Please Consider & Enter into the Legislative and Public Records.
Date:	Sunday, January 8, 2023 12:58:32 AM

Dear Supervisors;

As you are aware, you previously delayed your voting on this matter because you received a multitude of oppositions. Therefore, your tactic was to have the voting on another day in the hopes that it will fall below the radar. This tactic does not serve the people and is extremely underhand and in my view needs to be adjudicated in another forum. This process of unilaterally delaying your voting and continuing the matter for a later date when you have received a plethora of oppositions has been the standard "response" by the Board. Your action shows bad faith and is evidence that you are aware of the true nature of the issue and what your votes should be based on the factual evidence presented to you and which you also have a fiduciary duty to be knowledgeable about before you vote. These 5 G towers are weaponized and can cause harm to humans. They have no business in front of anyone's home. **Would you please also incorporate all the previous oppositions you received on this matter into your upcoming hearing and any future hearings**. I respectfully ask that you do the right thing and vote for Light rather than Darkness. God is watching. May God bless and protect you all and empower you to do what's good for Humanity.

"The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children."

Here is a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed. https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling. https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you and sincerely,

JPetzold

From: Fanny Magier
To: ExecutiveOffice
Subject: About 5 G installation
Date: Sunday, January 8, 2023 8:41:48 PM

CAUTION: External Email. Proceed Responsibly.

No on letting installed 5 G tower or other installation of 5 G in any property.
It’s going to kill a lot of people and you do know that.
It’s a bioweapon and you do know that and millions of people do know that.
And apparently if you want 5G there is something even better to run faster the internet ..and I believe cheaper!

Fanny Magier
Intuitive Coach for the soul, mind, and body
Stress relief helper
Spiritual consultant
Family coach specializing in adoptive families
1(310)890-3176
http://secure-web.cisco.com/1iaB1Tjy1t1bE0Feo0W23eQXrUtpws8IED8yuiir2hNrkH8Ea6C5hJupqPSZCivtxZDaK_Ceeti9wJEHCZM_N9QQ8YEoMdsQKiEuNCkWKsYfwDmW_1Galfo6Ku8rnshaULGNG3j87_zQi3e4t3eHYF-ObinDFzouhulQ_t2XiK3c0KcY1D9sNVp1OHDZ6d4w5fAvbIA87C4O1cv5CswYjumK_2XzjKJ3pGNtRGTYFgJOmUjBfslvbW48ePxsXY8_k6gIlrFTFobovbWt_3kbC6U9AgE0MS583vZ7lq-xZyD9ctDkZNx8mydDA-MPKssF4Ye21upDspG9KbjoiBnPuJ0HrLM3f971eFeLtvj0ZmEIZPfuoQPyidkKpbnjagYE5/http%3A%2F%2Fwww.FannyEnergyHealer.com

Remove the Fear, Love will appear

From: Kelly Brinn
To: ExecutiveOffice
Subject: County Code, Title 16 – Highways and Title 22 – Planning and Zoning Amendments
Date: Sunday, January 8, 2023 5:09:44 PM

I request my written comments be part of the public record for **Agenda Item #59, County Code, Title 16 – Highways and Title 22 – Planning and Zoning Amendments** for the January 10th LA County Board of Supervisors Meeting.

Don't take away our rights and protections.

I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. **Please vote NO.** I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing, or opportunity to appeal, and without any fire or safety provisions, and without regard to critical environmental protections.

I want a reversal of the Categorical Exemptions to CEQA in Titles 16 and 22, so the County Code complies fully with CEQA. I also request the Board of Supervisors adopt the **proposed redline changes to Titles 16 and 22** that were submitted by **Fiber First LA**.

Sincerely,

Kelly Brinn

From: ExecutiveOffice
To: PublicComments
Subject: FW: No 5G
Date: Monday, January 9, 2023 12:06:45 PM

The following correspondence is being forwarded to you for your review/information

From: Michelle Mohawk <aquachiro@gmail.com>
Sent: Tuesday, January 3, 2023 8:32 PM
To: ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Subject: No 5G

I request my written comments be part of the public record for Amendments to Titles 16 & 22 of LA County Code at the
January 10th LA County Board of Supervisors Meeting.

Don't take away our rights and protections.
I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.
I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully withCEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

Amendments to Titles 16 & 22 of LA County Code at the
January 10th LA County Board of Supervisors Meeting.

Don't take away our rights and protections.
I oppose LA County's proposed amendments to Titles 16 and 22 of the LA County Code. Please vote NO.
I do not want a cell tower or small cell facility installed right outside my home or in my neighborhood without any prior notice, public hearing or opportunity to appeal, without any fire or safety provisions, and without regard to critical environmental protections.

I want a reversal of the Categorical Exemptions to CEQA in Titles 16 & 22, so the County Code complies fully withCEQA. I also request the Board of Supervisors adopt the proposed redline changes to Titles 16 & 22 that were submitted by Fiber First LA.

These Amendments will increase Fire Risk. Four of the last major local fires have been caused by telecommunications equipment.

The claim that hundreds of new small cells are required for 911 calls is false. With loss of electricity, all 911 calls will depend solely upon the macro towers that have already been backed up per the California Public Utilities Commission (CPUC) Order.

Wireless broadband uses ten times as much energy as fiber optic broadband, therefore significantly increasing our carbon footprint. The Board of Supervisors should prioritize fast, reliable and secure future-proof fiber to the home for everyone in Los Angeles County.

Thanks for your consideration in this important matter.

Sincerely,

Dr. Michelle Mohawk, DC (Sherman Oaks homeowner)

--

Dr. Michelle McLafferty, DC

www.aquatherapynow.com

From:	ExecutiveOffice
To:	First District; Holly J. Mitchell; Third District; Supervisor Janice Hahn (Fourth District); Barger, Kathryn
Cc:	PublicComments
Subject:	FW: cell
Date:	Monday, January 9, 2023 1:52:20 PM

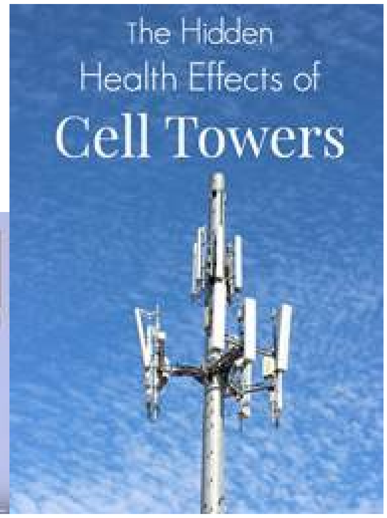
The following correspondence is being forwarded to you for your review/information.

From: Eddy.N@verizon.net <Eddy.N@verizon.net>
Sent: Monday, January 9, 2023 1:48 PM
To: ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Subject: cell

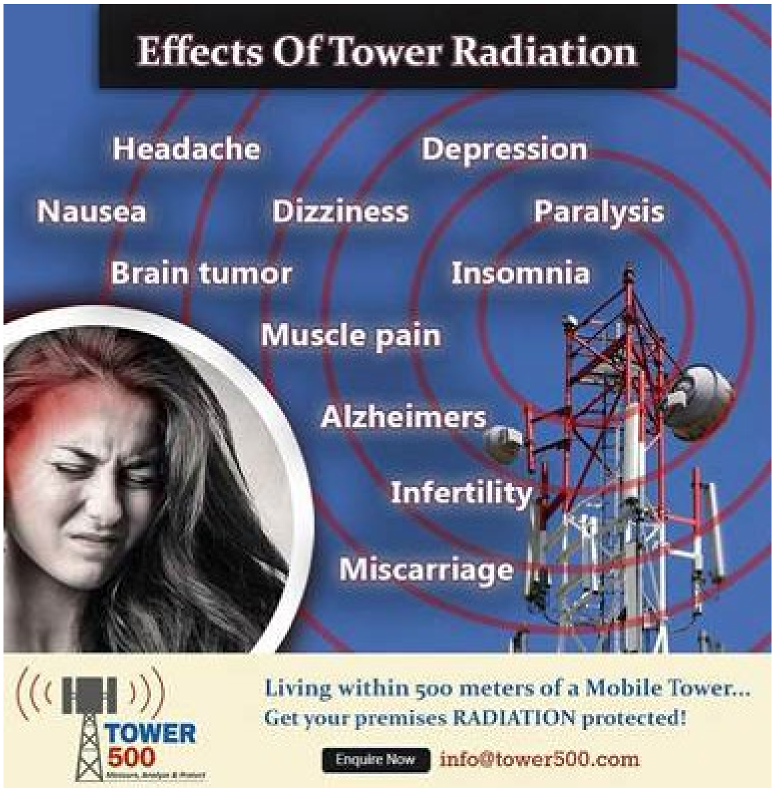
CAUTION: External Email. Proceed Responsibly.

Dear LA County Board of Supervisors

The people of LA are concerned about our health and safety, and we demand the Board vote NO changes to Titles 16 and 22 of LA County Code, because if proposed changes pass, wireless facilities will be installed without any prior notice, **public hearing or opportunity to appeal** — without fire or safety scrutiny and without regard to critical environmental protections. The Board must serve the public interest, not corporate interests, and vote NO on proposed changes to Titles 16 and 22 to safeguard due process rights. We have seen time and time again that policies adopted in California quickly spread to other states. If adopted in LA, similar changes will pass throughout California and the rest of the United States.



Telecom giants will get a free pass to further fast-track the installation of cell towers and small cells in our yards and next to our children's schools. Due process rights will be stripped from residents. These installations are not safe but pose a significant health and fire risk and continuously expose us, our children and the environment to toxic levels of RF radiation. Wireless facilities will be installed without any prior notice, public hearing or opportunity to appeal — without fire or safety scrutiny and without regard to critical environmental protections, so why are these harmful changes to LA County Code to benefit telecom companies at OUR expense even on the table?



LA County must not give up local control, but stop these dangerous developments now, before they are proposed in other cities. LA County Board of Supervisors must safeguard OUR due process rights by voting NO to the proposed changes to Titles 16 and 22, and we demand the following protections:

- **Safeguard Due Process Rights**: Radiation emitted from cell towers is not safe for humans or the environment. Therefore, placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.
- **Adopt the Redline**: Board of Supervisors must adopt redline for Titles 16 and 22 that Fiber First L.A. submitted. Demand them to invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods.

- **Protect Us From Telecom Wildfires**: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecom equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers.
- **Stick to Facts**: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon macro towers that receive backup power per California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and must not be used as an argument for the amendments.

From:	ExecutiveOffice
To:	PublicComments
Subject:	FW: Opposition to County Code, Title 16 - Highways and Title 22 - Planning and Zoning Amendments
Date:	Monday, January 9, 2023 1:58:57 PM
Attachments:	MELA Opposition to Title 16 and 22 1.9.23.pdf

The following/attached correspondence is being forwarded to you for your review/information.

From: Sofia Olivares <sofia@barrioplanners.com>
Sent: Monday, January 9, 2023 11:24 AM
To: ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Cc: First District <firstdistrict@bos.lacounty.gov>; Holly J. Mitchell <HollyJMitchell@bos.lacounty.gov>; Sheila <Sheila@bos.lacounty.gov>; Supervisor Janice Hahn (Fourth District) <fourthdistrict@bos.lacounty.gov>; Barger, Kathryn <Kathryn@bos.lacounty.gov>; Dawyn Harrison <dharrison@counsel.lacounty.gov>; Third District <ThirdDistrict@bos.lacounty.gov>; Frank Villalobos, FAIA <frank@barrioplanners.com>; Brenda Martinez <brenda.bhnc@gmail.com>
Subject: Opposition to County Code, Title 16 - Highways and Title 22 - Planning and Zoning Amendments

CAUTION: External Email. Proceed Responsibly.

Good morning,

This email is sent on behalf of Mothers of East LA, a CA 501 (c)(3) nonprofit organization, in opposition to County Code, Title 16 - Highways and Title 22 - Planning and Zoning Amendments.

We urge the Board of Supervisors to take our attached statement into consideration and vote No on the ordinance as written. We urge the Board to adopt the redline copy of Title 16 & 22 submitted by Fiber First L.A. for the safety and wellbeing of the community of East LA.

Thank you,
Teresa Griffin, Secretary

From:	Susan Vezina
To:	PublicComments
Subject:	Reject S.R. Cell Tower & facility -Email 5 LA County Board of Supervisors & Public Comment
Date:	Monday, January 9, 2023 2:44:36 PM

CAUTION: External Email. Proceed Responsibly.

I am writing to oppose the AT&T cell tower. If approved, the cell
tower will be 75-95 feet in height, violating the recently adopted Los Angeles County Wireless Facilities Ordinance, which restricts cell tower height to 35-feet in residential-zoned areas, such as Stevenson Ranch.
The cell tower would be in the center of our community, very close to homes and in their line of sight, adjacent to the park, and with the top of the cell tower antennas aligned directly with the elementary school playground, classrooms and daycare, about 1/8 of a mile, 660 feet, from the main tower radiation source because the school is just uphill from the tower.
The cell tower will impede my enjoyment of the community and be an eyesore. The individual residents of Stevenson Ranch need protection from this powerful commercial industry. It is
important to me that the community is zoned residential and does not suffer from the large industrial intrusion of a 75 - 95 ft cell tower with its out-building and loud commercial generators. I enjoy the views from my home. I enjoy the view from the
park and the feel of the modest bedroom community when I go for a walk. A 75-foot commercial tower will be far taller than any other
structures in the community. The commercial structure enclosing the tower will be ugly and the generator noisy. It is also dangerous and a fire hazard. AT&T has just received the largest fine due to its lack of attention to on-site cell tower facility toxic waste. This does not belong in-between homes and next to hundreds of children.
Decorating the cell tower to look like a giant pine tree will not solve this problem, it will be ugly and highly visible, and a detriment to the local environment.
Cell coverage in Stevenson Ranch is not accurately reflected on AT&T's coverage maps. The maps identify the majority of
the community as having no vehicle or indoor coverage, which simply is not true. Many homeowners with AT&T coverage have testified to this. Additionally, to the extent there are
gaps, the tower is not necessary. This was admitted by AT&T. AT&T representatives testified at prior hearings and spoke
at an HOA meeting. AT&T told the community that it is proceeding with the tower because it is the cheapest option for
AT&T to enhance coverage. AT&T has said a plan utilizing other locations and microsites would fill the perceived data
gaps, but AT&T is not interested in collaborating with the community to identify an acceptable solution, simply because it does not want to spend the money or take the time.
Shockingly, at the hearing before the Planning Commission, staff for the Planning Commission testified that it takes AT&T's representations regarding gaps and its alternatives analysis (which failed to identify a single alternative as having been considered) "at face value." Staff claimed it could not substantively review the materials because it does not have
telecommunications engineers on staff. This is unacceptable. If the County does not have staff capable of performing
reviews, it should hire consultants to conduct a legitimate study and offer alternative considerations, not simply perform ministerial reviews. This unbiased consultant should be paid at the expense of the tower applicant.
I am concerned about the potential health effects of the macro tower. I have been told the County of Los Angeles cannot
consider health effects in its ruling, but I believe AT&T should not be permitted to jeopardize the health and safety of our families.
Finally, I am concerned about the negative effect the cell tower will have on my property value. Local realtors who have
worked in Santa Clarita and Stevenson Ranch have submitted materials to the Planning Commission stating property values will decrease up to 10-20 percent and may not sell at all during a down market. Homes in the line of sight of the

cell tower will suffer the most – and there are many homes that will be in the line of sight given the chosen location.
Neighborhood esthetics are an amenity that provide value to homes. The ugly incongruity of a macrosite wireless facility in the middle of the residential neighborhood would push homebuyers to nearby Santa Clarita neighborhoods that maintain their zoning integrity and do not have cell towers next to their schools.
Please protect our homes and community and deny the requested conditional use permit. AT&T should evaluate alternatives and work with the community to find an acceptable solution.
Thank you,
Susan Vezina

November 13,2022

Dear Board of Supervisor:

Le escribimos para pedirle que vote NO a los cambios propuestos a los Títulos 16 y 22 del Código del Condado de Los Ángeles. Estos cambios, que supuestamente cerrarán la brecha digital, solo empeorarán las cosas asegurándose de que las comunidades minoritarias obtengan conexiones inalámbricas inferiores mientras que las comunidades más acomodadas obtengan fibra óptica. Esto provocará otra brecha digital que persistirá durante muchos años.

Las conexiones inalámbricas a Internet son lentas, poco fiables, caras (si quieres cualquier tipo de conexión decente), no reguladas (por lo que las compañías inalámbricas pueden cobrar lo que quieran), y vienen con una serie de otros problemas, incluyendo incendios y peligros para la salud e impactos ambientales negativos. Wireless nunca será capaz de proporcionar las velocidades que se requerirán de las conexiones a Internet en un futuro próximo

En resumen, la banda ancha inalámbrica es una tecnología perdedora que se impone a las comunidades minoritarias en un intento bien intencionado pero inútil de compensar lo que las telecomunicaciones no han logrado hacer durante veinte años - conectar a los clientes en su área de servicio con la banda ancha de fibra óptica, como prometieron, y como se les pagó para hacer

Todo el mundo merece una conexión de fibra óptica a Internet, y eso incluye a todas las familias que viven en comunidades minoritarias en Los Ángeles. No queremos un servicio inalámbrico deficiente. Necesitamos las mismas conexiones de banda ancha de calidad que todos los demás

Por favor vote NO a los cambios a los Títulos 16 y 22 y exija que el Condado de Los Ángeles use su poder e influencia para conectar a todos con fibra óptica.

Sinceramente,
Union Binacional de Organizaciones de Trabajadores Mexicanos Exbraceros 1942-1964
Baldomero Capiz
Coordinador Binacional

January 9, 2023

Board of Supervisors
Los Angeles County
500 West Temple Street
Los Angeles, CA 90012

Re: Item 59 Hearing On Wireless Facilities Ordinance – Titles 16 & 22 – Oppose

Dear Board of Supervisors:

Due Process Concerns

I support Fiber First LA's Model Legislation for Title 16 & 22 as submitted to the Board of Supervisors. I strongly oppose all other opposing revisions to Title 16 & 22.

The corporate placement of wireless infrastructure within the community must become public knowledge and be subject to public comment in every instance.

The changes proposed remove due process rights of everyone concerned with the amplified microwave frequencies issued by 5G, which includes a growing number of people who do not yet know they are affected by 5G. Under the proposed Title 16 & 22, wireless antennas and towers will be constructed in affected neighborhoods with NO corporate disclosure, no public notification, NO public hearings and NO opportunity to complain to the governing 5G regulator. Affected persons literally wake up one morning and see a 5G tower or array being put up right next to the affected house or apartment. These 5G installations are corporate overreach into individual health opportunities decisions and is undemocratic!

Second, we all live in a shared, single, fragile atmospheric environment. Wireless technology transmits amplified microwave energy through the atmosphere containing air necessary for human consumption. 5G infrastructure, the amplified microwave repeating electric transformers, intrude concentrated electron fields within the everyday personal living space of a community faced with the overuse of 5G. Safe, grounded fiber optic infrastructure connections are being ignored, and corporate 5G atmospheric radiation increases and now reaches within the walls of the community. This increases the combined carbon footprint of us all and puts vulnerable people at risk.

Balancing Test of Cellular Data Benefits to Environmental Health Hazards

Wireless technology is not safe for our natural world. We need our atmosphere to be healthy.

Cell towers and antennas are prone to fire. Cell towers, antennas and repeaters since 2007 have been found to have caused, in whole or in part, four major California wildfires at a cost of billions in losses.

The 5G plastic fake trees being used to camouflage the high-output 5G cell antennas discharge environmentally dangerous microplastics, with lead, and other California Prop 65 chemicals into the shared atmospheric environment in which we breathe. Birds, bees, plants and trees are the first to uptake the 5G plastic into the food chain where we live and where it enters our lives.

Since 2009, repeated scientific studies confirmed that radiofrequency radiation (RFR) emissions from 5G infrastructure contributes to the further decline in bee populations and have adversely affected navigation of migratory birds, their habitat, growth and reproductive cycles. Trees 5G radiation has harmed trees by causing thinner cell walls to grow and increases volatile terpenes in tree sap which makes trees more flammable, especially in drought.

In 2019 a ten-year study by the National Toxicology Program of the National Institutes of Health, found "clear evidence" of increased cancer risk among lab animals exposed to RF radiation, as well as evidence of DNA damage and other biological impacts. Increasingly, peer-reviewed studies which demonstrate biological harm from exposure to RF radiation now appear with radiation above threshold levels considered safe by the FCC.

5G will be radiating this community, and in communities across the country, after a threshold is crossed, and lives move from voluntary 5G exposure to involuntary 5G exposures. Highly concerned and sensitized residents feel forced to fortify their living spaces with EMF-blocking materials or abandon their homes and apartments to seek safe refuge from amplified radiation fields in their homes caused by 5G.

<u>Corporate Overreach Into Public Regulation Governing Radition Outputs By Communications Industry</u>

Since 2007, the California Public Utilities Commission has faulted telecom companies for their role in fires caused by their infrastructure neglect in rural areas. The Board of Supervisors has this information, so how can BOS justify giving the CPUC-sanctioned telecom companies an unregulated right to build new amplified wireless cellular radiation sites without strict governmental oversight?

5G infrastructure is rated at a 5-year life cycle with no cradle-to-cradle design for reuse. It is the same e-waste disposable product cycle adding to disposal costs. I want the Supervisors to invest our time and resources in superior Fiber Optic Broadband Infrastructure that will last 15 to 20 years. I do not want the Supervisors to pursue a build out of inferior Wireless Broadband that has a short 5 year life span. The telecom companies have already been paid to install fiber optics communication transmission infrastructure.

For these reasons I urge you to vote NO on the proposed changes.

Jack Neff
600 ½ N. Beachwood Dr.

BOYLE HEIGHTS COMMUNITY GARDEN

To: Los Angeles County ("LAC") Board of Supervisors Members:

Hilda L. Solis, Holly J. Mitchell, Janice Hahn, Kathryn Barger, Lindsay Horvath

Cc: Chair LA County Regional Planning Department ("LACRPD"): Yolanda Duarte-White,

Director of Public Works: Mark Pestrella , Dawyn R. Harrison, Acting County Counsel

From: 5G Free California, Inc.

Re: Petition Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage Scheduled for December 6, 2022)

Date: December 5, 2022

Dear LAC Board of Supervisors Members (and Other Concerned with the above captioned matter):

Our organization Boyle Heights Community Garden strongly urges that you Board of Supervisors Members vote 'No' on the above captioned matter. Our organization is focused on sustainability, our environment and the communities' wellbeing. We are deeply concerned that a vote in favor of amendments to Titles 16 and 22 will cause great harm to our members and all the residents of Los Angeles, County.

Communities in East Los Angeles, have been victims of environmental racism for decades, being environmentally impacted by many contaminants. Our soil is contaminated by lead and arsenic from EXIDE (battery recycling center). Our air is polluted by the car smog of heavy traffic from six major freeways that surrounds us. The racism has expanded to even the number of trees planted in our streets. Our water is contaminated. We have been victimized and being lack of our basic human rights, clean air, water and soil!!

Now the Board of Supervisors, advice by the Planning Commission, in an effort to make a buck is willing to risk the wellbeing of our communities once again. This ordinance, as drafted, eliminates requirements regarding distance between cell towers; advance notice or provide to our residents the opportunity to appeal. There are no fire (specially electrical fires) setbacks in front of homes, schools, daycare and hospitals allowing little to no time to escape in the event of fires and earthquakes.

Not allowing for fire setbacks could potentially set us up for severe or even deadly fires. California has suffered devastating fire losses due to telecom equipment, yet no wireless carrier or their agents carry liability insurance for claims of injury or death* In fact since 2007 four major Southern California fires were caused by telecommunication equipment failures including the Woosley fire, which caused $6 billion worth of damages and devastated Los Angeles County. The criminal investigation by Attorney General found that "Consistent with the scientific findings contained in the report issued by Cal Fire and the Ventura County Fire Department, investigators determined that electrical and communication equipment owned by Southern California Edison caused the Woolsey Fire"**. This fire claimed many lives, displaced approximately 295,000 people,(** https://oag.ca.gov)

These ordinances will not close the "Digital Divide." We have an abundance of cell service in our neighborhood and yet many cannot afford safe, inexpensive and reliable internet access. A viable solution to closing the "digital divide" is fiber optics. This proposed wireless build-out is depriving low income and minority communities of an immediately viable, safe, fast, cyber-secure, energy efficient alternative. According to a research from the USC study, "Who gets access to Fast Broadband? Evidence from Los Angeles County," by Dr. Hernan Galperin, "*The findings indicate that competition and fiber-based services are less likely in low-income areas and communities of color, with the most severe deficits observed in census block groups that combine poverty and a large percentage of people of color."*

Other Concerns:

The Board of Supervisors is overriding federal statutes/protections: Public entities such as counties must comply with the Historic Preservation Act, the Endangered Species Act, the Americans with Disabilities Act, and the Fair Housing Amendments Act. In its search for a balanced solution for cell towers, it will be beneficial for the Board of Supervisors to consider these federal statutes they preempted by the 1996 Telecommunications Act.

No environmental assessments: California Environmental Quality Act (CEQA) and federal National Environmental Policy Act (NEPA). No residential setbacks between homes/towers. Antennas and cell tower will be set in their front yard may also violate FCC guidelines and no Environmental Impact Report will be required.

California Consumer Privacy Act: These ordinances will deny millions of constituents and stakeholders in Los Angeles County their right to opt out from the most personal and private information being packaged, sold, and resold without their consent. The California Consumer Privacy Act established in 2018, new amended protections in 2020, in the areas of privacy, technology and consumer rights ensure that consumer's privacy and data rights are safeguarded.

We look to your support to oppose these ordinances and encourage the option of municipal fiber-optic, wired broadband. Los Angeles County could follow the example of the city of Chattanoga,TN, their Community Fiber Optic network proved to be energy efficient, reduced power outages, bridged digital divide, decreased environmental damage, enable job creations and retentions. There are so many illegalities in the proposed amendments, really think about WHO will benefit from this changes!!!

Adopt the redline provided by Fiber First LA. Oppose these ordinances; let's explore safer, protective practices that reflect heightened vigilance, care, and precaution by our publicly elected Board of Supervisors.

We deeply appreciate your consideration and support.

Sincerely,

Brenda Trujillo-Martinez

Director of BHCG

BOYLE HEIGHTS COMMUNITY PARTNERS
Unity with Strength for History, Community and Historic Preservation
603 North Breed Street
Los Angeles, California 90033
BHCP

5 December 2022

Los Angeles County Supervisor Hilda L. Solis, First District
856 Kenneth Hahn Hall of Administration
500 West Temple Street
Los Angeles, CA 90012

Re: Petition Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage Scheduled for December 6, 2022)

Dear LAC Board of Supervisors Members:

Our organization **Boyle Heights Community Partners** strongly urges that you Board of Supervisors Members vote 'No' on the above captioned matter. Our organization is focused on guiding our supervisors in the direction of listing to the voice of your constituents, and hear what is best for us, including small businesses and avoid corruption in working with lobbyist and deep pockets, which have proven to cause more harm.

We are deeply concerned that a vote in favor of amendments to Titles 16 and 22 will cause great harm to residents and businesses large and small in our Los Angeles, County. Therefore, directly undermine our mission for the following reasons.

Why Fiber:

- **Fiber is faster:** Fiber is easily capable of speeds of 100Gbps, with that fast of a connection, everyone can send emails faster, send files faster, download large attachments and upload information quickly. That saves time and money, and fiber internet is faster and more reliable than the 5G network.
- **Fiber is scalable:** Flexible bandwidth options ensure quality performance, and whatever is required, internet service delivered over a fiber network can be easily adjusted to accommodate growth needs without additional hardware.
- **Fiber is more secure and more available:** A fiber line is dedicated, which means the service is much more secure, with less opportunity for interference
- **Fiber is cost-effective:** The switch to fiber requires an up-front investment, but the long-term benefits minimize the costs over time. The increased speed alone ensures increased productivity and efficiency, and Fiber also comes with far fewer maintenance requirements than other broadband platforms. Fiber is no longer just a telecommunications industry buzzword. It's a widely available, viable internet service option. Its positive impact on the bottom line demonstrates just how valuable it is to the future.

Title 16

- Does not provide for a meaningful evaluation of the impact a contemplated wireless facility will have on historic resources. There is no requirement for notice to historic preservation authorities and groups that a wireless facility is proposed on or near to an historic resource so they will not have an opportunity to independently analyze and comment on the project or its potential impact.

- Nothing in the ordinances requires any showing by the applicant that it has performed all required reviews and consultations.
- Both ordinances are inconsistent with federal requirements, in particular section 106 of the National Historic Preservation Act, as amended, 54 U.S.C. § 306108 and the regulations of the Advisory Council on Historic Preservation, 36 CFR Part 800.
- They do not comport with state CEQA obligations because the proposed ordinances purport to excuse the county from performing any impact evaluation based on a claimed "exemption" that ignores the Historic Resources Exception. See CEQA Guidelines 15300.2(f).
- The Title 16 proposal is the most egregious because it completely ignores the entire topic.
- The entire process is deemed "ministerial." It does not require any notice to any historic preservation office or group, and it does not allow any opportunity to comment or contest.
- It does not require any notice to any historic preservation office or group, and it does not allow any opportunity to comment or contest. It is entirely possible a proposed small cell on county-owned right-of-way that is within or near an historic resource will negatively impact that resource in some way, however, including but not limited to aesthetics and ground disturbances.

Title 22

- Title 22 proposals do at least make a nod toward historic resources. By way of background, the county has a process for special recognition of historic resources. See County Code Ch. 22.124. A resource that has gone through that process it can receive special protection, and the proposed amendments would preserve any that currently exist for those resources. But there are many sites in the county that are listed or eligible for listing on the National, California, or County historic registers that have not been nominated for or gone through the Ch. 22.124 process and are therefore not procedurally or substantively protected. A wireless facility project that would affect an historic resource that has not been listed under Ch. 22.124 will be assigned to "ministerial" treatment. This means there is no required notice to any historic preservation office or group and no opportunity for any party to comment or object. Nor does the proposed ordinance require that the wireless provider or county conduct any impact review. All it says is that the Director of Regional Planning has <u>discretion</u> to require an Historic Resource Assessment. See proposed Ch. 22.140.700(E)(1)(b)(iv).[1] But even then, there is no express requirement that the provider or Director involve any historic preservation office or group.
- Proposed Ch. 22.140.700(E)(1)(b)(iv) does provide that "New wireless facilities shall not be installed on buildings or structures listed or eligible for listing on the National, California, or County historic registers." This is meaningful, to be sure. It goes on to provide that "[n]ew towers and support structures installed on the grounds of properties listed or eligible for listing on the National, California, or County historic registers shall be located and designed to eliminate impacts to the historic resource."

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[1] "A Historic Resource Assessment, prepared to the satisfaction of the Director, may be required for a facility to be located on a site containing an eligible resource to identify impacts to historic resources, and identify mitigation to minimize impacts."

BOYLE HEIGHTS COMMUNITY PARTNERS
Unity with Strength for History, Community and Historic Preservation
603 North Breed Street
Los Angeles, California 90033
BHCP

- The proposed ordinance does not, however, require notice to or collaboration with historic preservation groups or allow any participatory rights to a party that wants to contest the application. The entire process is internal and conducted in secret. Nor is there any provision for an appeal of the Director's "ministerial" determinations to the Planning Commission or Board of Supervisors if someone does manage to find out about the project. The public in general and those concerned with historic preservation are required to trust that the Director will always get it right in these no-notice, closed-door proceedings.

In addition to this grave expression of concern, we are well informed by our legal advisors that the proposed action is illegal under various federal and state statutes and infringes U.S. and state due process protections.

We deeply appreciate your consideration and support.

Thank you!

Sincerely,

Vivian M. Escalante
President & CEO

cc
Hilda L. Solis, Los Angeles County Supervisor-First District
Holly J. Mitchell, Los Angeles County Supervisor-Second District
Sheila J. Kuehl, Supervisor, Los Angeles County Supervisor-Third District
Lindsey P. Horvath, Supervisor-Elect Los Angeles County Supervisor-Third District
Janice K. Hahn, Los Angeles County Supervisor-Forth District
Kathryn A. Barger, Los Angeles County Supervisor-Fifth District
Dawyn R. Harrison, Acting County Counsel

Subject: Vote NO on Jan. 10 to the Proposed Changes to Titles 16 and 22

Re: Agenda Item 59.

I strongly oppose the proposed changes to Titles 16 and 22 of the L.A. County Code. Please vote NO on Jan. 10 and safeguard our due process rights, maintain local control and adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Do NOT institute some sort of rubber-stamp process for cellular antenna placement approval (smaller or larger antennas).

It is never okay to install cell towers or small cells outside residents' homes (or any location where people may reside, presently or in future planning, including fire stations) without prior notice, public hearing or opportunity to appeal, without fire or safety scrutiny and without regard to critical environmental protections that are supposed to keep us all safe. I urge you to implement the following protections regarding the installation of wireless communications infrastructure:

■ Safeguard Due Process Rights: The radiation emitted from cell towers is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified. Do NOT operate via some "ministerial" or bureaucratic process which bypasses proper notice, setbacks, safety/environmental review, hearings, and rights of appeal.

■ Adopt the Redline: I urge you to adopt the redline for Titles 16 and 22 that was submitted by Fiber First L.A. Rather, invest in resources and take advantage of federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods.

■ Protect Us From Telecom Wildfires: In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions would allow cell towers to be too close to homes, schools and daycare centers.

■ Stick to Facts: In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that are already backed up per the California Public Utilities Commission (CPUC) Order. The claim that hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.
--------------→ You must prioritize the health and safety of residents and the protection of the environment. Please vote NO.

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Cellco Partnership d/b/a Verizon Wireless	)	File No.: EB-SED-22-00033134
	)	CD Acct. No.: 202332100007
	)	FRN: 0003290673
	)	
	)	

ORDER

Adopted: December 19, 2022 **Released: December 19, 2022**

By the Chief, Enforcement Bureau:

1. The Enforcement Bureau of the Federal Communications Commission has entered into a Consent Decree to resolve its investigation into whether Cellco Partnership d/b/a Verizon Wireless (Verizon Wireless) constructed wireless facilities without complying with the Commission's environmental and historic preservation rules, including rules implementing the National Environmental Policy Act of 1969 (NEPA) and the National Historic Preservation Act (NHPA).[1] To implement NEPA and section 106 of the NHPA, the Commission's environmental and historic preservation rules require that current and prospective licensees and tower registrants assess certain types of proposed facilities, prior to the start of any construction, to determine the potential for a significant impact on the environment or historic properties. The Commission's rules also direct these entities to coordinate with relevant state governments and tribal nations.[2] To settle this matter, Verizon Wireless (i) admits that it violated the Commission's environmental and historic preservation rules by prematurely constructing wireless facilities prior to completing the required environmental or historical reviews and by constructing wireless facilities without onsite monitoring as requested by the affected tribes, (ii) will implement a robust compliance plan to ensure that it does not violate these rules in the future, and (iii) will pay a $950,000 civil penalty.

2. After reviewing the terms of the Consent Decree and evaluating the facts before us, we find that the public interest would be served by adopting the Consent Decree and terminating the referenced investigation regarding Verizon Wireless's compliance with environmental and historic preservation requirements found in sections 1.1307 and 1.1312 of the Commission's rules, implementing NEPA and NHPA.[3]

3. In the absence of material new evidence relating to this matter, we do not set for hearing the question of Verizon Wireless's basic qualifications to hold or obtain any Commission license or authorization.[4]

[1] 47 CFR §§ 1.1307, 1.1312; National Environmental Policy Act of 1969, Pub. L. No. 91-190, 83 Stat. 852 (1970) (codified as amended at 42 U.S.C. § 4321 *et seq.*); National Historic Preservation Act, Pub. L. No. 89-665, 80 Stat. 915 (1966) (codified as amended at 54 U.S.C. § 300101 *et seq.*).

[2] *See* 47 CFR § 1.1301 *et seq*.

[3] *See* 42 U.S.C. § 4321 *et seq.*; 54 U.S.C. § 300101 *et seq*.; 47 CFR §§ 1.1307, 1.1312.

[4] *See* 47 CFR § 1.93(b).

4. Accordingly, **IT IS ORDERED** that, pursuant to section 4(i) of the Communications Act of 1934, as amended,[5] and the authority delegated by sections 0.111 and 0.311 of the Commission's rules,[6] the attached Consent Decree **IS ADOPTED** and its terms incorporated by reference.

5. **IT IS FURTHER ORDERED** that the above-captioned matter **IS TERMINATED** in accordance with the terms of the attached Consent Decree.

6. **IT IS FURTHER ORDERED** that a copy of this Order and Consent Decree shall be sent by first class mail and certified mail, return receipt requested, to Chris Miller, Senior Vice President & Deputy General Counsel, Verizon, 1300 I Street, NW, Suite 500 East, Washington, D.C. 20005, and e-mail to chris.m.miller@verizon.com.

FEDERAL COMMUNICATIONS COMMISSION

Loyaan A. Egal
Chief
Enforcement Bureau

[5] 47 U.S.C. § 154(i).

[6] 47 CFR §§ 0.111, 0.311.

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Cellco Partnership d/b/a Verizon Wireless	)	File No.: EB-SED-22-00033134
	)	CD Acct. No.: 202332100007
	)	FRN: 0003290673
	)	
	)	

CONSENT DECREE

1. The Enforcement Bureau of the Federal Communications Commission and Cellco Partnership d/b/a Verizon Wireless, by their authorized representatives, hereby enter into this Consent Decree for the purpose of terminating the Enforcement Bureau's investigation into whether Verizon Wireless violated sections 1.1307(a) and 1.1312(a) of the Rules in connection with construction of wireless telecommunications facilities in Arizona, Indiana, Kentucky, Pennsylvania, and Tennessee. To resolve this matter, Verizon Wireless agrees to the terms and conditions below, including to implement a compliance plan and pay a $950,000 civil penalty.

I. DEFINITIONS

2. For the purposes of this Consent Decree, the following definitions shall apply:

(a) "Act" means the Communications Act of 1934, as amended.[1]

(b) "Adopting Order" means an order of the Bureau adopting the terms of this Consent Decree without change, addition, deletion, or modification.

(c) "Bureau" means the Enforcement Bureau of the Federal Communications Commission.

(d) "CD Acct No." means account number 202332100007, associated with payment obligations described in paragraph 19 of this Consent Decree.

(e) "Commission" and "FCC" mean the Federal Communications Commission and all of its bureaus and offices.

(f) "Communications Laws" means collectively, the Act, the Rules, and the published and promulgated orders and decisions of the Commission to which Verizon Wireless is subject by virtue of its business activities, including but not limited to the Environmental Rules.

(g) "Compliance Plan" means the compliance obligations, program, and procedures described in this Consent Decree at paragraph 13.

(h) "Covered Facilities" means wireless telecommunications facilities, including without limitation those that were the subject of the Investigation, involving a new build of one or more small cell antennae and associated equipment for use in Verizon Wireless's network that must be assessed for compliance with the Environmental Rules.

(i) "Covered Vendor" means all third parties (including contractors and entities that Verizon Wireless refers to as "NEPA vendors") that perform, supervise, oversee, or manage the performance of duties on Verizon Wireless's behalf, that relate to

[1] 47 U.S.C. § 151 *et seq.*

Verizon Wireless's responsibilities for Covered Facilities under the Environmental Rules, including assessing what regulatory approvals are necessary prior to construction of Covered Facilities, submitting the appropriate regulatory submissions prior to construction of such facilities, or identifying any required monitoring or special requirements during construction of such facilities.[2] Covered Vendors assessing National Environmental Policy Act (NEPA)[3] or National Historic Preservation Act (NHPA)[4] requirements for Verizon Wireless must have sufficient experience and expertise to perform those assessments in an accurate and timely manner and be able to identify any associated regulatory approvals or monitoring that are required. The person from each Covered Vendor responsible for the assessment of NEPA requirements for each Verizon Wireless Covered Facility must possess relevant expertise demonstrated by either (i) a Master of Science degree or Bachelors of Science degree in Environmental Science, Biology, or Environmental Planning, with experience implementing Federal agency NEPA requirements, or (ii) a NEPA certification from an accredited program recognized by The Council on Environmental Quality.[5] The person from each Covered Vendor responsible for the assessment of NHPA requirements for each Verizon Wireless Covered Facility must meet a minimum of one relevant Secretary of the Interior's Professional Qualifications Standards.[6] Verizon Wireless will require that Covered Vendors complete compliance training programs as described in paragraph 13.

(j) "Covered Employees" means all employees of Verizon Wireless who perform, supervise, oversee, or manage the performance of, duties that relate to Verizon Wireless's responsibilities for Covered Facilities under the Environmental Rules, including, but not limited to, assessing what regulatory approvals are necessary prior to construction of Covered Facilities, submitting the appropriate regulatory submissions prior to construction of such facilities, or identifying any required monitoring or special requirements during construction of such facilities.[7] Covered Employees must complete the compliance training programs described in paragraph 13. In addition, the Covered Employees in Verizon Wireless's centralized Network and Regulatory Compliance group[8] must also complete the National Preservation

[2] The requirements covered by paragraphs 12-16 do not pertain to employees or vendors who perform, supervise, oversee, or manage the performance of duties that relate to Verizon Wireless's responsibilities under the Commission's radio frequency exposure rules and their work relates only to such rules. *See* 47 CFR §§ 1.1307(b), 1.1310.

[3] National Environmental Policy Act of 1969, Pub. L. No. 91-190, 83 Stat. 852 (1970) (codified as amended at 42 U.S.C. § 4321 *et seq.*).

[4] National Historic Preservation Act, Pub. L. No. 89-665, 80 Stat. 915 (1966) (codified as amended at 54 U.S.C. § 300101 *et seq.*).

[5] *See* The Council on Environmental Quality, *National Environmental Policy Act*, Training, https://ceq.doe.gov/nepa-practice/training.html (last visited Nov. 3, 2022) (listing accredited NEPA certification programs recognized by The Council on Environmental Quality).

[6] *See* Archeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines, Department of the Interior, National Park Service, 48 Fed. Reg. 44716 (Sept. 29, 1983), https://www.doi.gov/pam/asset-management/historic-preservation/pqs (last visited Nov. 3, 2022).

[7] *See supra* note 2.

[8] The Network and Regulatory Compliance group is the team within the Company that is responsible for regulatory filings, implementation, and compliance for wireless facility construction projects on a centralized, nationwide basis, as opposed to regional or market-specific duties. As defined herein, this term will include any successor group within Verizon Wireless that performs this function.

Institute Section 106 Basics[9] training and NEPA Compliance and Cultural Resources training,[10] as well as the compliance training programs described in paragraph 13.

(k) "Effective Date" means the date by which both the Bureau and Verizon Wireless have signed the Consent Decree and the Bureau has released an Adopting Order.

(l) "Environmental Rules" means sections 1.1301-1.1320, 17.4 of the Rules[11] and other Communications Laws implementing NEPA, and other environmental statutes, and the Rules implementing NHPA, including part 1, Appx. C, Nationwide Programmatic Agreement for Review of Effects on Historic Properties for Certain Undertakings Approved by the Federal Communications Commission,[12] and part 1, Appx. B, Nationwide Programmatic Agreement for the Collocation of Wireless Antennas.[13]

(m) "Investigation" means the investigation commenced by the Bureau in File No. EB-SED-22-00033134 regarding whether Verizon Wireless violated the Environmental Rules.

(n) "Operating Procedures" means the standard internal operating procedures and compliance policies established by Verizon Wireless to implement the Compliance Plan.

(o) "Parties" means Verizon Wireless and the Bureau, each of which is a "Party."

(p) "Rules" means the Commission's regulations found in Title 47 of the Code of Federal Regulations.

(q) "SHPO" means State Historic Preservation Officer as set forth in the NHPA.

(r) "THPO" means Tribal Historic Preservation Officer as set forth in the NHPA.

(s) "Verizon Wireless" or "Company" means Cellco Partnership d/b/a Verizon Wireless and its affiliates, subsidiaries, predecessors-in-interest, and successors-in-interest that offer wireless services.

II. BACKGROUND

3. Under the Commission's Environmental Rules, applicants and licensees are required to assess whether certain proposed facilities may significantly affect the environment, as defined in section 1.1307 of the Rules.[14] Section 1.1307(a) addresses facilities that may significantly affect the environment for which an Environmental Assessment (EA) must be prepared prior to construction, including, but not limited to those that: (i) may affect districts, sites, buildings, structures or objects that are listed, or

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[9] *See* National Preservation Institute, Section 106: The Basics for Planners, Project Managers, and Developers, https://training.npi.org/courses/section106basics (last visited Nov. 3, 2022).

[10] *See* National Preservation Institute, NEPA Compliance and Cultural Resources, https://www.npi.org/seminars/laws-and-regulations/nepa-compliance-and-cultural-resources (last visited Nov. 3, 2022).

[11] 47 CFR §§ 1.1301-1.1320, 17.4. For purposes of this Consent Decree, sections 1.1307(b) and 1.1310 of the Rules pertaining to radio frequency exposure are not at issue in this investigation. *See supra* note 2.

[12] 47 CFR pt. 1, Appx. C.

[13] 47 CFR pt. 1, Appx. B.

[14] 47 CFR § 1.1307.

eligible for listing, in the National Register of Historic Places;[15] (ii) may affect Native American religious sites; or (iii) will involve significant change in surface features.[16] In considering potential effects on historic properties, section 1.1307(a)(4) requires applicants to follow the prescribed procedures set forth in the rules of the Advisory Council,[17] as modified by the Nationwide Programmatic Agreement for the Collocation of Wireless Antennas (Collocation NPA)[18] and the Nationwide Programmatic Agreement Regarding the Section 106 National Historic Preservation Act Review Process (Wireless Facilities NPA).[19] These agreements tailor and streamline the review and consultation procedures routinely required by the NHPA[20] and the implementing regulations issued by the Advisory Council.[21] Pursuant to section 1.1312 of the Rules, unless an applicant is exempt, these environmental review obligations expressly apply to wireless facilities for which no Commission authorization prior to construction is required.[22]

[15] 47 CFR § 1.1307(a)(4). National Register refers to the National Register of Historic Places, which is maintained by the Secretary of the Interior's Office of the Keeper of the National Register. 47 CFR pt. 1, Appx. C, section II.(A)(10).

[16] 47 CFR § 1.1307.

[17] 36 CFR pt. 800.

[18] 47 CFR pt. 1, App. B; *see Wireless Telecommunications Bureau Announces Execution of Programmatic Agreement with respect to Collocating Wireless Antennas on Existing Structures*, Public Notice, 16 FCC Rcd 5574 (WTB 2001) (announcing execution of the NPA streamlining procedures for review of collocations of antennas under the NHPA), *recons. denied*, 20 FCC Rcd 4084 (WTB 2005).

[19] 47 CFR pt. 1, App. C; *see Nationwide Programmatic Agreement Regarding the Section 106 National Historic Preservation Act Review Process*, WT Docket No. 03-128, Report and Order, 20 FCC Rcd 1073 (2004) (*NPA Report and Order*), *clarified*, 20 FCC Rcd 17995 (2005), *aff'd*, *CTIA-The Wireless Ass'n. v. FCC*, 466 F.3d 105 (D.C. Cir. 2006) (announcing implementation of NPA and adopted rule changes); *see also Implementation of State and Local Governments' Obligation to Approve Certain Wireless Facility Modification Requests Under Section 6409(a) of the Spectrum Act of 2012*, WT Docket No. 19-250, Declaratory Ruling and Notice of Proposed Rulemaking, 35 FCC Rcd 5977, 6000-6003, paras. 45-50 (2020) (an applicant or licensee is not required to file an EA if a proposed facility may have an adverse effect on the environment, provided that the FCC and the applicant or licensee enters into a memorandum of agreement to mitigate the effects of the proposed facility).

[20] 54 U.S.C. § 300101 *et seq*. The NHPA requires that a federal agency consider the effects of its federal undertakings, including actions that it authorizes or approves, on historic properties prior to issuing federal licenses, permits, or approvals. *See* 54 U.S.C. §§ 306108, 300320. This review is commonly referred to as "Section 106 Review" because the provision requiring the review was originally enacted as section 106 of the NHPA. In considering such effects, the NHPA further requires the federal agency to consider the views of expert agencies. Specifically, the NHPA requires the federal agency to consider the views of the Advisory Council, which is the federal agency responsible for implementing the NHPA; the appropriate SHPO; and, if historic properties of religious or cultural significance to federally recognized Tribal nations or Native Hawaiian organizations may be affected, their representatives. *See* 54 U.S.C. §§ 302104, 302706, 306108, 304101. As authorized by the Advisory Council, the Commission's Environmental Rules delegate to its licensees, permittees, and applicants initial responsibility for identifying historic properties and evaluating the effects that their proposed facilities may have on such properties, but the Commission remains ultimately responsible for ensuring that the "Section 106 Review" occurs in accordance with applicable statutory and regulatory provisions, as well as for government-to-government consultation with federally recognized Tribal nations. *See* 47 CFR § 1.1307(a)(4); *see also* 36 CFR § 800.2(a)(3); *NPA Report and Order*, 20 FCC Rcd at 1076-77, para. 5.

[21] *See* 36 CFR pt. 800 (regulations issued by the Advisory Council that set forth the process through which federal agencies comply with their Section 106 Review duties).

[22] *See* 47 CFR § 1.1312.

4. Verizon Wireless is a general partnership, and it and its affiliates hold several thousand FCC licenses.[23] Verizon Wireless offers wireless services in the United States.[24] By early 2020, Verizon Wireless had been deploying newer technology, commonly referred to as small cells, in a variety of markets in the United States.[25] The small cell antennas can be mounted on infrastructure such as replacement streetlight poles, traffic control structures, or utility poles for the purpose of improving wireless service.[26] As early as June 2020, Verizon Wireless commenced construction on the small cell antennas at issue in the Investigation in several U.S. markets.[27]

5. Verizon Wireless reported to the Wireless Telecommunications Bureau (WTB) concerns regarding its compliance with the Environmental Rules for certain wireless facilities construction projects in Pennsylvania. WTB initially referred this matter to the Enforcement Bureau, and the Enforcement Bureau's Spectrum Enforcement Division (SED) opened the Investigation. On January 5, 2022, SED issued a Letter of Inquiry (LOI) to the Company, directing it to submit a sworn written response to a series of questions relating to its compliance with the Commission's Environmental Rules.[28] Verizon Wireless filed responses on February 9, 2022,[29] March 30, 2022,[30] May 13, 2022,[31] June 22, 2022,[32] and August 26, 2022.[33] The investigation revealed that Verizon Wireless commenced and/or completed construction of wireless facilities in Indiana, Kentucky, and Pennsylvania prior to or without completing the required Section 106 Review and Tribal notification processes.[34] The Investigation further revealed

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[23] Response to Letter of Inquiry, from David Haga, Associate General Counsel, Verizon Wireless, to Daniela Arregui, Attorney Advisor, Spectrum Enforcement Division, FCC Enforcement Bureau, Response to Inquiry 1 at 11, Response to Inquiry 6 at 13-14 (Feb. 9, 2022) (on file in EB-SED-22-00033134) (LOI Response).

[24] *See* LOI Response, Response to Inquiry 6 at 13-14.

[25] *See* LOI Response, Response to Inquiry 14 at 19-22 (Harrisburg sites); Response to April 20, 2022 LOI, from David Haga, Associate General Counsel, Verizon Wireless, to Daniela Arregui, Attorney Advisor, Spectrum Enforcement Division, FCC Enforcement Bureau, Response to Inquiry 2 at 11, n.7 (Nashville site), 15-16 (Boise sites), 16-18 (Fort Wayne sites), 19-20 (Evansville and Louisville sites), 20-21 (Phoenix-Mesa-Chandler sites), 23-25 (Wilkes-Barre sites) (May 13, 2022) (on file in EB-SED-22-00033134) (May 13, 2022 LOI Response).

[26] *See* LOI Response, Response to Inquiry 12 at 18-19 (Harrisburg sites); *see also* May 13, 2022 LOI Response, Response to Inquiry 2 at 12 (all other site locations).

[27] Between January 2021 and March 2022, construction on the small cell antennas within the statute of limitations in the Investigation occurred, however, construction commenced as early as June 2020. *See generally* LOI Response; May 13, 2022 LOI Response.

[28] Letter of Inquiry from Elizabeth Y. Mumaw, Chief, Spectrum Enforcement Division, FCC Enforcement Bureau, to Nakul Mate, Sr. Manager Network Regulatory, Verizon Wireless, and David Haga, Associate General Counsel, Verizon Wireless (Jan. 5, 2022) (on file in EB-SED-22-00033134).

[29] *See generally* LOI Response.

[30] Supplemental Response to Letter of Inquiry, from David Haga, Associate General Counsel, Verizon Wireless, to Daniela Arregui, Attorney Advisor, Spectrum Enforcement Division, FCC Enforcement Bureau (Mar. 30, 2022) (on file in EB-SED-22-00033134) (Supplemental Response).

[31] *See* May 13, 2022 LOI Response.

[32] Response to June 16, 2022 Follow-Up Questions to Letter of Inquiry, from David Haga, Associate General Counsel, Verizon Wireless, to Daniela Arregui, Attorney Advisor, Spectrum Enforcement Division, FCC Enforcement Bureau (on file in EB-SED-22-00033134) (June 22, 2022 Follow-Up LOI Response).

[33] Second Supplemental Response to Letter of Inquiry, from David Haga, Associate General Counsel, Verizon Wireless, to Daniela Arregui, Attorney Advisor, Spectrum Enforcement Division, FCC Enforcement Bureau (Aug. 26, 2022) (on file in EB-SED-22-00033134) (Second Supplemental Response).

[34] May 13, 2022 LOI Response, Response to Inquiry 2 at Response to Inquiry 2 at 16-18 (Fort Wayne sites), Response to Inquiry 2 at 19-20 (Louisville sites) Response to Inquiry 2 at 20 (Louisville and Evansville sites), Response to Inquiry 2 at 23-25 (Wilkes-Barre sites), Response to Inquiry 2 at 28-32 (Fort Wayne and Louisville sites), Response to Inquiry 2 at 40-41 (Wilkes-Barre sites).

that Verizon Wireless failed to comply with Tribal notification procedures by failing to meet requests by SHPO and Tribal representatives to have Tribal onsite monitoring of construction during all ground disturbance activity for wireless construction projects in Arizona and Tennessee.[35] Moreover, the Investigation revealed that some of the noncompliant construction was caused by miscommunication between Verizon Wireless employees and its third-party contractors; other violations were caused by a single Verizon Wireless employee that reviewed and managed project sites but lacked NEPA/NHPA expertise.[36] Verizon Wireless acknowledges that it is responsible for complying with applicable Commission rules and the actions and inactions of its Covered Employees and Covered Vendors, as described in this paragraph. Prior to and during the course of the Investigation, in order to comply with the Environmental Rules, Verizon Wireless states that it informed the applicable SHPOs and THPOs of construction projects completed without the required SHPO/THPO concurrence and began the process of removing any wireless facilities determined to have an adverse effect on historic streetscapes.[37] In order to prevent future miscommunication and errors by Verizon Wireless employees, Verizon Wireless revised its operational procedures to transition to its third-party vendors with NEPA/NHPA expertise (i.e., Covered Vendors) the performance of the initial review of all future project sites subject to the Environmental Rules.[38]

6. To settle this matter, Verizon Wireless and the Bureau entered into this Consent Decree and agree to the following terms and conditions.

III. TERMS OF AGREEMENT

7. **Adopting Order**. The provisions of this Consent Decree shall be incorporated by the Bureau in an Adopting Order.

8. **Jurisdiction**. Verizon Wireless agrees that the Bureau has jurisdiction over it and the matters contained in this Consent Decree and has the authority to enter into and adopt this Consent Decree.

9. **Effective Date**. The Parties agree that this Consent Decree shall become effective on the Effective Date as defined herein. As of the Effective Date, the Parties agree that this Consent Decree shall have the same force and effect as any other order of the Commission.

10. **Termination of Investigation**. In express reliance on the covenants and representations in this Consent Decree and to avoid further expenditure of public resources, the Bureau agrees to terminate the Investigation. In consideration for the termination of the Investigation, Verizon Wireless agrees to the terms, conditions, and procedures contained herein. The Bureau further agrees that, in the absence of new material evidence, it will not use the facts developed in the Investigation through the Effective Date, or the existence of this Consent Decree, to institute any new proceeding on its own motion against Verizon Wireless concerning the matters that were the subject of the Investigation, or to set for hearing the question of Verizon Wireless's basic qualifications to be a Commission licensee or hold Commission licenses or authorizations based on the matters that were the subject of the Investigation.[39]

11. **Admission of Liability**. Verizon Wireless admits for the purpose of this Consent Decree and for Commission civil enforcement purposes, and in express reliance on the provisions of paragraph 10 herein, that it constructed facilities prior to receiving all required approvals and/or without required monitoring present in violation of the Environmental Rules.

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[35] *See* May 13, 2022 LOI Response, Response to Inquiry 2 at 11 (Nashville site), Response to Inquiry 2 at 20-21 (Phoenix-Mesa-Chandler sites), Response to Inquiry 2 at 35-37 (Phoenix-Mesa-Chandler sites).

[36] *See supra* notes 32-33.

[37] *See generally* LOI Response; May 13, 2022 LOI Response.

[38] *See* LOI Response at 10.

[39] *See* 47 CFR § 1.93(b).

12. **Compliance Officer**. Within thirty (30) calendar days after the Effective Date, Verizon Wireless shall designate and maintain a single senior corporate manager who has specific responsibility for, and detailed experience and expertise in, NEPA and NHPA regulatory compliance. The person designated as the Compliance Officer must have the requisite corporate and organizational authority to serve as a Compliance Officer and to discharge the duties set forth below. The person designated as the Compliance Officer shall be responsible for developing, implementing, and administering the Compliance Plan and ensuring that Verizon Wireless complies with the terms and conditions of the Compliance Plan and this Consent Decree. The Compliance Officer shall have specific knowledge of and experience with the Environmental Rules necessary to discharge his or her duties under this Consent Decree prior to assuming his/her duties. The Compliance Officer must also complete the training curriculum offered by the National Preservation Institute, including but not limited to, Section 106 Basics,[40] the Utah State University Department of Environment and Society,[41] NEPA Compliance and Cultural Resources,[42] and complete the training identified in paragraphs 2 and 13 within the time frames specified therein.

13. **Compliance Plan**. For purposes of settling the matters set forth herein, Verizon Wireless agrees that it shall, within sixty (60) calendar days after the Effective Date, develop and implement a Compliance Plan designed to ensure future compliance with the Environmental Rules and with the terms and conditions of this Consent Decree. Verizon Wireless will implement, at a minimum, the following procedures:

(a) **Operating Procedures**. Within sixty (60) calendar days after the Effective Date, Verizon Wireless shall establish Operating Procedures that all Covered Employees and Covered Vendors must follow to ensure Verizon Wireless's compliance with the Environmental Rules for Covered Facilities. Verizon Wireless's Operating Procedures shall include internal procedures and policies specifically designed to ensure that all environmental review and historic preservation obligations are fully satisfied prior to commencing construction, and during all subsequent construction phases, on any proposed Covered Facilities. These Operating Procedures shall include, but are not limited to:

i. Covered Vendors must first assess each proposed Covered Facility and complete relevant documentation to ensure that, prior to construction: (a) SHPO/THPO concurrences are received, and/or (b) Memoranda of Agreement[43] (MOAs) are executed to address adverse effects. This assessment must also include an analysis and determination as to whether the proposed wireless facility is categorically excluded from environmental

[40] *See* National Preservation Institute, Section 106: The Basics for Planners, Project Managers, and Developers, https://training.npi.org/courses/section106basics (last visited Nov. 3, 2022).

[41] Required coursework must include NEPA 6260: "Cultural and Natural Resource Management" and NEPA 6380: "Managing NEPA Projects and Teams." *See* Utah State University, NEPA Certification Program, Quinney College of Natural Resources or Shipley course equivalents, as listed at https://qcnr.usu.edu/nepa/curriculum (last visited Nov. 3, 2022).

[42] *See* National Preservation Institute, NEPA Compliance and Cultural Resources, https://www.npi.org/seminars/laws-and-regulations/nepa-compliance-and-cultural-resources (last visited Nov. 3, 2022).

[43] If at any planning or construction stage, Verizon Wireless finds that a proposed undertaking would have an adverse effect on a historic property, or if the Commission finds that the proposed undertaking would have an adverse effect, Verizon Wireless must submit to the SHPO/THPO a plan designed to avoid, minimize, or mitigate the adverse effect, and to follow procedures in accordance with Stipulation VII.D of the NPA. *See* 47 CFR pt. 1, Appx. C., Stip. VII, D. Any resulting Memorandum of Agreement negotiated by Verizon Wireless, SHPO/THPO, and consulting parties shall be sent to the Commission for review and execution. *See* 47 CFR pt. 1, Appx. C., Stip. VII.D.4.

processing under section 1.1306(a)-(b) of the Rules,[44] or may have a significant environmental effect, pursuant to sections 1.1307(a) or (b) of the Rules,[45] thus requiring an EA. Covered Vendors must complete any NEPA review consistent with the WTB NEPA checklist[46] to identify whether any facility requires the preparation of an EA and, if so, complete and file EAs as required by section 1.1307(a) of the Rules.[47]

ii. After Covered Vendors have completed their initial site assessment and any additional work for a Covered Facility, Verizon Wireless must apply a quality assurance and quality control process to help ensure that the assessments by Covered Vendors accurately identify all applicable environmental review and historic preservation obligations prior to construction. That process shall include Covered Employee(s) and/or Covered Vendor(s) not involved in the initial site assessment conducting regular, second-level review for a sample set of Covered Facilities.

iii. As part of the review process identified in paragraph 13(a)(ii), Covered Employees or Covered Vendors not involved in initial site assessments must carefully review all environmental records for the proposed Covered Facility under review, including but not limited to: (a) SHPO/THPO concurrences, (b) TCNS filings, (c) SHPO/THPO communications, (d) Findings of No Significant Impact (FONSI), if applicable, (e) conditions established by the U.S. Fish and Wildlife Service or other reviewing agencies,[48] (f) elevation requirements associated with sites located in floodplains, to ensure compliance with any relevant condition(s),[49] (g) monitoring and mitigation obligation(s), and (h) shall direct and/or escalate any SHPO/THPO request to the appropriate Covered Employee and/or Covered Vendor for further action(s).

iv. Covered Employees and/or Covered Vendors must engage in timely and equivalent levels of communication with affected SHPO/THPOs and WTB personnel to address SHPO/THPO requests and as otherwise necessary and appropriate during all construction phases.

v. Verizon Wireless shall submit any monitoring requests from SHPOs or THPOs to TCNSHELP@fcc.gov within five (5) calendar days of receiving such request, copying the entity making the monitoring request (e.g., Tribe or SHPO).

Verizon Wireless shall also develop a Compliance Checklist that describes the steps that a Covered Employee and Covered Vendor must follow to ensure compliance

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[44] *See* 47 CFR § 1.1306.

[45] *See* 47 CFR § 1.1307.

[46] *See* FCC Environmental Assessment Processing, NEPA and EA Checklists (June 24, 2022), https://us-fcc.app.box.com/s/f2rbaxbka6ni4e30jwun4nms6lbk18kf (last visited Nov. 7, 2022); *see generally* Competition and Infrastructure Policy Division, Wireless Telecommunication Bureau, Tower and Antenna Siting, https://www.fcc.gov/wireless/bureau-divisions/competition-infrastructure-policy-division/tower-and-antenna-siting (last visited Nov. 7, 2022).

[47] *See* 47 CFR § 1.1307.

[48] *See, e.g.*, 36 CFR § 800.5(b); *see also* July 9, 2003 Delegation Letter from Susan H. Steiman, Associate General Counsel, FCC Office of General Counsel, to Steve Williams, Director, U.S. Fish and Wildlife Service, U.S. Department of the Interior, (*available at* https://www.fcc.gov/file/14748/download (last visited Nov. 16, 2022)).

[49] 47 CFR § 1.1307(a).

with the Environmental Rules, prior to and during all subsequent construction phases. The Compliance Checklist shall include, but not be limited to, the requirements in subsections (i)-(v), immediately above.

(b) **Compliance Manual**. Within ninety (90) calendar days after the Effective Date, the Compliance Officer shall develop and distribute a Compliance Manual to all Covered Employees and Covered Vendors. The Compliance Manual shall explain the Environmental Rules and set forth the Operating Procedures that Covered Employees and Covered Vendors shall follow to help ensure Verizon Wireless's compliance with the Environmental Rules. Verizon Wireless shall periodically review and revise the Compliance Manual as necessary to ensure that the information set forth therein remains current and accurate. Verizon Wireless shall distribute any revisions to the Compliance Manual promptly to all Covered Employees and Covered Vendors.

(c) **Compliance Training Program**. Verizon Wireless shall establish and implement a Compliance Training Program on compliance with the Environmental Rules and the Operating Procedures. As part of the Compliance Training Program, Covered Employees and Covered Vendors shall be advised of Verizon Wireless's obligation to report any noncompliance with the Environmental Rules under paragraph 14 of this Consent Decree and shall be instructed on how to disclose noncompliance to the Compliance Officer. All Covered Employees shall be trained pursuant to the Compliance Training Program within one-hundred twenty (120) calendar days after the Effective Date, except that any person who becomes a Covered Employee at any time after the initial Compliance Training Program shall be trained within ninety (90) calendar days after the date such person becomes a Covered Employee. Verizon Wireless shall repeat compliance training on an annual basis, and shall periodically review and revise the Compliance Training Program as necessary to ensure that it remains current and complete and to enhance its effectiveness. Verizon Wireless will require that Covered Vendors take the Compliance Training Program as described above. Additionally, the Compliance Officer, all Covered Vendors, and all Covered Employees within the centralized Network and Regulatory Compliance group[50] shall be required to attend, virtually or in-person, the most recent workshop related to NEPA and NHPA compliance offered by the Commission between the Effective Date and the Termination Date; archived workshops are available on the Commission's website.[51] Covered Vendors and Covered Employees within the centralized Network and Regulatory Compliance group[52] should certify their attendance of such workshops to the Compliance Officer.

14. **Reporting Noncompliance**. Verizon Wireless shall report any material noncompliance with the Environmental Rules and with the terms and conditions of this Consent Decree within fifteen (15) calendar days after discovery of such noncompliance. Such reports shall include a detailed explanation of: (i) each instance of material noncompliance; (ii) the steps that Verizon Wireless has taken or will take to remedy such noncompliance; (iii) the schedule on which such remedial actions will be taken; and (iv) the steps that Verizon Wireless has taken or will take to prevent the recurrence of any such

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[50] *See supra* note 8.

[51] *See* FCC, Archived Events, 2022 Workshop on Environmental Compliance and Historic Preservation Review Procedures (Sept. 13, 2022), https://www.fcc.gov/news-events/events/2022/09/workshop-environmental-compliance-and-historic-preservation-review (last visited Nov. 4, 2022). All FCC Archived Events are searchable and available online. *See* FCC, Archived Events, https://www.fcc.gov/news-events/events/archived (last visited Nov. 4, 2022).

[52] *See supra* note 8.

noncompliance. All reports of noncompliance shall be submitted to EB-SED-Response@fcc.gov, with a copy submitted electronically to Daniela.Arregui@fcc.gov and towercomments@fcc.gov.

15. **Covered Vendor and Employee Certification**. Verizon Wireless shall require each Covered Vendor conducting the initial assessment for a Covered Facility under paragraph 14(a)(i) to certify at the time the assessment is submitted that the Covered Vendor: (i) has utilized the Compliance Manual in completing the assessment for the Covered Facility project; and (ii) has reviewed each such project to ensure that it fully complies with the Environmental Rules. Verizon Wireless shall require Covered Employees and/or Covered Vendors to make the same certification for all Covered Facilities reviewed pursuant to the process identified in paragraph 13(a)(ii). All certifications pursuant to this paragraph will be submitted to and subject to further review by the Compliance Officer.

16. **Compliance Reports**. Verizon Wireless shall file compliance reports with the Commission ninety (90) calendar days after the Effective Date, six (6) months after the Effective Date, twelve (12) months after the Effective Date, twenty-four (24) months after the Effective Date, and thirty-six (36) months after the Effective Date.

(a) Each Compliance Report shall include a detailed description of Verizon Wireless's efforts during the relevant period to comply with the terms and conditions of this Consent Decree and the Environmental Rules. In addition, each Compliance Report shall include a certification by the Compliance Officer, as an agent of and on behalf of Verizon Wireless, stating that the Compliance Officer has personal knowledge that Verizon Wireless: (i) has established and implemented the Compliance Plan; (ii) has utilized the Operating Procedures since the implementation of the Compliance Plan; and (iii) is not aware of any instances of noncompliance with the terms and conditions of this Consent Decree, including the reporting obligations set forth in paragraph 14 of this Consent Decree.

(b) The Compliance Officer's certification shall be accompanied by a statement explaining the basis for such certification and shall comply with section 1.16 of the Rules and be subscribed to as true under penalty of perjury in substantially the form set forth therein.[53]

(c) If the Compliance Officer cannot provide the requisite certification, the Compliance Officer, as an agent of and on behalf of Verizon Wireless, shall provide the Commission with a detailed explanation of the reason(s) why and describe fully: (i) each instance of noncompliance; (ii) identification of the Environmental Rules that apply to the instance of noncompliance along with any supporting information; (iii) the steps that Verizon Wireless has taken or will take to remedy such noncompliance, including the schedule on which proposed remedial actions will be taken; and (iv) the steps that Verizon Wireless has taken or will take to prevent the recurrence of any such noncompliance, including the schedule on which such preventive action will be taken.

(d) All Compliance Reports shall be submitted to EB-SED-Response@fcc.gov, with a copy submitted electronically to Daniela.Arregui@fcc.gov.

17. **Termination Date**. Unless stated otherwise, the requirements set forth in paragraphs 1312 through 16 of this Consent Decree shall expire thirty-six (36) months after the Effective Date.

18. **Section 208 Complaints; Subsequent Investigations**. Nothing in this Consent Decree shall prevent the Commission or its delegated authority from adjudicating complaints filed pursuant to section 208 of the Act[54] against Verizon Wireless or its affiliates for alleged violations of the Act, or for any other type of alleged misconduct, regardless of when such misconduct took place. The Commission's

[53] 47 CFR § 1.16.

[54] 47 U.S.C. § 208.

adjudication of any such complaint will be based solely on the record developed in that proceeding. Except as expressly provided in this Consent Decree, this Consent Decree shall not prevent the Commission from investigating new evidence of noncompliance by Verizon Wireless with the Communications Laws.

19. **Civil Penalty**. Verizon Wireless will pay a civil penalty to the United States Treasury in the amount of Nine Hundred and Fifty-Thousand Dollars ($950,000) within thirty (30) calendar days of the Effective Date. Verizon Wireless acknowledges and agrees that upon execution of this Consent Decree, the Civil Penalty shall become a "Claim" or "Debt" as defined in 31 U.S.C. § 3701(b)(1).[55] Upon an Event of Default, all procedures for collection as permitted by law may, at the Commission's discretion, be initiated. Verizon Wireless shall send electronic notification of payment to EB-SED-Response@fcc.gov on the date said payment is made. Payment of the Civil Penalty must be made by credit card using the Commission's Registration System (CORES) at https://apps.fcc.gov/cores/userLogin.do, ACH (Automated Clearing House) debit from a bank account, or by wire transfer from a bank account. The Commission no longer accepts Civil Penalty payments by check or money order. Below are instructions that payors should follow based on the form of payment selected:[56]

- Payment by wire transfer must be made to ABA Number 021030004, receiving bank TREAS/NYC, and Account Number 27000001. In the OBI field, enter the FRN(s) captioned above and the letters "FORF". In addition, a completed Form 159[57] or printed CORES form[58] must be faxed to the Federal Communications Commission at 202-418-2843 or e-mailed to RROGWireFaxes@fcc.gov on the same business day the wire transfer is initiated. Failure to provide all required information in Form 159 or CORES may result in payment not being recognized as having been received. When completing FCC Form 159 or CORES, enter the Account Number in block number 23A (call sign/other ID), enter the letters "FORF" in block number 24A (payment type code), and enter in block number 11 the FRN(s) captioned above (Payor FRN).[59] For additional detail and wire transfer instructions, go to https://www.fcc.gov/licensing-databases/fees/wire-transfer.
- Payment by credit card must be made by using CORES at https://apps.fcc.gov/cores/userLogin.do. To pay by credit card, log-in using the FCC Username associated to the FRN captioned above. If payment must be split across FRNs, complete this process for each FRN. Next, select "Manage Existing FRNs | FRN Financial | Bills & Fees" from the CORES Menu, then select FRN Financial and the view/make payments option next to the FRN. Select the "Open Bills" tab and find the bill number associated with the CD Acct. No. The bill number is the CD Acct. No. with the first two digits excluded (e.g., CD 1912345678 would be associated with FCC Bill Number 12345678). After selecting the bill for payment, choose the "Pay by Credit Card" option. Please note that there is a $24,999.99 limit on credit card transactions.
- Payment by ACH must be made by using CORES at https://apps.fcc.gov/cores/userLogin.do. To pay by ACH, log in using the FCC Username associated to the FRN captioned above. If payment must be split across FRNs, complete this process for each FRN. Next, select "Manage Existing FRNs | FRN Financial | Bills & Fees" on the CORES Menu, then select FRN Financial and the view/make payments option next to the FRN. Select the "Open Bills" tab and find the bill number

55 Debt Collection Improvement Act of 1996, Pub. L. No. 104-134, 110 Stat. 1321, 1358 (Apr. 26, 1996).

56 For questions regarding payment procedures, please contact the Financial Operations Group Help Desk by phone at 1-877-480-3201 (option #1).

57 FCC Form 159 is accessible at https://www.fcc.gov/licensing-databases/fees/fcc-remittance-advice-form-159.

58 Information completed using the Commission's Registration System (CORES) does not require the submission of an FCC Form 159. CORES is accessible at https://apps.fcc.gov/cores/userLogin.do.

59 Instructions for completing the form may be obtained at http://www.fcc.gov/Forms/Form159/159.pdf.

associated with the CD Acct. No. The bill number is the CD Acct. No. with the first two digits excluded (e.g., CD 1912345678 would be associated with FCC Bill Number 12345678). Finally, choose the "Pay from Bank Account" option. Please contact the appropriate financial institution to confirm the correct Routing Number and the correct account number from which payment will be made and verify with that financial institution that the designated account has authorization to accept ACH transactions.

20. **Event of Default**. Verizon Wireless agrees that an Event of Default shall occur upon the failure by Verizon Wireless to pay the full amount of the Civil Penalty on or before the due dates specified in this Consent Decree.

21. **Interest, Charges for Collection, and Acceleration of Maturity Date**. After an Event of Default has occurred under this Consent Decree, the then unpaid amount of the Civil Penalty shall accrue interest, computed using the U.S. Prime Rate in effect on the date of the Event of Default plus 4.75%, from the date of the Event of Default until payment in full. Upon an Event of Default, the then unpaid amount of the Civil Penalty, together with interest, any penalties permitted and/or required by the law, including but not limited to 31 U.S.C. § 3717 and administrative charges, plus the costs of collection, litigation, and attorneys' fees, shall become immediately due and payable, without notice, presentment, demand, protest, or notice of protest of any kind, all of which are waived by Verizon Wireless.

22. **Waivers**. As of the Effective Date, Verizon Wireless waives any and all rights it may have to seek administrative or judicial reconsideration, review, appeal or stay, or to otherwise challenge or contest the validity of this Consent Decree and the Adopting Order. Verizon Wireless shall retain the right to challenge Commission interpretation of the Consent Decree or any terms contained herein. If either Party (or the United States on behalf of the Commission) brings a judicial action to enforce the terms of the Consent Decree or the Adopting Order, neither Verizon Wireless nor the Commission shall contest the validity of the Consent Decree or the Adopting Order, and Verizon Wireless shall waive any statutory right to a trial *de novo*. Verizon Wireless hereby agrees to waive any claims it may otherwise have under the Equal Access to Justice Act[60] relating to the matters addressed in this Consent Decree.

23. **Severability**. The Parties agree that if any of the provisions of the Consent Decree shall be held unenforceable by any court of competent jurisdiction, such unenforceability shall not render unenforceable the entire Consent Decree, but rather the entire Consent Decree shall be construed as if not containing the particular unenforceable provision or provisions, and the rights and obligations of the Parties shall be construed and enforced accordingly.

24. **Invalidity**. In the event that this Consent Decree in its entirety is rendered invalid by any court of competent jurisdiction, it shall become null and void and may not be used in any manner in any legal proceeding.

25. **Subsequent Rule or Order**. The Parties agree that if any provision of the Consent Decree conflicts with any subsequent Rule or order adopted by the Commission (except an order specifically intended to revise the terms of this Consent Decree to which Verizon Wireless does not expressly consent) that provision will be superseded by such Rule or order.

26. **Successors and Assigns**. Verizon Wireless agrees that the provisions of this Consent Decree shall be binding on its successors, assigns, and transferees.

27. **Final Settlement**. The Parties agree and acknowledge that this Consent Decree shall constitute a final settlement between the Parties with respect to the Investigation.

28. **Modifications**. This Consent Decree cannot be modified without the advance written consent of both Parties.

[60] *See* 5 U.S.C. § 504; 47 CFR §§ 1.1501–1.1530.

29. **Paragraph Headings**. The headings of the paragraphs in this Consent Decree are inserted for convenience only and are not intended to affect the meaning or interpretation of this Consent Decree.

30. **Authorized Representative**. Each Party represents and warrants to the other that it has full power and authority to enter into this Consent Decree. Each person signing this Consent Decree on behalf of a Party hereby represents that he or she is fully authorized by the Party to execute this Consent Decree and to bind the Party to its terms and conditions.

31. **Counterparts**. This Consent Decree may be signed in counterpart (including electronically or by facsimile). Each counterpart, when executed and delivered, shall be an original, and all of the counterparts together shall constitute one and the same fully executed instrument.

____

Loyaan A. Egal
Chief
Enforcement Bureau

____

Date

____

Chris Miller
Senior Vice President & Deputy General Counsel
Verizon

____

Date

S

8834 Tapaderas Loop• Roseville, CA 95747
Phone: 9164745281 • sharilatch@gmail.com

01/09/2023

LOS ANGELES COUNTY BOARD OF SUPERVISORS
500 W Temple St #383,
Los Angeles, CA 90012
executiveoffice@bos.lacounty.gov

DEAR BOARD OF SUPERVISORS,

I am writing you to let you know why I am opposing Title 16 and Title 22, unless amended, in relations to radiation emitted from cell tower. This radiation is not safe for humans or the environment. Therefore, the placement of antennas is a matter of urgent public interest. Cutting off debate, eliminating public input and ignoring environmental laws (including CEQA) is unjustified.

I would urge the Board of Supervisors to adopt the redline for Titles 16 and 22 that Fiber First L.A. submitted. Please invest in resources that are offered through federal dollars to provide superior fiber optic broadband connections rather than slow, unreliable, expensive, unregulated and hazardous wireless broadband that requires hundreds of new antennas in our residential neighborhoods.

PLEASE PROTECT US FROM TELECOM WILDFIRES. In the last 15 years, there have been four major Southern California wildfires initiated, in whole or in part, by telecommunications equipment. Cell tower fires are electrical fires that firefighters cannot fight until the grid is cut, which can take up to 60 minutes. Cell tower placement close to homes or schools may not allow enough time for escape in the event of a fire. The proposed revisions enable cell towers to be too close to homes, schools and daycare centers.

In case of emergency, should there be a loss of electricity, 911 calls would depend solely upon the macro towers that receive backup power per the California Public Utilities Commission (CPUC) Order. The claim that has been made about hundreds of new small cell antennas are required for 911 calls is false and should not be used as an argument for the amendments.

The telecommunications industry has almost complete control of the FCC, according to Captured Agency, a monograph written by journalist Norm Alster during his 2014-15 fellowships at Harvard University's Center for Ethics. There's a revolving door between the membership of the FCC and high-level people within the telecom industry that's been going on for a couple of decades now.

This industry spends about $100 million a year lobbying Congress. The CTIA, which is the major telecom-lobbying group, spends $12.5 million per year on 70 lobbyists. According to one of their spokespersons, lobbyists meet roughly 500 times a year with the FCC to lobby on various issues.

As a whole, this industry spends $132 million a year on lobbying and provides $18 million in political contributions to members of Congress and others at the federal level. Can you please send a clear message to the Telecommunications Industry and the Special Interest Lobbyists, that you will not allow LA Residents, or the rest of us, be exposed to harmful radiation from these towers?

Our Health Matters!

Sincerely,

Sharina Latch

REFERENCES: Children's Health Defense, https://news.berkeley.edu/2021/07/01/health-risks-of-cell-phone-radiation/, https://emfscientist.org/,

January 9, 2023

To: Los Angeles County ("LAC") Board of Supervisors Members:
Hilda L. Solis, Holly J. Mitchell, Janice Hahn, Kathryn Barger, Lindsay Horvath
Cc: Chair LA County Regional Planning Department ("LACRPD"): Yolanda Duarte-White,
Director of Public Works: Mark Pestrella, Dawyn R. Harrison, Acting County Counsel

Re: Petition Relating to Proposed Amendments to Title 16 & 22 (Vote on Final Passage Scheduled for January 10, 2023)

Dear LAC Board of Supervisors Members (and Other Concerned with the above captioned matter):

We oppose the proposed Amendments to Title 16 & 22 and urge the Board of Supervisors to vote "No" on this measure. This proposed wireless antenna system will impact East LA, a community adjacent to Boyle Heights, a community that has historically struggled to receive services and resources. This is not the fault of the system, but rather the fault of industry, which have over long periods abused their power over the community of East LA.

The proposed wireless systems is harmful to children because the radiation is invisible and on at all times, which will affect the community for 24 hours every day without rest. We believe the alternative fiber optics system is a significantly safer alternative because it relies on existing infrastructure and does not introduce harmful radiation waves to the community.

We urge you to vote "No".

The East LA Coalition

From: ExecutiveOffice
To: PublicComments
Subject: FW: Oppose Agenda Item 59: Titles 16 & 22 - CA Fire and Firefighters
Date: Tuesday, January 10, 2023 7:37:49 AM
Attachments: CA Fires and Firefighters NO to 1-9-2023.pdf
Executed Copy Malibu Res. 21-17.PDF

The following correspondence is being forwarded to you for your review/information.

From: Susan Foster <susan.foster@dotlaw.biz>
Sent: Monday, January 9, 2023 9:20 PM
To: Supervisor Janice Hahn (Fourth District) <fourthdistrict@bos.lacounty.gov>; Holly J. Mitchell <HollyJMitchell@bos.lacounty.gov>; First District <firstdistrict@bos.lacounty.gov>; Barger, Kathryn <Kathryn@bos.lacounty.gov>; Third District <ThirdDistrict@bos.lacounty.gov>; ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Subject: Oppose Agenda Item 59: Titles 16 & 22 - CA Fire and Firefighters

CAUTION: External Email. Proceed Responsibly.

Supervisor Janice Hahn – FourthDistrict@bos.lacounty.gov
Supervisor Holly J. Mitchell – HollyJMitchell@bos.lacounty.gov
Supervisor Hilda Solis – firstdistrict@bos.lacounty.gov
Supervisor Kathryn Barger – Kathryn@bos.lacounty.gov
Supervisor Lindsey Horvath – Lindsey@bos.lacounty.gov
Los Angeles County Board of Supervisors – executiveoffice@bos.lacounty.gov

Oppose Agenda Item 59: Titles 16 & 22

Dear Hon. Sup. Hahn and Members of the Board:

Attached please find two documents:

1) My letter as co-founder of the nonprofit California Fires and Firefighters yet I am also reaching out to you in my capacity as a member of Fiber First LA.

2) Resolution 21-17 passed unanimously by the Malibu Planning Commission & Malibu City Council.

Respectfully submitted,

SUSAN FOSTER
Co-Founder, California Fires and Firefighters
Fire & Utility Consultant
PO Box 1444
Lyons, CO 80540
858-756-3532
susan.foster@dotlaw.biz

CALIFORNIA FIRES AND FIREFIGHTERS

PO Box 1444
Lyons, CO 80540
susan.foster04@gmail.com

January 9, 2023

Supervisor Janice Hahn – FourthDistrict@bos.lacounty.gov
Supervisor Holly J. Mitchell – HollyJMitchell@bos.lacounty.gov
Supervisor Hilda Solis – firstdistrict@bos.lacounty.gov
Supervisor Kathryn Barger – Kathryn@bos.lacounty.gov
Supervisor Lindsey Horvath – Lindsey@bos.lacounty.gov
Los Angeles County Board of Supervisors – executiveoffice@bos.lacounty.gov

Oppose Agenda Item 59: Titles 16 & 22

Dear Hon. Sup. Hahn and Members of the Board:

The Staff's recent changes to the proposed amendments to County Code Titles 16 and 22 do not meaningfully address the concerns raised by the Board of Supervisors or those concerns raised by residents and experts in the field of public safety.

I have written to the Board, spoken before you, and submitted my white paper on telecommunications fires, "Protecting LA County's Future." I have, in my capacity as a member of Fiber First LA and as cofounder of the nonprofit California Fires and Firefighters, met with members of your staffs; in one of those meetings LA County Planning and County Counsel were represented.

I believe you have heard our concerns on the added fire risks that thousands of new cell towers in Los Angeles County will bring, but the proposed changes to Titles 16 and 22 are nothing more than window dressing. I will address only those changes that appear intended to focus on the fire and structural safety risks because the revisions do nothing to ensure a minimum standard for protection.

Telecom will still be left to police telecom when it comes to structural, electrical and fire safety, and you will have another telecom-initiated Malibu Canyon Fire (2007) on your hands or another fire from SCE's own telecommunications facilities like with the Woolsey Fire (2018).

Big problems deserve substantive solutions. Merely asking telecom to "maintain" their macro towers and/or small cells is profoundly inadequate. They should be built right in the first place.

People need an escape route and time. Towers are fire risks so they should not be placed next to homes and schools. Cell tower fires are electrical fires, and they cannot be fought through conventional means until the grid is cut; that can take up to 60 minutes.

Please require the fire and structural safety provisions in Fiber First LA redlines to Titles 16 and 22. These provisions were adopted in Malibu, a city in Sup. Horvath's district after it burned twice at the hands of telecom-equipment.

Here are the County's proposed changes that attempt to address fire but fall far short:

> **Proposed change #1:** "including all applicable public safety requirements."
>
> **Proposed change #2:** "Safety. All SCFs shall be designed and installed to ensure that the SCFs and supporting structures meet minimum standards for public safety. All SCFs shall be maintained to prevent electrical and fire hazards."

In our one meeting with Mr. Durbin he explained he was neither an engineer nor an attorney, nor did he review applications or permits. He said he was only an ordinance writer. He presumably therefore knows that merely stating that all relevant codes apply does nothing since the county has expressly exempted wireless from all otherwise relevant codes. Presumably Ms. Bodek is equally familiar, and they likely figure the Supervisors do not understand that Los Angeles County has expressly chosen to be "different" than the state and exempt these wireless providers from the Building and Electrical Codes:

> **Building Code Sec. 101.3:** "The provisions of this Code shall not apply to work located primarily in a public way other than pedestrian protection structures required by Chapter 33; public utility towers and poles; certain governmental agencies, special districts, and public utilities as determined by the Building Official;..."
>
> **Electrical Code 80-3:** "The provisions of this Code shall not apply to public utilities; or to electrical wiring for street lighting or traffic signals located primarily in a public way; or to mechanical equipment not specifically regulated in this Code."

Your staff knows the proposed changes listed above look inviting but are completely meaningless. Your staff is not providing you with the language or the policy necessary to protect the residents of LA County. Your residents are at risk, your renters are at risk, your property values are at risk and your property itself is at risk. Suggesting an adherence to public safety standards that staff knows have been exempted is deceptive.

Please note further that your staff is suggesting safety standards for the supporting structures only; they are leaving scrutiny of engineering designs including structural, building, electrical and fire safety to telecom. Such reliance upon telecom has been proven to be a costly error. [Please see my white paper "Protecting LA County's Future."]

Additionally, LA County must expressly incorporate **APCO ANS 2.106.1, Public Safety Grade Site Hardening Requirements** to impose meaningful structural safety requirements - the national standard for public safety telecommunications infrastructure. It does not apply on its own as California has not yet adopted this federal standard as its own. Therefore, LA County must do so and Staff did not add this critical structural integrity requirement.

Fiber First LA stands ready to assist the County with the fire safety protocol we designed specifically for Malibu and that town adopted because it is a city that has burned twice, as supervisor Horvath well knows. What many do not know is that both of these fires were telecommunications-initiated. Both of these fires were avoidable and together they cost well over $6 billion.

The Malibu Planning Commission and Malibu City Council unanimously passed our fire safety protocol in Res. 21-17 [attached] calling for inspection of eight critical yet nonetheless basic engineering tests for each cell tower permit application in Malibu.

Your Staff needs to provide a robust application checklist upfront, a tolling of the shot clock if an application is incomplete, and review of the safety and design specifications for each new cell tower and small cell in Los Angeles County. Staff and consultants can be added and the additional cost for reviewing each application charged to the carrier. This is legal and as it should be.

I strongly urge the Los Angeles County Board of Supervisors to vote No on Titles 16 & 22.

Respectfully submitted,

Susan Foster

SUSAN FOSTER

Cc: W. Scott McCollough, Esq.
Doug Wood, FFLA

Attachment: Resolution 21-17, Malibu Municipal Code

RESOLUTION NO. 21-17

A RESOLUTION OF THE CITY OF MALIBU ADOPTING ENGINEERING, DESIGN AND LOCATION STANDARDS, CONDITIONS OF APPROVAL AND BASIC APPLICATION REQUIREMENTS FOR WIRELESS COMMUNICATIONS FACILITIES ON LAND OTHER THAN PUBLIC RIGHT-OF-WAY; AND FINDING THE SAME EXEMPT FROM THE CALIFORNIA ENVIRONMENTAL QUALITY ACT

The City Council of the City of Malibu does hereby find, resolve and order as follows:

SECTION 1. Recitals

A. Malibu Municipal Code (MMC) Chapter 17.46 governs the permitting, installation, and regulation of wireless communications facilities in the City, other than those in the public right-of-way, which are subject to MMC Chapter 12.02.

B. Section 17.46.060(D) provides that "[a]ll applicants shall engineer, design and locate the wireless communications facilities in accordance with the standards and wireless regulations set forth separately though the resolution adopted by the City Council."

C. Being authorized to do so, the City wishes to establish engineering, design and development standards applicable to wireless installations.

D. The City also wishes to set standard conditions of approval and basic application requirements applicable to wireless permits.

E. On April 12_, 2021 the City Council conducted a duly noticed public hearing and received testimony from City staff and all interested parties regarding the and the standards, conditions and requirements.

SECTION 2. Purpose. The purpose of this document is to (1) establish design and location standards (Standards) for wireless communications facilities on land other than public right-of-way; (2) set standard conditions of approval for Wireless Permits (WPs); and (3) set basic application requirements for WPs.

SECTION 3. Definitions. For the purposes of these Standards, the definitions set forth in Malibu Municipal Code (MMC) Section 17.46.040 are incorporated by reference into this Resolution and in addition the following definitions apply:

A. "Park" A parcel, parcels of land or a portion of a parcel intended for active public recreation uses. Parks may include sports fields, playgrounds community buildings and unique or specialized activity areas. Land dedicated for open space and trails are not considered parks for the purposes of this Chapter.

B. "Playground" A portion of land used for and equipped with public facilities for recreation specially by children. A playground includes the sand or rubberized floor around the apparatus.

C. "Pole-mounted facility" means a wireless communications facility that is, or is proposed to be, attached to or contained in a pole.

D. "School" any building, campus or sports field which is designed, constructed or used for education, instruction or school sports, whether public or private, in any branch of knowledge.

E. "Stealth facility" (or "stealth facilities") means a wireless communications facility designed to look like something other than a wireless tower or base station.

SECTION 4. General Standards for all Facilities The following general requirements apply at all times to all wireless communications facilities located in all zoning districts:

A. All wireless communications facilities shall be engineered and designed to minimize the visual impact by means of placement, screening, camouflaging, painting and texturing and to be compatible with existing architectural elements, building materials and other site characteristics. The applicant shall use the smallest and least visible antenna possible to accomplish the facility's objectives. All antennas and support structures shall be painted and/or textured to achieve architectural compatibility with the structures for which they are attached and/or located.

B. Each facility must comply with any and all applicable provisions of the Malibu Municipal Code, including but not limited to provisions of the California Building Code, California Electric Code, California Plumbing Code, California Mechanical Code, and California Fire Code, and any conditions of approval imposed as part of the approval process.

C. Each facility must comply with any and all applicable regulations and standards promulgated or imposed by any state or federal agency, including, but not limited to, the Federal Communications Commission (FCC) and the Federal Aviation Administration (FAA). Further, all wireless communications facilities, associated equipment and services shall comply with Americans with Disabilities Act (ADA) requirements.

D. Fire and Electrical Safety Standards. All wireless communications facilities shall contain:

1. Surge protection for lightning discharge or other significant electrical disturbances; and

2. Signage as required by the permit conditions, the National Electric Code or the Los Angeles County Fire Department Chief or their designee.

E. The facility must at all times comply with all applicable health requirements and standards pertaining to radio frequency emissions.

F. All antennas shall meet the minimum siting distances to habitable structures required for compliance with FCC regulations and standards governing the environmental effects of radio frequency emissions.

G. Noise. Wireless communications facilities and equipment must comply with the City's noise ordinance in MMC Chapter 8.24, or any successor provisions, and be designed to prevent noise and sound from being plainly audible at a distance of fifty (50) feet from the facility or within ten (10) feet of any residence.

H. Signs. No facility may display any signage or advertisement unless it is expressly allowed by this paragraph, necessary for stealth concealment purposes, or required by law or a permit condition. Every facility shall at all times display signage that accurately identifies the facility owner and provides the owner's unique site number and a local or toll-free telephone number to contact the facility owner's operations center.

I. Landscaping. Where appropriate, facilities shall be installed so as to maintain and enhance existing landscaping on the site, including trees, foliage and shrubs, whether or not utilized for screening. In addition to any landscaping used for concealment or screening purposes, the applicant shall replace any existing landscaping displaced during construction or installation of the applicant's facility. The applicant's landscaping plan shall be subject to the City's review and approval but shall, at a minimum, match the existing landscaping and foliage surrounding the installation site consistent with MMC Section 17.53.090. The permittee shall ensure that any vegetation allowed to remain in place under the Fire Code, including vegetation provided for screening, is properly maintained and watered.

J. All electrical support equipment located within cabinets, shelters, or similar structures shall be screened from public view. Roof-mounted electrical support equipment shall be discouraged. Ground-mounted electrical support equipment shall be encouraged. In addition, under grounding of support equipment is required wherever practicable.

K. All antennas shall be located such that any person walking adjacent to the transmitting surface of the antenna will be walking on a grade that is a minimum of eight and one-half feet below the transmitting surface.

L. Lighting of antenna structures and their electrical support equipment is prohibited, except as required by any order or regulation of the FCC or the FAA and except for manually operated emergency lights for use when official operating personnel are on site.

M. A backup power supply must be required for all new wireless communications facilities to the extent allowed by law and in compliance with California Fire Code 1206.2.2.

SECTION 5. Location Standards for All Facilities The location standards for all wireless communications facilities, other than those that qualify as eligible facilities requests, are as follows:

A. No wireless telecommunication facility shall be located within five hundred (500) feet of any school, playground, or park unless a finding is made, based on technical evidence acceptable to the reviewing authority showing a clear need for the facility and that no technically feasible alternative site exists. Except for facilities installed on the same pole or tower as an existing wireless telecommunication facility, wireless telecommunication facilities located within any residential zone district shall not be located within one thousand (1,000) feet of any other wireless communications facility, except from those facilities placed on utility poles along Pacific Coast Highway, unless a waiver is granted.

B. All new freestanding wireless communications facilities and monopoles shall be set back a minimum distance of at least one hundred and twenty (120) percent of the height of the facility or monopole from any property line abutting a residentially zoned property. This minimum setback is not subject to the waivers allowed under Section 7 of this Resolution.

C. Location preference for wireless communications facilities should be given to the following:

1. Property designated non-residential (except for public open space and recreational vehicle park zoning districts), unless otherwise prohibited pursuant to this title.

2. Facilities attached or sited adjacent to existing structures. Whenever possible, facilities shall be located on and/or inside existing structures. Appropriate types of existing structures may include, but are not limited to: buildings, water tanks, telephone poles and utility towers and poles, sign standards, light standards and roadway overpasses.

3. Sites with minimum separation. Sites that are more than five hundred (500) feet from school, playgrounds, and parks.

4. Sites that are not highly visible from adjacent roadways.

5. Unless otherwise indicated in MMC Chapter 17.46 or these Standards, no wireless facility shall be installed on an exposed ridgeline unless the facility blends with the surrounding existing natural and man-made environment and a finding is made that no other location is technically feasible.

6. The City expressly designates residential, public open space and recreational vehicle park zoning districts, parks and schools as the least appropriate possible locations, and the absolute last choices for siting.

SECTION 6. Engineering and Design Standards for all Facilities The general design standards for wireless communications facilities subject to MMC Chapter 17.46 are as follows:

A. Basic Requirements. The proposed wireless facility and its supporting structure (if needed) shall be limited to the minimum size necessary to serve the defined service objectives of the wireless service provider or providers that will be using the facility, except where a larger facility has superior concealment elements.

B. Materials. The materials used shall be non-reflective and non-flammable.

C. Cabinet doors and other openings must be designed to stay securely closed, and openings in all facilities shall be shielded or made the smallest size feasible to protect against fire and wind-blown embers.

D. The tower, or other support structure, and all equipment shall be designed to withstand forces from seismic events. To that end, all wireless facility sites must be built to the applicable standards of Hardening Requirements including but not limited to APCO ANSI 2.106.1–2019, or their replacements. The telecommunications tower, pole or structure when fully loaded with antennas, transmitters, and other equipment and camouflaging shall be designed as determined by the Building Official. All equipment mounting racks and equipment used shall be anchored in such a manner that such a quake will not tip them over, throw the equipment off its shelves, or otherwise act to damage it.

E. All connections between various components of the facility, power lines, and conduit shall be designed in a manner to protect against damage by a natural disaster, a vehicular accident, an act of vandalism or similar external forces.

F. Stealth. The wireless facility shall be stealth. Stealth elements and techniques should be used to blend the facility with surrounding materials and colors of the support structure and make the facility appear to be something other than a wireless facility. Stealth elements include, but are not limited to, the following:

1. Radio frequency (RF) transparent screening or shrouds;

2. Matching the color of the existing support structure by painting, coating, or otherwise coloring the wireless facility, equipment, mounting brackets, and cabling;

3. Placing cables and wires inside the pole or beneath conduit of the smallest size possible;

4. Minimizing the size of the site;

5. Installing new infrastructure that matches existing infrastructure in the area surrounding the proposed site; and

6. Using paint of durable quality.

7. Built with weather-resistant materials while permitting weathered treatment for aesthetic reasons and to avoid reflective material.

G. Minimum Height. All antennas shall be located such that: (1) any person walking adjacent to the transmitting surface of the antenna will be walking on a grade that is a minimum of eight and one-half feet below the transmitting surface; and (2) no person at ground level will be exposed to an exposure level that is higher than allowed by the FCC's general population exposure rules.

H. Facade-Mounted Equipment. Facade-mounted antennas and equipment shall be architecturally integrated into the building, or other support structure, design and otherwise made as unobtrusive as possible so that the facility does not appear to be a wireless facility. Antennas and equipment should be located entirely within an existing or newly created architectural feature so as to be completely screened from view. Facade-mounted facilities shall generally not extend more than eighteen (18) inches out from and may not project above the building face. Façade-mounted wireless telecommunication facilities shall not exceed twenty-eight (28) feet in height above the ground. However, antenna elements, mounted flush on the facade of an existing structure that exceeds twenty-eight (28) feet, may have a height equal to the height of the building.

I. Ground-Mounted Equipment. Outdoor ground-mounted equipment associated with base stations shall be avoided whenever feasible. In locations visible or accessible to the public, applicants shall conceal outdoor ground-mounted equipment, including ancillary power generation equipment, with opaque fences or landscape features that mimic the adjacent structure(s) (including, but not limited to, dumpster corrals and other accessory structures) and by painting, texturing, or otherwise concealing the facility as much as possible. Ground-mounted wireless communications facilities shall be located near existing structures or trees at similar heights for screening purposes where feasible. Not more than one ground-mounted antenna, provided that licensed amateur radio station antennas consistent with MMC 17.46.020(B)(2), shall also be permitted on each site.

J. Roof-Mounted Facilities. Roof-mounted antennas and necessary equipment shall be screened from above if visible from higher elevations. Rooftop-mounted wireless telecommunication facilities shall not exceed twenty-eight (28) feet in height or three (3) feet above the roof parapet from which they are attached, whichever is less restrictive. Associated roof-mounted equipment cabinets shall not extend more than three (3) feet above the roof from which it is attached and shall be set back a minimum of ten (10) feet from the edge of the roof. All roof-mounted equipment cabinets shall be located behind a mechanical screen wall. In the event that a roof parapet wall screens the equipment cabinets, a mechanical screen wall will not be required.

K. Freestanding Facilities. Freestanding facilities requiring a new monopole or other new support structure shall be stealth facilities. Further, they shall be located as close as possible to existing above-ground utilities, such as electrical towers or utility poles (which are not scheduled for removal or under grounding for at least 18 months after the date of application), light poles, trees of comparable heights, and in areas where they will not detract from the appearance of the City.

1. Freestanding wireless telecommunication facilities, including monopoles, shall not exceed twenty-eight (28) feet in height and shall not extend higher than the top of the ridgeline nearest the antenna. The height of a freestanding facility shall be measured from the natural undisturbed ground surface below the center of the base of the tower itself to the tip of the highest antenna or piece of equipment attached thereto.

2. Aside from the antenna itself, no additional equipment may be visible. All cables, including, but not limited to, electrical and utility cables, shall be run within the interior of the freestanding facility and shall be camouflaged or hidden to the fullest extent feasible without jeopardizing the physical integrity of the facility.

3. Monopole installations shall be situated so as to utilize existing natural or man-made features including topography, vegetation, buildings, or other structures to provide the greatest amount of visual screening.

4. All antenna components and accessory wireless equipment shall be treated with exterior coatings of a color and texture to match the predominant visual background or existing architectural elements so as to visually blend in with the surrounding development. Subdued colors and non-reflective materials that blend with surrounding materials and colors shall be used.

5. Monopoles shall be no greater in diameter or other cross-sectional dimensions than is necessary for the proper functioning of the facility.

L. All wireless telecommunication facilities shall be designed to prevent unauthorized climbing and graffiti.

M. Fire Safety Standards. All wireless facilities designs shall include:

1. a power shut off, such as by means of rapid entry Knox or similar type systems shall be installed;

2. surge protection devices capable of mitigating a direct or partial direct lightning discharge; and

3. surge protection devices capable of mitigating significant electrical disturbances that may enter the facility via conductive cables.

N. Satellite dish or parabolic antennas shall be situated as close to the ground as possible to reduce visual impact without compromising their function.

O. Support equipment pads, cabinets, shelters and buildings require architectural, landscape, color, fencing, or other camouflage treatment to minimize visual impacts to the extent deemed necessary by the Planning Director. Landscaping screening should also be provided if irrigation water is available.

P. No freestanding facility or ancillary support equipment may be located between the face of a building and a public street, bikeway, park or residence.

SECTION 7. Waivers of These Standards.

A. A waiver of one or more of these Standards may be granted in the following circumstances:

1. Pursuant to MMC Section 17.46.060(D), if an applicant demonstrates to the Planning Commission through clear and convincing evidence that denial of an application would, within the meaning of federal law, prohibit or effectively prohibit the provision of personal wireless services, or otherwise violate applicable laws or regulations;

2. If an applicant demonstrates to the Planning Commission through clear and convincing evidence set forth in a feasibility study that compliance with a requirement of these Standards would be technically infeasible and the proposed wireless facility complies with the requirements of these Standards to the greatest extent technically feasible. For example, an exception to a requirement to conceal antennas in a shroud may be granted if shrouding is shown to be technically infeasible and an alternative concealment such as a colored film wrap is proposed; or

3. If an applicant demonstrates to the Planning Commission with clear and convincing evidence that the particular engineering, design or location proposed involves an alternative that better meets the purposes of Chapter 17.46 and only minor non-compliance with a requirement of these design Standards and results in no increase in public visual impact to the community or provides other benefits. For example, an exception to the wireless facility location limitations may be granted when the applicant can demonstrate that the placement is less visible from viewsheds of residences or shielded by vegetation or existing infrastructure (such as barriers), or is less physically intrusive (for example, less impactful to tree roots or reduces noise). Among other factors, in deciding whether or not to grant an exception, the Planning Commission may consider the impact of expansions to the facility that the applicant would be entitled to make as of right if granted.

B. Waivers may only be requested at the time an application is initially submitted for a discretionary permit. The request must include both the specific provision(s) from which waiver is sought and the basis of the request, including all supporting evidence on which the applicant relies. Any request for waiver after the City has deemed an application complete constitutes a material change to the proposed wireless facility and shall be considered a new application. A request for waiver from one or more requirements does not relieve the applicant from compliance with all other applicable provisions of law or of MMC Section 17.46.060.

SECTION 8. Standard Conditions of Approval for Permits Under MMC Chapter 17.46.

A. **Generally.** In addition to any supplemental conditions imposed by the Planning Director or Planning Commission, as the case may be, all development permits or conditional use permits granted for wireless communications facilities subject to this Chapter 17.46 shall be subject to the following conditions, unless modified by the approving authority:

1. The permittee shall defend, indemnify, and hold harmless the city or any of its boards, commissions, agents, officers, and employees from any claim, action or proceeding against the city, its boards, commission, agents, officers, or employees to attack, set aside, void, or annul, the approval of the project, or to hold the City liable in whole or in part as a result of the engineering, design, construction or operation of the facility. The City shall promptly notify the provider(s) of any such claim, action or proceeding if the city bears its own attorney's fees and costs, and the city defends the action in good faith.

2. The permittee shall be strictly liable for interference caused by its facilities with city communications systems. The permittee shall be responsible for costs for determining the source of the interference, all costs associated with eliminating the interference (including but not limited to filtering, installing cavities, installing directional antennas, powering down systems, and engineering analysis), and all costs arising from third party claims against the city attributable to the interference.

3. Subsequent submittals for this project shall be in substantial compliance with the plans date-stamped received by the Planning Department on _____________. The project shall comply with all conditions of approval stipulated in the referral sheets attached to the agenda report for this project. In the event the project plans conflict with any condition of approval, the condition shall take precedence and revised plans shall be submitted and approved by the Planning Director prior to the Environmental Sustainability Department for plan check.

4. The permit and rights conferred in this approval shall not be effective until the permittee signs, notarizes and returns the Acceptance of Conditions Affidavit accepting the conditions set forth herein. The applicant shall file this form with the Planning Department within 30 days of this decision or prior to issuance of

any development, conditional use, building, electrical or encroachment permit.

5. The applicant shall digitally submit a complete set of plans, including the items required in Condition No. 6 to the Planning Department for consistency review and approval prior to plan check and again prior to the issuance of any building or development permits.

6. The Notice of Decision (including the signed and notarized Acceptance of Conditions Affidavit) shall be copied in its entirety and placed directly onto a separate plan sheet(s) to be included in the development plans prior to submitting any development permits from the City of Malibu Environmental Sustainability Department and encroachment permit.

7. A development permit or conditional use permit, as applicable, shall be valid for a period of ten (10) years from issuance, unless pursuant to another provision of the Code or these conditions, it expires sooner or is terminated. At the end of ten (10) years from the date of issuance, such development or conditional use permit shall automatically expire, unless an extension or renewal has been granted. A person holding a development permit or conditional use permit must either (1) remove the facility within thirty (30) days following the permit's expiration (provided that removal of support structure owned by City, a utility, or another entity authorized to maintain a support structure need not be removed, but must be restored to its prior condition, except as specifically permitted by the City); or (2) prior to expiration, submit an application to renew the permit, which application must, among all other requirements, demonstrate that the impact of the wireless facility cannot be reduced. The wireless facility must remain in place until it is acted upon by the City and all appeals from the City's decision exhausted.

8. The installation and construction authorized by a permit shall be completed within three (3) years after its approval, or it will expire without further action by the City unless prior to the three (3) years the applicant submit an extension request and the City, in its sole discretion, grants a time extension for due cause. The installation and construction authorized by a permit shall conclude, including any necessary post-installation repairs and/or restoration to the property, within thirty (30) days following the day construction commenced. The permittee must provide written notice to City within ten (10) days after completing construction, and may not begin operations until all City and Fire Department (if applicable) inspections have been completed and the project is found to be

consistent with the permit. The expiration date shall be suspended until an appeal and/or litigation regarding the subject permit is resolved.

9. The Planning Director may grant up to four one-year extensions of the timeline, in Condition 7 above, for completing the installation and construction authorized by a development or condition use permit, if the Planning Director finds that the conditions, including but not limited to changes in the wireless ordinance under which the permit approval was issued, have not significantly changed.

10. Any questions of intent or interpretation of any condition of approval will be resolved by the Planning Director upon written request of such interpretation.

11. All structures shall conform to the requirements of the Environmental Sustainability Department, City Public Works Department, FCC and Los Angeles County Fire Department requirements, as applicable. Notwithstanding this review, all required permits, including but not limited to an encroachment permit from the City, shall be secured.

12. Minor changes to the approved plans or the conditions of approval may be approved by the Planning Director, provided such changes achieve substantially the same results and the project is still in compliance with the MMC. An application with all required materials and fees shall be required.

Cultural Resources

13. In the event that potentially important cultural resources are found in the course of geologic testing, work shall immediately cease until a qualified archaeologist can provide an evaluation of the nature and significance of the resources and until the Planning Director can review this information. Where, as a result of this evaluation, the Planning Director determines that the project may have an adverse impact on cultural resources, a Phase II Evaluation of cultural resources shall be required pursuant to MMC Section 17.54.040(D)(4)(b).

14. If human bone is discovered, the procedures described in Section 7050.5 of the California Health and Safety Code shall be followed. These procedures require notification of the coroner. If the coroner determines that the remains are those of a Native American, the applicant shall notify the Native American Heritage Commission by phone within 24 hours. Following notification of the Native

American Heritage Commission, the procedures described in Section 5097.94 and Section 5097.98 of the California Public Resources Code shall be followed.

Wireless Facility Conditions

15. All antennas shall meet the minimum siting distances to public/uncontrolled areas required for compliance with the FCC regulations and standards governing the environmental effects of radio frequency emissions. Permittee shall keep up-to-date on current information from the FCC in regards to maximum permissible radio frequency exposure levels. In the event that the FCC changes its guidelines for human exposure to radio frequency, permittee shall, within 30 days after any such change, submit to the Planning Director a report prepared by a qualified engineer that demonstrates actual compliance with such changed guidelines. The Director may, at permittee's sole cost, retain an independent consultant to evaluate the compliance report and any potential modifications to the permit necessary to conform to the FCC's guidelines. Failure to submit the compliance report required under this condition, or failure to maintain compliance with the FCC's guidelines for human exposure to radio frequency at all times shall constitute grounds for permit revocation.

16. All antennas shall be located so that any person walking adjacent to the transmitting surface of the antenna will be walking on a grade, which is a minimum of eight and one-half feet below the transmitting surface.

17. All antennas, equipment, and support structures shall be engineered and designed to prevent unauthorized climbing.

18. The wireless facility shall be erected, operated, and maintained in compliance with the general requirements set forth in the Standards and any specific requirements in the permit.

19. The antenna and electrical support equipment shall, at all times, be operated in a manner that conforms to the applicable health and safety standards, including those imposed by MMC Chapter 17.46 and this Resolution.

20. Wireless communications facilities and equipment must comply with the City's noise ordinance in MMC 8.24, or any successor provisions, and prevent noise and sound from being plainly audible at a distance of fifty (50) feet from the facility or within ten (10) feet of any residence.

21. The Planning Director's approval is required if a generator is to be placed onsite for temporary or permanent use.

22. All non-ground-mounted equipment associated with the application shall be located no lower than eight feet above grade or ground level on the monopole or support structure.

23. The City or its designee may enter onto the facility area to inspect the facility upon 48 hours prior notice to the permittee. The permittee shall cooperate with all inspections and may be present for any inspection of its facility by the City. The City reserves the right to enter or direct its designee to enter the facility and support, repair, disable, or remove any elements of the facility in emergencies or when the facility threatens imminent harm to persons or property. The City shall make an effort to contact the permittee prior to disabling or removing any facility elements, but in any case, shall notify permittee within 24 hours of doing so.

24. Testing of any equipment shall take place on weekdays only, and only between the hours of 8:30 a.m. and 4:30 p.m., except that testing is prohibited on holidays that fall on a weekday. In addition, testing is prohibited on weekend days.

25. Permittee shall obtain and maintain throughout the term of the permit commercial general liability insurance with a limit of five million dollars ($5,000,000) per occurrence for bodily injury and property damage and six million dollars ($6,000,000) general aggregate including premises operations, contractual liability, personal injury, and products completed operations. The relevant policy(ies) shall name the City, its elected/appointed officials, commission members, officers, representatives, agents, and employees as additional insureds. A true and correct copy of the policy of insurance shall constitute proof of insurance required by this Subsection. Permittee shall use its best efforts to provide thirty (30) days' prior notice to the City of to the cancellation or material modification of any applicable insurance policy. Failure to maintain insurance consistent with this Condition shall automatically void the permit, and the permittee shall immediately deenergize and remove the facility from operation. The policy shall not have a pollution or other exclusion which excludes injuries or damages from EMF/RF exposures.

26. Prior to issuance of a City permit or encroachment permit, the permittee shall file with the City, and shall maintain in good standing throughout the term of the approval, a performance bond or other surety or another form of security for the removal of the

facility in the event that the use is abandoned or the permit expires, or is revoked, or is otherwise terminated. The security shall be in the amount equal to the cost of physically removing the facility and all related facilities and equipment on the site, based on the higher of two contractor's quotes for removal that are provided by the permittee. The permittee shall reimburse the city for staff time associated with the processing and tracking of the bond, based on the hourly rate adopted by the City Council. Reimbursement shall be paid when the security is posted and during each administrative review.

27. Permittee shall not move, alter, temporarily relocate, change, or interfere with any existing structure, improvement, or property without the prior consent of the owner of that structure, improvement, or property. No structure, improvement, or property owned by the City shall be moved to accommodate a permitted activity or encroachment, unless the City determines that such movement will not adversely affect the City or any surrounding businesses or residents, and the Permittee pays all costs and expenses related to the relocation of the City's structure, improvement, or property. Prior to commencement of any work pursuant to any permit, the permittee shall provide the City with documentation establishing to the city's satisfaction that the permittee has the legal right to use or interfere with any other structure, improvement, or property to be affected by permittee's facilities.

28. No possessory interest is created by a Wireless Permit. However, to the extent that a possessory interest is deemed created by a governmental entity with taxation authority, permittee acknowledges that City has given to permittee notice pursuant to California Revenue and Taxation Code Section 107.6 that the use or occupancy of any public property pursuant to a development or conditional use permit may create a possessory interest which may be subject to the payment of property taxes levied upon such interest. Permittee shall be solely liable for, and shall pay and discharge prior to delinquency, any and all possessory interact taxes or other taxes, fees, and assessments levied against permittee's right to possession, occupancy, or use of any public property pursuant to any right of possession, occupancy, or use created by this development or conditional use permit.

29. If not already completed, permittee shall enter into the appropriate agreement with the City, as determined by the City, prior to

constructing, attaching, or operating a facility on municipal infrastructure. This permit is not a substitute for such agreement.

30. If a facility is not operated for a continuous period of three (3) months, the Wireless Permit and any other permit or approval therefor shall be deemed abandoned and terminated automatically, unless before the end of the three (3) month period (i) the Director has determined that the facility has resumed operations, or (ii) the City has received an application to transfer the permit to another service provider. No later than ninety (90) days from the date the facility is determined to have ceased operation, or the permittee has notified the Director of its intent to vacate the site, the permittee shall remove all equipment and improvements associated with the use and shall restore the site to its original condition to the satisfaction of the Director. The permittee shall provide written verification of the removal of the facilities within thirty (30) days of the date the removal is completed. If the facility is not removed within thirty (30) days after the permit has been discontinued pursuant to this subsection, the site shall be deemed to be a nuisance, and the City may cause the facility to be removed at permittee's expense or by calling any bond or other financial assurance to pay for removal. If there are two (2) or more users of a single facility or support structure, then this provision shall apply to the specific elements or parts thereof that were abandoned but will not be effective for the entirety thereof until all users cease use thereof.

31. In the event the City determines that it is necessary to take legal action to enforce any of these conditions, or to revoke a permit, and such legal action is taken, the permittee shall be required to pay any and all costs of such legal action, including reasonable attorney's fees, incurred by the City, even if the matter is not prosecuted to a final judgment or is amicably resolved, unless the City otherwise agrees, in its complete discretion, to waive said fees or any part thereof.

32. Interference with city communications systems and other governmental emergency systems is prohibited. Further, no permits issued pursuant to this chapter of the City Code establish any guarantee or warranty that Licensee's facility will be free from interference from city or third-party communication systems.

<u>Construction</u>

33. Installation hours shall be limited to Monday through Friday from 7:00 a.m. to 7:00 p.m. and Saturdays from 8:00 a.m. to 5:00 p.m. No installation activities shall be permitted on Sundays and City-

designated holidays. The restricted work hours described in this condition do not apply to emergency maintenance necessary to protect health or property. The City of Malibu may issue a Stop Work Order if permittee violates this condition. Construction activities shall be conducted in compliance with, and abide by, all applicable safety codes and permit conditions.

34. All sites must be designed and build to the standards of ANSI/APCO Public Safety Grade Site Hardening Requirements, also referred to as "APCO ANSI 2.106.1-2019".

Site Specific Conditions

35. In the event that the electric service provider does not currently offer an alternative metering option, the permittee shall remove the above-grade electric meter when such option becomes available. Prior to removing the above-grade electric meter, the permittee shall apply for any encroachment and/or other ministerial permit(s) required to perform the removal. Upon removal, the permittee shall restore the affected area to its original condition that existed prior to installation of the equipment.

36. The permittee acknowledges that the City specifically includes conditions of approval related to (a) painting, coloring or finishing the equipment to match the monopole or support structure; (b) undergrounding all equipment to the extent possible; (c) installing equipment within shrouds, conduits and risers as concealment elements engineered and designed to integrate the wireless facility with the surrounding built and natural environment; and (d) specific structural, seismic, electrical, fire and operating/maintenance requirements. Any future modifications to the permittee's wireless facility must maintain or improve all concealment elements and safety precautions.

37. Before the permittee submits any applications for construction, encroachment, excavation or other required permits in connection with this permit, the permittee must incorporate a true and correct copy of this permit, all conditions associated with this permit and any approved photo simulations into the project plans (collectively, the "Approved Plans"). The permittee must construct, install and operate the wireless facility in substantial compliance with the Approved Plans as determined by the Director or the Director's designee. Any substantial or material alterations, modifications or other changes to the Approved Plans, whether requested by the permittee or required by other departments or public agencies with jurisdiction over the wireless facility, must be submitted in a written

request subject to the Director's prior review and approval, who may refer the request to the original approval authority if the Director finds that the requested alteration, modification or other change substantially deviates from the Approved Plans or implicates a significant or substantial land-use concern.

38. The permittee shall install and at all times maintain in good condition a "Network Operations Center Information" and "RF Caution" sign on the utility pole no less than three (3) feet below the antenna (measured from the top of the sign) and no less than nine (9) feet above the ground line (measured from the bottom of the sign). Signs required under this condition shall be installed so that a person can clearly see the sign as he or she approaches within three (3) feet of the antenna structure. If any person on or within the property is or may be exposed to emissions that exceed applicable FCC uncontrolled/general population limits at any time the sign shall expressly so state, and provide instructions on how persons can avoid any such exposure. The sign shall also include the name(s) of the facility owner(s), equipment owner(s) and operator(s)/carrier(s) of the antenna(s), property owner name, as well as emergency phone number(s) for all such parties. The sign shall not be lighted, unless applicable law, rule or regulation requires lighting. No signs or advertising devices other than required certification, warning, required seals or signage, other signage required by law, this Chapter, any City or applicable state code or the Los Angeles County Fire Department Chief or his or her designee shall be permitted. The sign shall be no larger than two (2) square feet.

39. The permittee shall ensure that all signage complies with FCC Office of Engineering and Technology Bulletin 65, CPUC General Order 95 or American National Standards Institute C95.2 for color, symbol, and content conventions. All such signage shall at all times provide a working local or toll-free telephone number to its network operations center, and such telephone number shall be able to reach a live person who can exert transmitter power-down control over this site as required by the FCC.

40. In the event that the FCC changes any of radio frequency signage requirements that are applicable to the project site approved herein or ANSI Z535.1, ANSI Z535.2, and ANSI C95.2 standards that are applicable to the project site approved herein are changed, the permittee, within 30 days of each such change, at its own cost and expense, shall replace the signage at the project site to comply with the current standards.

41. The permittee shall maintain the paint, color and finish of the facility in good condition at all times.

42. All improvements, including foundations, and appurtenant ground wires, shall be removed from the property and the site restored to its original pre-installation conditions within 90 days of cessation of operation or abandonment of the facility.

43. Build-Out Conditions.

    a. Permittee shall not commence any excavation, construction, installation or other work on the project site until and unless it demonstrates to the City Public Works Department that the project complies with these Conditions along with all applicable laws, regulations, codes and other rules related to public health and safety, including without limitation all applicable provisions in California Public Utilities Commission General Order 95 and MMC Chapters 8.12, 8.24 and 15.08.

    b. To the extent that a pole owner or any provision in the MMC or this resolution require greater or more restrictive standards than California Public Utilities Commission General Order 95, if applicable, those standards shall control.

44. Permittee shall at all times maintain compliance with all applicable federal, State and local laws, regulations, ordinances and other rules, including Americans with Disabilities Act (ADA) requirements.

45. The permittee shall cooperate with all inspections. The City and its designees reserve the right to support, repair, disable or remove any elements of the facility in emergencies or when the facility threatens imminent harm to persons or property.

46. Permittee shall at all times maintain accurate contact information for all parties responsible for the facility, which shall include a phone number, street mailing address and email address for at least one natural person. All such contact information for responsible parties shall be provided to the Planning Department at the time of permit issuance and within one business day of permittee's receipt of City staff's written request.

47. Permittee shall undertake all reasonable efforts to avoid undue adverse impacts to adjacent properties and/or uses that may arise

from the construction, operation, maintenance, modification and removal of the facility.

48. The site and the facility must be maintained in a neat and clean manner and in accordance with all approved plans and conditions of approval.

49. Permittee shall promptly remove any graffiti on the wireless facility at permittee's sole expense within 48 hours after notice.

Prior to Operation

50. The applicant shall request a final Planning Department inspection and final building inspection by the City of Malibu Environmental Sustainability Department immediately after the wireless facility has been installed and prior to the commencement of services.

51. Within thirty (30) calendar days following the installation of any wireless communications facilities, the applicant shall provide to the Planning Department with a field report prepared by a qualified engineer verifying that the unit has been inspected, tested, and is operating in compliance with FCC standards. Specifically, the on-site post-installation radiofrequency (RF) emissions testing must demonstrate actual compliance with the FCC OET Bulletin 65 RF emissions safety guidelines for general population/uncontrolled RF exposure in all sectors. For this testing, the transmitter shall be operating at maximum operating power, and the testing shall occur outwards to a distance where the RF emissions no longer exceed the uncontrolled/general population limit. Such report and documentation shall include the make and model (or other identifying information) of the unit tested, the date and time of the inspection, a certification that the unit is properly installed and working within applicable FCC limits, and a specific notation of the distance from the transmitter at which the emissions are equal to or less than the uncontrolled/general population limit.

52. The operation of the approved facility shall commence no later than one (1) month after the City completes its post-installation inspections of the facility, any issues with the facility are resolved, and the City receives the RF testing report required in the condition of approval above, or the development or conditional use permit will expire without further action by the City.

Fixed Conditions

53. Violation of any of the conditions of this approval shall be cause for revocation and termination of all rights thereunder.

Eligible Facilities Requests

All permits for an eligible facilities requests under MMC Chapter 17.46 shall be subject to the following conditions and all of the other conditions of approval placed on a Wireless Permit, unless modified by the approving authority:

54. Any permit granted in response to an application qualifying as an eligible facilities request shall be subject to the terms and conditions of the underlying permit.

55. The City's grant or grant by operation of law of an eligible facilities request permit constitutes a federally-mandated modification to the underlying permit or approval for the subject tower or base station. Notwithstanding any permit duration established in another permit condition, the City's grant or grant by operation of law of a eligible facilities request permit will not extend the permit term for the underlying permit or any other underlying regulatory approval, and its term shall be coterminous with the underlying permit or other regulatory approval for the subject tower or base station.

56. The City's grant or grant by operation of law of an eligible facilities request does not waive, and shall not be construed to waive, any standing by the City to challenge Section 6409(a) of the Spectrum Act, any FCC rules that interpret Section 6409(a) of the Spectrum Act, or any modification to Section 6409(a) of the Spectrum Act.

Small Cell Facilities

In addition to the other conditions of approval placed on a Wireless Permit, all permits for a small cell facility under MMC Chapter 17.46 shall be subject to the following additional condition, unless modified by the approving authority:

57. The City's grant of a permit for a small cell facility request does not waive, and shall not be construed to waive, any standing by the city to challenge any FCC orders or rules related to small cell facilities, or any modification to those FCC orders or rules.

SECTION 9. Basic Application Requirements for Permits Under MMC Chapter 17.46.

A. Generally. In addition to providing all required fees, all wireless telecommunication facility carriers or providers shall provide the information required by a separate application form published, and updated from time to time, by the City. If no such form is available, then the applicant must submit all documents, information, and any other materials necessary to allow the City to make required findings and ensure that the proposed facility will comply with applicable laws and not endanger the public health, safety, or welfare. Such information may include:

1. Contact information for:
   a. Applicant and their representatives
   b. Owner of proposed wireless communications facility
   c. If different from facility owner, the identity of the person or entity responsible for operating the proposed wireless facility
   d. The property owner or owner of the structure on which the proposed wireless facility would be installed
   e. Names, addresses, telephone numbers, and email addresses of anyone acting on behalf of the applicant with regard to the application;
   f. The name, address and phone number of all persons that prepared or assisted in preparing the application and any required reports;
   g. The postal address, parcel number, or utility pole identifier of the property;
   h. The location of the schools, playgrounds and parks within 500 feet of the project site;
   i. Local contact person for emergencies
   j. Assessor's Parcel Number
2. Purpose of new wireless communications facility or amendment
3. Type of Application (Select all that apply)
   a. Eligible Facilities Request
   b. Small Cell – Collocation
   c. Small Cell – New Structure
   d. Collocation (Non-Small Cell)
   e. All Other Wireless Communications Facilities
   f. Permit Renewal
   g. Waiver
4. Letter of authorization signed by the property owner authorizing the applicant to submit and process the application, including executed copies of any leases, letters of agency, or proof of ownership, of private property involved in the project.
5. Authorizations, and Licenses
6. Provide previous approvals, if applicable, and Certificate of Completion. Site inspection fees may apply if a final inspection was never requested
7. Identify all other required permits and approvals for the subject facility.

8. Electrical and Structural Safety Information. The following engineering documents prepared under the responsible charge of and sealed by a California licensed Professional Engineer must be included in the application:
   a. A short circuit and coordination study ("SCCS") calculated pursuant to the IEEE 551-2006: Recommended Practice for Calculating AC Short-Circuit Currents in Industrial and Commercial Power Systems or the latest version of that standard. The study must demonstrate the protection devices will ensure the equipment enclosure will not be breached. The SCCS must include analysis of Voltage Transient Surges due to contact of conductors of different voltages;
   b. A one-line diagram of the electrical system;
   c. Voltage Drop & Load Flow Study;
   d. Load Calculation;
   e. Panel Directories;
   f. A plot plan showing the location of the mounting structure including address, or structure designation, or GPS location on the front sheet;
   g. A plot plan showing the location of the service disconnecting means; and
   h. An elevation drawing of the equipment and the service disconnecting means.
9. Structural Safety Information. The structural/civil engineering documents prepared under the responsible charge of and sealed by a California licensed professional civil engineer.
   a. Photo simulations, from at least three different angles, showing the pole and streetscape before and after installation. In some cases, more than three different angles may be required;
   b. The azimuth, size and center-line height location of all proposed and existing antenna(s) on the supporting structure;
   c. The number, type and model of the antenna(s) that will be used with a copy of the specification sheet;
   d. The make, model, type and manufacturer of any tower involved and a design plan stating the tower's capacity to accommodate multiple users;
   e. Site and Construction Plans. Complete and accurate plans, drawn to scale, signed, and sealed by a California-licensed engineer, land surveyor, and/or architect, which include the following items.
      (1) A site plan and elevation drawings for the facility as existing and as proposed with all height and width measurements explicitly stated.

(2) A site plan describing the proposed tower and antenna(s) and all related fixtures, structures, appurtenances and apparatus, including height above pre-existing grade, materials, color and lighting;
(3) A depiction, with height and width measurements explicitly stated, of all existing and proposed transmission equipment.
(4) A depiction of all existing and proposed utility runs and points of contact.
(5) A depiction of the leased or licensed area of the site with all rights-of-way and easements for access and utilities labeled in plan view.

f. Detailed map with locations of the poles or other property on which equipment is to be located, including specific pole identification number, if applicable, and the areas it will service;

g. Description as to why the desired location is superior to other similar locations, from a community perspective, including, but not limited to:
(1) Proximity to residential buildings and descriptions of efforts to prevent any blocking of views of impressive scenes; and
(2) Written documentation demonstrating a good faith effort to locate the proposed facility in the least intrusive location in accordance with the location requirements of this Resolution.

h. A description in writing and a visual rendering demonstrating effective screening of all ground-mounted or roof-mounted equipment of the facility from view.

i. Color-coded carrier-generated RF Coverage (propagation) maps, at a scale no smaller than 1 inch (1") to a quarter (1/4) mile with all appropriate legends, showing the coverage for the highest and lowest frequencies to be used by the facility. Frequencies are to be stated numerically, not qualitatively. Provide a represented value in dB of each colors it specifically represents.

j. If the project involves, modifies or will use an existing facility or structure, a description of the type of structure (e.g., guyed, self-supporting lattice or monopole), and a report on the physical condition of the facility certified by a professional engineer licensed in the state of California.

k. If the application is for a new tower, clear and convincing technical evidence by a carrier or wireless service provider justifying the total height of the proposed facility and the need for such to the exclusion of all reasonable alternatives.

Evidence in the form of propagation studies must include all modeling data and assumptions used to produce the studies at the requested height and should take into consideration the ability to collocate other carriers in the future.

l. A siting analysis which identifies other feasible locations within or outside the City which could serve the area intended to be served by the facility, unless the applicant provides compelling technical reasons for providing fewer than the minimum.

m. An affirmation, under penalty of perjury, that the proposed installation will be FCC compliant, in that it will not cause members of the general public to be exposed to RF levels that exceed the emissions levels deemed safe by the FCC. A copy of the fully completed FCC form "A Local Government Official's Guide to Transmitting Antenna RF Emission Safety: Rules, Procedures, and Practical Guidance: Appendix A" titled "Optional Checklist for Determination of Whether a Facility is Categorically Excluded" for each frequency band of RF emissions to be transmitted from the proposed facility upon the approval of the application. All planned radio frequency emissions on all frequency bands must be shown on the Appendix A form(s) attached to the application. All planned radio frequency emissions are to be entered on each Appendix A form only in wattage units of "effective radiated power."

n. A statement detailing the frequency, modulation and class of service of radio or other transmitting equipment;

o. A copy of the FCC license applicable for the intended use of the proposed facilities;

p. A HazMat Business Plan for all new generators, and any storage and/or use of hazardous materials during the project, to include:

   i. A list of toxic substances that may develop during arcing or fire that may impede fire suppression efforts;

   ii. A list of hazards that may develop during arcing or fire that may impede fire suppression efforts;

q. A demolition plan, if applicable.

r. A written statement of the applicant's willingness to allow other carriers to co-locate on the proposed personal wireless service facility where technically and economically feasible and aesthetically desirable, subject to the qualification that colocation should not occur when public exposures from the resulting higher cumulative sources would exceed FCC limits.

s. Such other information as the Director shall establish.

t. A statement signed by a person with legal authority to bind the applicant attesting under penalty of perjury to the accuracy of the information provided in the application. If attester not an authorized employee of the applicant, then the attester must demonstrate that it is an authorized agent of the applicant, with lawful Power of Attorney from the applicant.

SECTION 10. Environmental Review

This Resolution is not a project within the meaning of Section 15378 of the State of California Environmental Quality Act (CEQA) Guidelines, because it has no potential for resulting in physical change in the environment, directly or indirectly. The Resolution does not authorize any specific development or installation on any specific piece of property within the City's boundaries. Moreover, when and if an application for installation is submitted, the City will at that time conduct preliminary review of the application in accordance with CEQA. Alternatively, even if the Resolution is a "project" within the meaning of State CEQA Guidelines section 15378, the Resolution is exempt from CEQA on multiple grounds. First, the Resolution is exempt CEQA because the City Council's adoption of the Resolution is covered by the general rule that CEQA applies only to projects which have the potential for causing a significant effect on the environment. (State CEQA Guidelines, § 15061(b)(3)). That is, approval of the Resolution will not result in the actual installation of any facilities in the City. In order to install a facility in accordance with this Resolution, the wireless provider would have to submit an application for installation of the wireless facility. At that time, the City will have specific and definite information regarding the facility to review in accordance with CEQA. And, in fact, the City will conduct preliminary review under CEQA at that time. Moreover, in the event that the Resolution is interpreted so as to permit installation of wireless communications facilities on a particular site, the installation would be exempt from CEQA review in accordance with either State CEQA Guidelines section 15302 (replacement or reconstruction), State CEQA Guidelines section 15303 (new construction or conversion of small structures), and/or State CEQA Guidelines section 15304 (minor alterations to land).

SECTION 11. This Resolution will become effective immediately upon adoption.

SECTION 12. The City Clerk shall certify to the passage and adoption of this resolution and enter it into the book of original resolutions.

PASSED, APPROVED, and ADOPTED this 12th day of April 2021.

MIKKE PIERSON, Mayor

ATTEST:

KELSEY PETTIJOHN, Acting City Clerk
(seal)

APPROVED AS TO FORM:

JOHN COTTI, Interim City Attorney

I CERTIFY THAT THE FOREGOING RESOLUTION NO. 21-17 was passed and adopted by the City Council of the City of Malibu at the Regular meeting thereof held on the 12th day of April 2021 by the following vote:

AYES:	5	Councilmembers:	Farrer, Silverstein, Uhring, Grisanti, Pierson
NOES:	0		
ABSTAIN:	0		
ABSENT:	0		

KELSEY PETTIJOHN, Acting City Clerk
(seal)

From:	ExecutiveOffice
To:	PublicComments
Subject:	FW: Oppose Agenda Item 59: Titles 16 & 22 – United Keetoowah Band of Cherokee Indians in Oklahoma
Date:	Tuesday, January 10, 2023 7:20:51 AM
Attachments:	Comment by UKB - LA - FCC.pdf

The following correspondence is being forwarded to you for your review/information.

From: Susan Foster <susan.foster@dotlaw.biz>
Sent: Monday, January 9, 2023 5:27 PM
To: Supervisor Janice Hahn (Fourth District) <fourthdistrict@bos.lacounty.gov>; Holly J. Mitchell <HollyJMitchell@bos.lacounty.gov>; First District <firstdistrict@bos.lacounty.gov>; Barger, Kathryn <Kathryn@bos.lacounty.gov>; Third District <ThirdDistrict@bos.lacounty.gov>; ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Cc: AG Klint Cowan <kcowan@fellerssnider.com>; W. Scott McCollough <wsmc@dotlaw.biz>
Subject: Oppose Agenda Item 59: Titles 16 & 22 – United Keetoowah Band of Cherokee Indians in Oklahoma

CAUTION: External Email. Proceed Responsibly.

Supervisor Janice Hahn – FourthDistrict@bos.lacounty.gov
Supervisor Holly J. Mitchell – HollyJMitchell@bos.lacounty.gov
Supervisor Hilda Solis – firstdistrict@bos.lacounty.gov
Supervisor Kathryn Barger – Kathryn@bos.lacounty.gov
Supervisor Lindsey Horvath – Lindsey@bos.lacounty.gov
Los Angeles County Board of Supervisors – executiveoffice@bos.lacounty.gov

Oppose Agenda Item 59: Titles 16 & 22

Dear Hon. Sup. Hahn and Members of the Board:

Attached please find him a letter to the Los Angeles County Board of Supervisors from Klint A. Cowan, Attorney General, United Keetoowah Band of Cherokee Indians in Oklahoma.

Thank you.

From:	lilrascal510@aol.com
To:	PublicComments; Barger, Kathryn; Supervisor Janice Hahn (Fourth District); Holly J. Mitchell; First District; Third District
Subject:	Project No. PRJ2021-000295/ CUP No. RPPL2021000766, Hearing 1/31/23
Date:	Tuesday, January 10, 2023 1:18:40 PM

To: Los Angeles County Board of Supervisors

I am a resident of the Stevenson Ranch community. I am writing to oppose the AT&T cell tower. If approved, the cell tower will be 75-95 feet in height, violating the recently adopted Los Angeles County Wireless Facilities Ordinance, which restricts cell tower height to 35-feet in residential-zoned areas, such as Stevenson Ranch.

The cell tower would be in the center of our community, hundreds of feet from homes and in their line of sight, adjacent to Richard Rioux Park, and about 1/8 of a mile from the elementary school and a daycare.

The cell tower will impede my enjoyment of the community and be an eyesore. When I moved to Stevenson Ranch, it was important to me that the community was zoned residential. I enjoy the views from my home. I enjoy the view from the park and the feel of the community when I go for a walk. A 75-foot commercial tower will be far taller than any other structure in the community. The commercial structure enclosing the tower will be ugly and the generator noisy. Decorating the cell tower to look like a giant pine tree will not solve this problem, it will be ugly and highly visible.

Coverage in Stevenson Ranch is not accurately reflected on AT&T's coverage maps. The maps identify the majority of the community as having no vehicle or indoor coverage, which simply is not true. Additionally, to the extent there are gaps, the tower is not necessary. This was admitted by AT&T. AT&T representatives testified at prior hearings and spoke at an HOA meeting. AT&T told the community that it is proceeding with the tower because it is the cheapest option for AT&T to enhance coverage. AT&T has said a plan utilizing other locations and microsites would fill the perceived data gaps, but AT&T is not interested in collaborating with the community to identify an acceptable solution, simply because it does not want to spend the money or take the time.

Shockingly, at the hearing before the Planning Commission, staff for the Planning Commission testified that it takes AT&T's representations regarding gaps and its alternatives analysis (which failed to identify a single alternative as having been considered) "at face value." Staff claimed it could not substantively review the materials because it does not have telecommunications engineers on staff. This is unacceptable. If the County does not have staff capable of performing reviews, it should hire consultants, not simply perform ministerial reviews.

I am concerned about the potential health effects of the macro tower. I have been told the County of Los Angeles cannot consider health effects in its ruling, but I believe AT&T should not be permitted to jeopardize the health and safety of our families.

Finally, I am concerned about the negative effect the cell tower will have on my property value. Local realtors who have worked in Santa Clarita and Stevenson Ranch have submitted materials to the Planning Commission stating property values will decrease up to 10-20 percent and may not sell at all during a down market. Homes in the line of sight of the cell tower will suffer the most – and there are many homes that will be in the line of sight given the chosen location.

Please protect our homes and community and deny the requested conditional use permit. AT&T should evaluate alternatives and work with the community to find an acceptable solution.

Thank you for you attention.

Patricia Krieger
lilrascal510@aol.com
8185850861

From:	ExecutiveOffice
To:	PublicComments
Subject:	FW: Please enter into public record for changes to Titles 16 and 22
Date:	Wednesday, January 11, 2023 2:38:21 PM

The following correspondence is being forwarded to you for your review/information.

From: Phil Wellman <phil@wellmanad.com>
Sent: Wednesday, January 11, 2023 1:37 PM
To: mwchrislock@redshift.com; First District <firstdistrict@bos.lacounty.gov>; Holly J. Mitchell <HollyJMitchell@bos.lacounty.gov>; Third District <ThirdDistrict@bos.lacounty.gov>; Supervisor Janice Hahn (Fourth District) <fourthdistrict@bos.lacounty.gov>; Barger, Kathryn <Kathryn@bos.lacounty.gov>; ExecutiveOffice <ExecutiveOffice@bos.lacounty.gov>
Subject: Please enter into public record for changes to Titles 16 and 22

Dear Supervisor,

Please do not expose my children and grandchildren to 5G technology. It has not been proven safe.

“The changes to titles 16 and 22 of the LA County code would strip us of our right to due process, annihilate our health in record time and open the county to massive losses in lawsuits due to the FCCs recent loss in a lawsuit on the issue of wireless radiation, health and environmental effects and children.”

Here is a link to a CBS news report of multiple children getting cancer from a cell tower placed on their school property, according to the parents interviewed.
https://www.cbsnews.com/news/cell-tower-shut-down-some-california-parents-link-to-several-cases-of-childhood-cancer/

And here is a link to the lawsuit the FCC just lost on this matter, which includes the complaint, 11,000 pages of evidence, 4 amicus briefs and the final ruling.
https://thepeoplesinitiative.org/lawsuits/fcc-lawsuit-2020-rf-standards/

PLEASE VOTE NO ON CHANGES TO TITLES 16 AND 22.

Thank you,

Phil Wellman