

To: Sofia Chang
Chief Executive Officer
The Girl Scouts of USA
420 Fifth Avenue
New York, NY 10018 USA
CC: Girl Scouts Public Policy and Advocacy Office

December 3, 2022

Suspend The Girl Scout 5G IOT Patch and Replace With “Safer Technology” Patch

Dear Ms. Sofia Chang,

We applaud and support the Girl Scouts in their efforts to support STEM education for girls. However, it is also critically important that Scouts are educated about how to minimize health risks of technology, and are provided with science based information.

Please immediately suspend Girl Scouts of America’s [5G and IOT Ericsson patch](#) because it disseminates scientifically inaccurate information and promotes a false and dangerous message. The activities for this badge are based entirely on materials developed by Ericsson (the Swedish multinational telecommunications firm), and they misleadingly state that 5G networks and phones are safe. In fact, [scientific evidence](#) clearly indicates that 5G and wireless networks are not safe.

5G will include low and mid band wireless frequencies that research links to [memory damage](#), [headaches](#), [oxidative stress](#) and impacts [to the brain](#), [endocrine system](#) and [reproduction](#) as well as [brain](#), [thyroid](#) and [breast cancer](#).

As experts in the health impacts of digital communications technology, and as several of us are former Girl Scouts and parents of Scouts, we ask that an independent expert group be convened to develop a *safer technology* patch that reflects the up to date scientific evidence and medical recommendations.

Most parents are aware that excessive use of screens is contributing to depression, inactivity, bullying and many other mental health issues in children. However, most are unaware that wireless devices emit invisible microwave radiofrequency (RF) radiation, an exposure which presents serious health risks according to [numerous scientists](#).

In addition, buried in the manual of cell phones are [manufacturer instructions](#) to keep the phone 5mm or further from the body.¹ [Research](#) shows that if the phones are in body contact, the radiation exposure can exceed government limits. That information, and so much more, is what Girl Scouts need to know.

The American Academy of Pediatrics states that children are “uniquely vulnerable” to RF radiation and has repeatedly [called](#) for an update to U.S. regulations because research finds children absorb up to 10 times [more](#) RF radiation into their brain, eyes and bone marrow. Most importantly, as the brains of children and teens are still developing, they remain far more sensitive to harmful effects.

One [activity](#) for the 5G Badge has the Scout explaining to an adult “how millimeter wave spectrum is safe and does not cause harm to our health.” This is simply not factual. No U.S. health agency has ever made such a safety determination for these frequencies, nor has any agency reviewed the totality of the science to develop health based safety standards for millimeter waves or wireless radiation. Most of the [5G patch activities](#) link to Ericsson content and [Facebook](#) and [Youtube videos](#) and [other advertisements](#).

The European Parliament’s research report [“Health Impact of 5G”](#) concluded that commonly used wireless frequencies (450 to 6000 MHz) are probably carcinogenic for humans and affect male fertility with possible adverse effects on the development of embryos, fetuses and newborns. No determination was made on 5G’s higher millimeter wave frequencies because there was an absence of adequate safety data regarding long term effects.

¹ On the iPhone go to “Settings” and then “General” and then “Legal & Regulatory” and then “RF Exposure”. See [fine-print-warnings](#) for more.

Current U.S. laws on allowable human exposures to wireless RF remain unchanged since 1996. In fact, the U.S. FCC's cell phone RF limits [are based](#) on a 220 pound man, not a young girl, and they do not consider long-term effects from years of exposure that will affect our girls.

Until U.S. regulations catch up with the science, the Girl Scouts can take a leadership role in supporting girls' health and safety.

We recommend that the Girl Scouts develop a "Safer Technology" patch that includes ways to be tech savvy in the twenty-first century. Similar to the Girl Scout' Screen Smart patch that educates girls about the overuse of screens, the new patch could teach girls how to minimize wireless radiation exposures, and how to choose, use, and design safer, non-wireless technologies for a healthy future. Activities could include addressing the environmental (impacts to [pollinators](#), [wildlife](#), [trees](#)) and life cycle impacts ([e-waste](#), [energy consumption](#), [human rights issues](#)) of unfettered 5G deployment.

Instead of relying on a corporation to provide safety materials on the radiation emissions of their own products, we recommend the Girl Scouts employ health information developed by independent medical and public health experts, for example:

American Academy of Pediatrics (AAP):

"Avoid carrying your phone against the body like in a pocket, sock, or bra. Cell phone manufacturers can't guarantee that the amount of radiation you're absorbing will be at a safe level."

"If you plan to watch a movie on your device, download it first, then switch to airplane mode while you watch in order to avoid unnecessary radiation exposure."

California Department of Public Health (CDPH)

"Don't sleep with your phone in your bed or near your head." [CDPH Advisory](#)

Massachusetts Breast Cancer Coalition (MBCC)

Cancer prevention education for students [MBCC Let's Talk Prevention Classroom Module3 on Cell Phones](#).

Environmental Health Trust (EHT)

As an independent think tank of expert scientists, engineers and physicians, EHT has also developed numerous resources to [reduce cell phone radiation](#). Parents and Girl Scouts leaders can learn how to reduce household wireless radiation at our Healthy Tech Home Project [healthytechhome.org](#).

We offer our expertise to support the development of a Safe Tech Patch and thank you so much for considering this important children's health issue.

Sincerely,

Devra Davis, PhD, MPH
President and Founder [Environmental Health Trust](#)
Fellow, American College of Epidemiology and Collegium Ramazzini

Frank Clegg
CEO Canadians For Safe Technology
Former President Microsoft Canada
[www.C4ST.org](#) [Reduce Exposure](#)

David O. Carpenter, M.D.
Director, Institute for Health and the Environment
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Linda S. Birnbaum, PhD
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Theodora Scarato MSW
Executive Director Environmental Health Trust
[ehtrust.org](#) and [healthytechhome.org](#)

Dr. Hugh Taylor MD,
Chair of Obstetrics, Gynecology and Reproductive Sciences, Yale School
of Medicine and Yale-New Haven Hospital

Lennart Hardell, MD, PhD, Professor
Department of Oncology, Faculty of Medicine and
Health, Örebro University, Sweden (retired)
[The Environment and Cancer
Research Foundation](#)

Joseph M. Sandri
CEO Thought Delivery Systems
President National Spectrum Management Association
COO The Balance Group

Anthony B. Miller, MD
Professor Emeritus, Dalla Lana School of Public Health, Univ. of
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on Cancer, formerly Director of the Epidemiology Unit of the National
Cancer Institute of Canada, Chair of the Department of Preventive
Medicine & Biostatistics at Univ. of Toronto

Hillel Z Baldwin, MD
Neuroscience Solutions, LLC

ATTACHMENTS

American Academy of Physicians ([2012, 2013](#)) [Letters to the FCC regarding the Need to Update Wireless Radiation Laws](#)

California Department of Health [Recommendations on Cell Phone Radiation \(2017\)](#)

New Jersey Educational Association: [Minimize health risks from electronic devices \(2017\)](#)

Environmental Working Group: [Protecting kids from wireless radiation in school and at home](#)

RESOURCES

- Alliance of Nurses for Healthy Environments [Textbook of Environmental Health in Nursing 2nd Edition Includes Cell Phone, Cell Tower and Wi-Fi Radiation and Electromagnetic Fields.](#)

Santa Clara Medical Association Magazine Articles

- ["Wireless Silent Spring"](#)
- ["A 5G Wireless Future: Will it give us a Smart Future"](#)
- ["Wi-Fi in Schools Are We Playing It Safe With Our Kids?" PDF](#)
- ["Shallow Minds: How the Internet and Wi-F in Schools Can Affect Learning"](#)

Girl Scouts 5G IOT Patch Resources

- [Girl Scouts of North East Texas and Ericsson Limited Edition 5G & IoT Patch](#)
- [Girl Scouts New Jersey 5G Patch \(Patch on Pull Down Menu\)](#)
- Girl Scout 5G Patch Resources for Middles School includes [Explaining 5G to kids |By Ericsson Careers | Facebook](#)
- [A Girl Scouts patch for 5G - IoT? Sign us up! 🙋 Our partnership with the Girl Scouts of Northeast Texas continues to bring excitement. As part of... | By Ericsson | Facebook](#)

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[ADDITIONAL SCIENTIFIC RESEARCH HERE](#)

How to Reduce Exposure to Radiofrequency Energy from Cell Phones



The use of cell phones has increased dramatically in recent years, including among children and young adults. These phones put out radio frequency (RF) energy.

Some scientists and public health officials believe RF energy may affect human health. This guidance document describes RF energy, lists some of the potential health concerns, and provides guidance on how people can reduce their exposure.

Why are people concerned about exposure to RF energy from cell phones?

Although the science is still evolving, some laboratory experiments and human health studies have suggested the possibility that long-term, high use of cell phones may be linked to certain types of cancer and other health effects, including:

- brain cancer and tumors of the acoustic nerve (needed for hearing and maintaining balance) and salivary glands
- lowers sperm counts and inactive or less mobile sperm
- headaches and effects on learning and memory, hearing, behavior, and sleep

These studies do not establish the link definitely, however, and scientists disagree about whether cell phones cause these health problems and how great the risks might be. This document is intended to provide guidance for those people who want to reduce their own and their families' exposures to RF energy from cell phones, despite this uncertainty.

What is RF energy?

Cell phones work by sending and receiving signals to and from cell phone towers. These signals are a form of electromagnetic radiation called radiofrequency (RF) energy. Other sources of RF energy include cell phone towers, TV and radio transmitters, smart meters, and microwave ovens. When a phone sends signals to a tower, the RF energy goes from the phone's antenna out in all directions, including into the head and body of the person using the phone. Cell phones also emit RF energy when using Wi-Fi and/or Bluetooth, but at lower levels.

RF energy is not as powerful or as damaging to cells or DNA as some other kinds of electromagnetic radiation, such as X-rays or UV rays from the sun. Some scientific studies have, however, suggested that there may be increased health risks from exposure to RF energy.

How can you reduce your exposure?

Keep your phone away from your body. Keeping your phone just a few feet away from you can make a big difference.

- ***When you talk on your cell phone, avoid holding it to your head—use the speakerphone or a headset instead.*** Wireless (Bluetooth) and wired headsets emit much less RF energy than cell phones.
- ***Send text messages instead of talking on the phone.***
- ***If you are streaming or if you are downloading or sending large files, try to keep the phone away from your head and body.***
- ***Carry your cell phone in a backpack, briefcase, or purse; NOT in a pocket, bra or belt holster.*** Because your phone's antenna tries to stay connected with a cell tower whenever it's on, it emits some RF energy even when you are not using it. It does not emit RF energy when it's in airplane mode. (Airplane mode turns off cellular, Wi-Fi, and Bluetooth.)

Reduce or avoid using your cell phone when it is sending out high levels of RF energy. This happens mainly when:

- ***You see only one or two bars displayed.*** Cell phones put out more RF energy to connect with cell towers when the signal is weak. If you must use your phone when the signal is weak, try to follow the other guidance on this page.
- ***You are in a fast-moving car, bus, or train.*** Your phone puts out more RF energy to maintain connections to avoid dropping calls as it switches connections from one cell tower to the next unless it is in airplane mode.
- ***You are streaming audio or video, or downloading or sending large files.*** To watch movies or listen to playlists on your phone, download them first, then switch to airplane mode while you watch or listen.

Don't sleep with your phone in your bed or near your head. Unless the phone is off or in airplane mode, keep it at least a few feet away from your bed.

Take off the headset when you're not on a call. Headsets release small amounts of RF energy even when you are not using your phone.



What about children?

Children may be more at risk for harm from exposure to RF energy because:

- RF energy can reach a larger area of a child's brain than an adult's brain.
- A child's brain and body grow and develop through the teen years. During this time, the body may be more easily affected by RF energy and the effect may be more harmful and longer lasting.
- A child who uses a cell phone will have many more years of exposure to RF energy in his or her lifetime than someone who started using a cell phone as an adult.

There is not a lot of research about the effects of cell phone RF energy on children or teenagers, but a few studies have shown that there may be hearing loss or ringing in the ears, headaches, and decreased general well-being.



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August 29, 2013

The Honorable Mignon L. Clyburn
Acting Commissioner
Federal Communications Commission
445 12th Street SW
Washington, DC 20054

The Honorable Dr. Margaret A. Hamburg
Commissioner
U.S. Food and Drug Administration
10903 New Hampshire Avenue
Silver Spring, MD 20993

Dear Acting Chairwoman Clyburn and Commissioner Hamburg:

The American Academy of Pediatrics (AAP), a non-profit professional organization of 60,000 primary care pediatricians, pediatric medical subspecialists, and pediatric surgical specialists dedicated to the health, safety and well-being of infants, children, adolescents, and young adults appreciates this opportunity to comment on the Proposed Rule “Reassessment of Exposure to Radiofrequency Electromagnetic Fields Limits and Policies” published in the Federal Register on June 4, 2013.

In the past few years, a number of American and international health and scientific bodies have contributed to the debate over cell phone radiation and its possible link to cancer. The International Agency for Research on Cancer (IARC), part of the United Nations’ World Health Organization, said in June 2011 that a family of frequencies that includes mobile-phone emissions is “possibly carcinogenic to humans.” The National Cancer Institute has stated that although studies have not demonstrated that RF energy from cell phones definitively causes cancer, more research is needed because cell phone technology and cell phone use are changing rapidly. These studies and others clearly demonstrate the need for further research into this area and highlight the importance of reassessing current policy to determine if it is adequately protective of human health.

As radiation standards are reassessed, the AAP urges the FCC to adopt radiation standards that:

- **Protect children’s health and well-being.** 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

Despite these dramatic changes in mobile phone technology and behavior, the FCC has not revisited the standard for cell phone radiation exposure since 1996. The current FCC standard for maximum radiation exposure levels is based on the heat emitted by mobile phones. These guidelines specify exposure limits for hand-held wireless devices in terms of the Specific Absorption Rate (SAR), which measures the rate the body absorbs radiofrequency (RF). The current allowable SAR limit is 1.6 watts per kilogram (W/kg), as averaged over one gram of tissue. Although wireless devices sold in the United States must ensure that they do not exceed the maximum allowable SAR limit when operating at the device's highest possible power level, concerns have been raised that long-term RF energy exposure at this level affects the brain and other tissues and may be connected to types of brain cancer, including glioma and meningioma.

In May 2011, the International Agency for Research on Cancer (IARC), the United Nations' World Health Organization's (WHO) agency promoting international cancer research collaboration, classified RF energy as "possibly carcinogenic to humans." In addition, the National Cancer Institute has stated that although studies have not definitively linked RF energy exposure from cell phones to cancer, more research is required to address rapidly changing cell phone technology and use patterns.

This and other research identified by the GAO demonstrates the need for further research on this issue, and makes clear that exposure standards should be reexamined.

The GAO concluded that the current exposure limits may not reflect the latest research on RF energy, and that current mobile phone testing requirements may not identify maximum RF energy exposure. The GAO proposed that the FCC formally reassess its limit and testing requirements to determine whether they are effective. The AAP commends the activities proposed under H.R. 6358, as they would address this research gap and improve consumer knowledge and safety. Establishing an expanded federal research program as the basis for exposure standards will ensure that consumer protections incorporate the latest research. Currently, the National Institute of Health (NIH), the only federal agency the GAO identified as directly funding research on this topic, provided approximately \$35 million from 2001 to 2011. Given this previous funding level, the AAP supports the \$50 million per fiscal year for seven years that H.R. 6358 would authorize.

The AAP appreciates your recognition of the need for new research and standards for mobile phone radiation, and is pleased to support H.R. 6358. For further assistance, please do not hesitate to contact Sonya Clay, Assistant Director, Department of Federal Affairs, at 202-347-8600 or sclay@aap.org.

Sincerely,

A handwritten signature in cursive script that reads "Thomas K. McInerny".

Thomas K. McInerny, MD, FAAP
President

protecting the youngest and most vulnerable populations to ensure they are safeguarded throughout their lifetimes.

- **Reflect current use patterns.** The FCC has not assessed the standard for cell phone radiation since 1996. Approximately 44 million people had mobile phones when the standard was set; today, there are more than 300 million mobile phones in use in the United States. While the prevalence of wireless phones and other devices has skyrocketed, the behaviors around cell phone uses have changed as well. The number of mobile phone calls per day, the length of each call, and the amount of time people use mobile phones has increased, while cell phone and wireless technology has undergone substantial changes. Many children, adolescents and young adults, now use cell phones as their only phone line and they begin using wireless phones at much younger ages. Pregnant women may carry their phones for many hours per day in a pocket that keeps the phone close to their uterus. Children born today will experience a longer period of exposure to radio-frequency fields from cellular phone use than will adults, because they start using cellular phones at earlier ages and will have longer lifetime exposures. FCC regulations should reflect how people are using their phones today.
- **Provide meaningful consumer disclosure.** The FCC has noted that it does not provide consumers with sufficient information about the RF exposure profile of individual phones to allow consumers to make informed purchasing decisions. The current metric of RF exposure available to consumers, the Specific Absorption Rate, is not an accurate predictor of actual exposure. AAP is supportive of FCC developing standards that provide consumers with the information they need to make informed choices in selecting mobile phone purchases, and to help parents to better understand any potential risks for their children. To that end, we support the use of metrics that are specific to the exposure children will experience.

The AAP supports the reassessment of radiation standards for cell phones and other wireless products and the adoption of standards that are protective of children and reflect current use patterns. If you have questions, please contact Clara Filice in the AAP's Washington Office at 202/347-8600.

Sincerely,



Thomas K. McInerny, MD FAAP
President

TKM/cf



For more information

- ✓ **“Job stress: Is it killing you?”** *NJEA Review*, May 2012. bit.ly/jobstress8
- ✓ **“As schools lift bans on cell phones, educators weigh pros and cons,”** Kinjo Kiema, *NEA Today*, Feb. 23, 2015. bit.ly/2b6eOr8
- ✓ **Be kind to your eyes,** *NJEA Review*, September 2012. bit.ly/2bdZnAp
- ✓ **Computer workstations eTool,** Occupational Safety and Health Administration (OSHA). bit.ly/2aJUeRw
- ✓ **“Stretching Exercises at Your Desk, 12 Simple Tips,”** WebMD. wb.md/2beOvUk
- ✓ **“Cell phone facts and tips,”** Grassroots Environmental Education. bit.ly/2bqpFQP
- ✓ **“Radiofrequency and microwave radiation,”** Occupational Safety and Health Administration (OSHA). bit.ly/2aR1TIY
- ✓ **“Report of Partial Findings from the National Toxicology Program (NTP) Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley SD Rats (Whole Body Exposure).”** bit.ly/2bqq8Cc
- ✓ **“Low EMF Best Practices,”** Collaborative for High Performance Schools (CHPS), 2014. bit.ly/2bs51Rx
- ✓ **Microsoft Accessibility Center:** www.microsoft.com/enable
- ✓ **Apple Accessibility Center:** www.apple.com/accessibility
- ✓ **Google/Android Accessibility Center:** www.google.com/accessibility/products-features.html



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.

Minimize health risks from electronic devices

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. 🛠️

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BE SUPER-SMART REDUCE WIRELESS

Simple steps to practice safe tech.



TURN IT OFF WHEN NOT IN USE.

Avoid unnecessary radiation by powering off wireless devices, network equipment, and hotspots when not in use, like at bedtime.



PRE-DOWNLOAD INSTEAD OF STREAMING.

Remember that when you wirelessly stream videos or music the radiation goes into your body. It is better to pre-download audio and video files and then watch or listen with wireless connections turned off.



USE A PLUG-IN ETHERNET CORD.

It is super fast. Whenever possible connect your laptop, tablet, or computer with an ethernet cord (with Wi-Fi OFF, and Bluetooth OFF).

CORDED PHONE

Corded phones do not emit wireless radiation.



WIRED (NOT WI-FI & NOT BLUETOOTH)

Use a wired mouse, speakers, printer, game system, keyboard, tv, etc.



DISTANCE MATTERS.

Maximize the distance between people and wireless devices.

HEALTHY SLEEP

Remove electronics and wireless devices from around your bed. Do not sleep with your cell phone.



MINIMIZE FACETIME AND SOCIAL MEDIA ON CELL PHONES.

When you use facetime or post images, your phone emits more radiation. Instead, do social media or video sharing on a computer connected to the Internet by ethernet cord (with Wi-Fi turned off).



Ways to **REDUCE** Cell Phone Radiation

Here are some examples of recommendations made by the American Academy of Pediatrics, the Vienna Medical Association, and the Cyprus Medical Association.

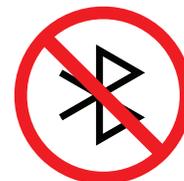


AIRPLANE MODE

Learn how to set your phone to Airplane Mode with antennas OFF. Airplane Mode turns off most of the wireless antennas.

ANTENNAS OFF

Also be sure the Wi-Fi, Bluetooth, and Mobile Data antennas are OFF in the phone settings. Even with antennas off, you still can play music, take photos, and make videos.



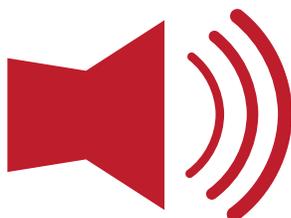
AVOID MAKING CALLS IN CARS

The cell phone works harder to get a signal through metal, so the radiation is stronger.



TEXT INSTEAD OF TALK

Remember to hold the phone away from your body. Pics and video increase radiation.



SPEAKERPHONE

Keep the phone away from your brain by using speakerphone.

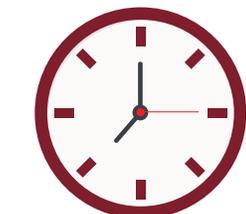
DO NOT SLEEP WITH YOUR PHONE

Use a battery-powered alarm clock, and power off the phone.



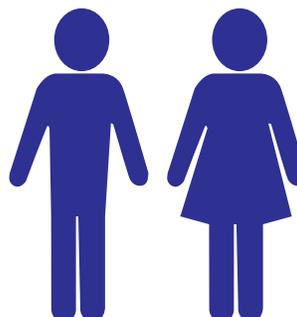
BEWARE THE LOW SIGNAL

The weaker your signal strength, the stronger the radiation from your phone.



REDUCE TIME

Reduce the time you spend on cell phone and wireless overall. Choose safer tech.



DISTANCE IS YOUR FRIEND

Phones should not be in your pocket, bra, or touching your body.

Learn more at www.ehtrust.org

Protecting kids from wireless radiation in school and at home

By Environmental Working Group

EWG's big picture recommendations for wireless devices



Default to airplane mode.



Increase distance from devices.



Turn off when not in use.



Used wired devices if possible.

Children are almost constantly exposed to wireless radiation, starting as early as the first weeks of life. As they get older, that exposure grows every day, thanks to the widespread use of smartphones, laptops and other wireless devices in the classroom and at home.

Wireless devices radiate radiofrequency electromagnetic fields. Research has raised concerns about the health risks of exposure to this radiation, including harm to the nervous and reproductive systems, and higher risk of cancer. Cell phone radiation was classified a "**possible carcinogen**" in 2011 by the International Agency for Research on Cancer, part of the World Health Organization. The agency said human epidemiological studies showed a link between higher risk of a type of malignant brain cancer and cell phone use.

At home

Parents and caregivers can exert more control over their kids' wireless radiation exposure at home than at school, and have more latitude to try new ways of using devices.

Getting started

To begin, inventory your home's electronic devices. Consider smart speakers, cordless phones and mice, gaming consoles, cell phones, wireless security systems and electric alarm clocks, among other types of technology. Even things you might not think emit electromagnetic radiofrequency radiation, like Fitbits and other wearable fitness devices, are a source of wireless radiation exposure and best for young kids to avoid.



Increase distance

The first, easiest-to-implement option is to increase the distance between your child and wireless devices in the home. The more distance, the less exposure.

Wired headphones or the speaker mode on a cell phone can put distance between the device and kids' bodies. They should carry the device in a backpack or bag, not a pocket.

When no one is actively using the device, make sure it's in airplane mode. Otherwise, the device will keep seeking the "signal" – it will continue trying to communicate with nearby cell towers, producing unnecessary radiation.

Another simple but important fix: Locate routers and cordless phone base stations – the worst radiation offenders – away from where your kids sleep, study and play. See if you can lower your Wi-Fi router's output. It may be set to "High" as a default, which could create more intense wireless radiation output than anyone in your household needs.

Choose wired

To reduce radiation exposures significantly, many experts recommend using wired devices whenever possible. Make replacing wireless headphones with wired your first step then, over time, choose auxiliary devices that plug in or are battery-powered, including keyboards, mouses and microphones. Wireless earbuds also emit radiofrequency radiation, so limit the use of such devices, especially for children and youth.

Here are some other ways to reduce exposure to electromagnetic radiation from wireless.

The big picture

Aside from the obvious devices (phones, tablets, computers, game consoles), think twice about wireless digital baby monitors and other wireless or virtual devices. If used, such devices and appliances should be kept away from bedrooms and other areas where children sleep.

Shut off all wireless devices, including your router, at night and when they're not in use.

Consult this [checklist for a low-electromagnetic field, or EMF, set-up](#) published by [Environmental Health Trust](#) if you or a family member spend a lot of time at a computer.

At night

Strongly encourage your child not to sleep near their wireless gadgets. If this isn't possible – and let's face it, with teenagers, you may not succeed at wresting the phone or tablet away – try to convince them to place it away from their head instead of under a pillow.

Even better, keep electronics out of bedrooms as much as possible, or at least away from beds. This includes TV screens and audio speakers.

Use an old-fashioned electric or battery alarm clock that doesn't connect to Wi-Fi. And get one for your children if they claim to need their cell phone so they can get up in the morning.

Move beds away from utility meters or large appliances, which also emit radiation, even if they're on the other side of a wall.

Studying, playing and communicating

Experts recommend starting a child's cell phone use as late as practical, considering the family and educational context and needs of each child. The younger kids are, the more vulnerable their bodies are to potentially harmful effects of wireless radiation exposure.

Encourage your children to use a device's speaker function or wired earbuds when they want to use their phone to talk.

Download movies and shows instead of streaming them, then watch in airplane mode. Even better, watch on a wired computer or screen.



Teach and encourage your children to use their laptop or tablet placed on a table or another hard surface, away from their bodies.

Get wired – consider getting cords and cables for your kids’ game console, and turning it off when your children finish playing.

Powering down

Put phones in airplane mode as much as possible when they are near children, with both Wi-Fi and Bluetooth turned off. If they (or you) want to put a phone in a pocket or backpack, turn it off first.

Also, power devices down when you’re in transit, like on a plane, train, bus or in a car.

Get to know when radiation emissions are highest – streaming video, traveling in a car, or when the signal is poor – and do what you can to help your child avoid these scenarios. (To see how strong or weak the signal is, check how many bars it has.)

At school

Parents and caregivers don’t have nearly as much control at school over how much their child is exposed to wireless radiation as they do at home. And with technology ever more prevalent in educational settings, chances are kids are close to a variety of devices all day.

Nearly half of U.S. schools report having a computer for every child, according to a Department of Education [study](#). Another 37 percent have a computer for each child in some age groups. In some cases, kids may take the device home with them for long or short periods. The survey also said 70 percent of teachers use technology in the classroom.

It’s tough to shield your child from wireless radiation exposure entirely. But you can take steps to lower their exposure based on advice published by experts. Start by approaching school administrators

with your concerns. Learn your school or district’s cell phone policy. If none exists, request that a committee be formed to develop a policy and plan trainings for teachers about safe technology use.

Here are a few ideas teachers can implement in the classroom or that schools and school districts can use. The gold standard: Whenever possible, use wired connections for laptops, tablets, interactive white boards, printers and other devices.

If a wired school network isn’t feasible:

Emphasize keeping devices off and turning them on only when in use – and issue frequent reminders.

Students’ personal electronic devices, like cell phones, should be turned off or in airplane mode during school.

Make sure the school policy on wireless device use is posted in classrooms.

Ask school districts to equip new facilities with wired technology.

Many experts recommend setting school Wi-Fi routers to the lowest possible level that still allows educational content access, as well as turning off routers when they’re not in use.

Wireless technology use during the pandemic

From the start of the coronavirus pandemic, wireless technology became the main path for accessing education and participating in virtual classrooms for kids and families in the U.S. and across the globe. In 2020, a [survey](#) found nearly half of 2- to 4-year-olds and about two in three kids ages 5 to 8 already owned their own mobile devices, a tablet or smartphone – and that was before the Covid-19-related school closures prompted desperate working parents nationwide to employ wireless devices as babysitters and educators.



That's many kids with constant access to wireless devices – and also exposed to the health risks of wireless radiation. Parents have taken note of these potential harms. A European citizens group coalition in March **called** for simple steps to protect kids by swapping wireless for cables in places where children spend time and educating the public about the **dangers of exposure**.

Earlier this year, **EWG together with more than 22,000 people** petitioned federal regulators to establish stricter standards for kids' exposure to wireless devices' radiofrequency radiation.

For more information

To find additional resources, advocacy guidance, tip sheets and other useful suggestions, consult the websites of one of these organizations:

The Environmental Health Trust's "**Wi-Fi in Schools Toolkit**" offers a wealth of resources, including fact sheets and **tip sheets**, background on the science of EMF exposure, and guidance for parents, teachers and schools. It also has more than a dozen **downloadable and printable posters** on exposure and sleep, children's development, and the effects of EMF exposure on breast cancer risk and male reproductive health.

An Environmental Health in Nursing textbook downloadable **chapter** on EMF, courtesy of the Alliance of Nurses for Healthy Environments, contains useful information, like a detailed explanation of the health impacts of EMF exposure, advocate organizations' tip sheets, and other valuable resources.

The **American Academy of Pediatrics** issued recommendations about EMF exposure.

The Massachusetts Breast Cancer Coalition offers a **downloadable backgrounder** for students and educators on "Cell Phones, Wireless and Your Health," which includes suggested activities to use in the classroom and as homework. It includes a list of additional websites you may choose to consult.

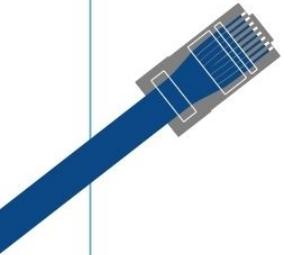
How to Hardwire Your Computer, Laptop or Tablet



1

YOU NEED AN ETHERNET CORD

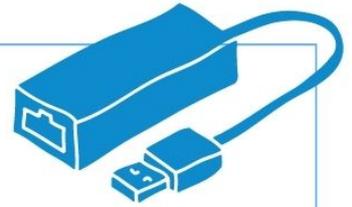
Ethernet cords come in different lengths. They allow data to flow super fast through the cord instead of wirelessly through the air.



2

DO YOU NEED AN ADAPTER?

Is there an ethernet-sized port on your device? If not, you will need an ethernet adapter. Adapters plug into USB or lightning ports. Research the correct "ethernet adapter" for your device's make and model.



3

PLUG ETHERNET CORD INTO YOUR MODEM

Plug one end of the ethernet cord into your modem or router.

You might also want an "ethernet switch" that "splits" the ethernet line so you can plug in multiple ethernet cords for multiple computers/devices.



4

PLUG ETHERNET CORD INTO YOUR LAPTOP OR TABLET

Connect the ethernet from your device to your router or modem. This is where you may need an ethernet adapter or maybe even a power adapter (for iPads).



5

TURN WI-FI & BLUETOOTH "OFF" IN DEVICE

Go into the device settings and turn the Wi-Fi/Bluetooth and any other wireless antennas OFF. For tablets, turn "Airplane Mode" ON & check that Bluetooth is OFF.



6

TURN WI-FI OFF IN ROUTER

Now that the ethernet is connected you can then turn Wi-Fi & other antennas OFF in router settings. Or buy your own Wi-Fi free modem

If you must have a Wi-Fi in the house, turn it OFF at bedtime and ensure it is not close to children.





How To Minimize Wireless

Medical doctors and scientists recommend people reduce exposure to cell phone, Wi-Fi and wireless radiation. Scientific research has linked wireless to memory problems, cancer and harm to reproductive organs.

Use Speaker

Protect your brain and body by keeping the phone at a distance.

Minimize use and do not carry phones in pockets or use them near children.



Airplane Mode

Turn antennas OFF with airplane mode more often. Remember to check that Bluetooth, Wi-Fi, 5G and other antennas are also OFF.

Tip: Instead of Wi-Fi streaming, pre-download music and videos so that devices can be used on Airplane Mode.



Corded Home Phone

Choose a corded phone over a wireless one. Why? Because cordless & DECT phones emit nonstop wireless radiation.



Switch to Wired Tech

Connect computers, laptops and tablets to the internet with ethernet, not Wi-Fi. Adapters allow you to plug ethernet into USB or lightning ports



5G & Cell Towers

Talk to your elected officials. 5G and 4G "small" cells towers should not be built near homes and schools.

Raise awareness in your community.



Tablets OFF Laps

Tablets and laptops expose your body to non-ionizing radiation.

Always use devices on a table or desk.



Simple Steps

Each step you take to reduce wireless exposure to your child will make a huge difference. Look around your home and one by one swap out each Wi-Fi and Bluetooth device with safer, corded and ethernet connected tech.

Safe technology is the way forward.



Risks to Health and Well-Being From Radio-Frequency Radiation Emitted by Cell Phones and Other Wireless Devices

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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 radiation¹ (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

¹Per 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 radio-frequency 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 Röööli 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 (SAR³), duration of exposure, and adverse outcomes, especially brain cancer, cardiomyopathies and abnormal cardiac rhythms, 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

²The FCC adopted the IEEE C95.1 1991 standard in 1996.

³When 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 countries⁴ 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

⁴Argentina, 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.

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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**.

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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Conflict of Interest Statement: The authors declare that this manuscript was drafted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest, although subsequent to its preparation, DD became a consultant to legal counsel representing persons with glioma attributed to radiation from cell phones.

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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 health 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