Response to Request for Information from U.S. Department of Health and Human Services on Electromagnetic Fields, Radiofrequency Radiation, and Wireless Radiation Exposure

Docket: HHS-OASH-2026-0397

Joel M. Moskowitz, Ph.D.

School of Public Health, University of California, Berkeley

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Background and Statement of Perspective

As a public health scientist in the School of Public Health, University of California, Berkeley, I have researched the health effects of electromagnetic fields (EMF), especially radiofrequency electromagnetic fields (RF-EMF), since 2009.

I co-founded and serve as a Commissioner on the International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF), serve as an advisor to the International EMF Scientist Appeal, and serve as a scientific advisor to Physicians for Safe Technology. I support the statements submitted to USDHHS on behalf of these organizations.

My Electromagnetic Radiation Safety website addresses key scientific and policy developments concerning the health risks from exposure to electromagnetic radiation (EMR) and non-ionizing electromagnetic fields (EMF). The website has recorded six million pageviews since 2013.

Since 2016, I have circulated monthly abstracts of newly published scientific papers on RF-EMF and non-ionizing fields to several hundred EMF scientists globally. The complete collection currently contains almost 3,000 abstracts with links to published papers.

This public submission consists of the following sections:

- Background and statement of perspective (pg. 1)
- Transcripts of published opinion pieces on RF-EMF from the *San Francisco Chronicle* (2010), *Scientific American* (2019), *The Washington Spectator* (2020), and a Q&A for UC Berkeley News (2021). (pp. 2-7)
- Specific responses to questions posed by HHS for this public submission (pp. 8-11)
- A list of my peer-reviewed publications in scientific health journals on RF-EMF (pp. 12-13)
- A list of my invited presentations and lectures on RF-EMF health effects (pg. 14)
- A list of key scientific and policy papers. (pp. 15-22)

Transcripts of Published Opinion Pieces

Government Must Inform Us of Cell Phone Risk

By Joel M. Moskowitz | San Francisco Chronicle — April 28, 2010

A huge, 30-year study called COSMOS has been launched in Europe to determine whether cell phones cause cancer and other health problems. Meanwhile, policymakers in Sacramento are considering legislation to ensure people know how much radiation their cell phones emit. The wireless industry vigorously opposes such legislation. It argues that its phones comply with regulations, and there is no consensus about risks so people don't need to know this. Our research review published in the Journal of Clinical Oncology found alarming results to the contrary.

We reviewed 23 case-control studies that examined tumor risk due to cell phone use. Although as a whole the data varied, among the 10 higher quality studies, we found a harmful association between phone use and tumor risk. The lower quality studies, which failed to meet scientific best practices, were primarily industry funded.

The 13 studies that investigated cell phone use for 10 or more years found a significant harmful association with tumor risk, especially for brain tumors, giving us ample reason for concern about long-term use.

Do federal regulations adequately protect the public? The 1996 Federal Communications Commission regulations are based upon the Specific Absorption Rate (SAR), a measure of heat generated by six minutes of cell phone exposure in an artificial model that represents a 200-pound man's brain. Although every cell phone model has a SAR, the industry doesn't make it easy to find it. Moreover, children, and adults who weigh less than 200 pounds, are exposed to more radiation than our government deems 'safe.'

It is time to revamp the FCC regulations. Laboratory scientists have found harmful effects from cell phones that emit less radiation than the FCC standard. Moreover, some scientists believe that cell phones' heat transfer is not what we should fear. These researchers have found that variation in the frequencies emitted by cell phones may be hazardous.

We should address this issue proactively even if we do not fully understand its magnitude. Our government has faced similar public health threats in the past. In 1965, although there was no scientific consensus about the harmful effects of cigarettes, Congress required a precautionary warning label on cigarette packages: 'Cigarette Smoking May Be Hazardous to Your Health.' More specific warnings were not required until 1984: 'Smoking Causes Lung Cancer, Heart Disease, Emphysema, And May Complicate Pregnancy.'

Should we have waited 19 years until absolutely certain before we informed the public about these risks?

Although more research on cell phone radiation is needed, we cannot afford to wait. There are 285 million cell phones in use in this country, and two-thirds of children over the age of seven use them. Manufacturers bury the SAR within their owner's manuals, along with safety instructions to keep your phone up to an inch away from your body.

Nine nations have issued precautionary warnings. It is time for our government to require health warnings and publicize simple steps to reduce the health risks of cell phone use.

We Have No Reason to Believe 5G is Safe

By Joel M. Moskowitz | Scientific American — October 17, 2019

The telecommunications industry and their experts have accused many scientists who have researched the effects of cell phone radiation of 'fear mongering' over the advent of wireless technology's 5G. Since much of our research is publicly-funded, we believe it is our ethical responsibility to inform the public about what the peer-reviewed scientific literature tells us about the health risks from wireless radiation.

The chairman of the Federal Communications Commission (FCC) recently announced through a press release that the commission will soon reaffirm the radiofrequency radiation (RFR) exposure limits that the FCC adopted in the late 1990s. These limits are based upon a behavioral change in rats exposed to microwave radiation and were designed to protect us from short-term heating risks due to RFR exposure.

Yet, since the FCC adopted these limits based largely on research from the 1980s, the preponderance of peer-reviewed research—more than 500 studies—has found harmful biologic or health effects from exposure to RFR at intensities too low to cause significant heating.

Citing this large body of research, more than 240 scientists who have published peer-reviewed research on the biologic and health effects of non-ionizing electromagnetic fields (EMF) signed the International EMF Scientist Appeal, which calls for stronger exposure limits. The appeal makes the following assertions:

'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.'

The scientists who signed this appeal arguably constitute the majority of experts on the effects of nonionizing radiation. They have published more than 2,000 papers and letters on EMF in professional journals.

The FCC's RFR exposure limits regulate the intensity of exposure, taking into account the frequency of the carrier waves, but ignore the signaling properties of the RFR. Along with the patterning and duration of exposures, certain characteristics of the signal (e.g., pulsing, polarization) increase the biologic and health impacts of the exposure. New exposure limits are needed which account for these differential effects. Moreover, these limits should be based on a biological effect, not a change in a laboratory rat's behavior.

The World Health Organization's International Agency for Research on Cancer (IARC) classified RFR as 'possibly carcinogenic to humans' in 2011. In 2018, a $30 million study conducted by the U.S. National Toxicology Program (NTP) found 'clear evidence' that two years of exposure to cell phone RFR increased cancer in male rats and damaged DNA in rats and mice of both sexes. The Ramazzini Institute in Italy replicated the key finding of the NTP using a different carrier frequency and much weaker exposure to cell phone radiation over the life of the rats.

Based upon the research published since 2011, including human and animal studies and mechanistic data, the IARC has prioritized RFR to be reviewed again. Since many EMF scientists believe we now have sufficient evidence to consider RFR as either a probable or known human carcinogen, the IARC will likely upgrade the carcinogenic potential of RFR.

Nonetheless, without conducting a formal risk assessment or a systematic review of the research on RFR health effects, the FDA reaffirmed the FCC's 1996 exposure limits in a letter to the FCC, stating that the agency had 'concluded that no changes to the current standards are warranted at this time,' and that 'NTP's experimental findings should not be applied to human cell phone usage.' The letter stated that 'the available scientific evidence to date does not support adverse health effects in humans due to exposures at or under the current limits.'

The 5G cellular technology employs millimeter waves in addition to microwaves that have been in use for older cellular technologies (2G through 4G). Given limited reach, 5G requires cell antennas every 100 to 200 meters, exposing many people to millimeter wave radiation. 5G also employs new technologies (e.g., active antennas capable of beam-forming; phased arrays; massive multiple inputs and outputs, known as massive MIMO) which pose unique challenges for measuring exposures.

Millimeter waves are mostly absorbed within a few millimeters of human skin and in the surface layers of the cornea. Short-term exposure can have adverse physiological effects in the peripheral nervous system, the immune system, and the cardiovascular system. Research suggests that long-term exposure may pose health risks to the skin (e.g., melanoma), the eyes (e.g., ocular melanoma), and the testes (e.g., sterility).

Since 5G is a new technology, there is no research on health effects, so we are 'flying blind.' However, we have considerable evidence about the harmful effects of 2G and 3G. Little is known about the effects of exposure to 4G because governments have been remiss in funding this research. Meanwhile, we are seeing increases in certain types of head and neck tumors in tumor registries, which may be at least partially attributable to the proliferation of cell phone radiation. These increases are consistent with results from case-control studies of tumor risk in heavy cell phone users.

5G will not replace 4G; it accompanies 4G. If there are synergistic effects from simultaneous exposures to multiple types of RFR, our overall risk of harm from RFR may increase substantially. Cancer is not the only risk, as there is considerable evidence that RFR causes neurological disorders and reproductive harm, likely due to oxidative stress.

As a society, should we invest hundreds of billions of dollars deploying 5G, a cellular

technology that requires the installation of 800,000 or more new cell antenna sites in the U.S. close to where we live, work, and play?

Instead, we should support the recommendations of the 250 scientists and medical doctors who signed the 5G Appeal that calls for an immediate moratorium on the deployment of 5G and demand that our government fund the research needed to adopt biologically based exposure limits that protect our health and safety.

Regulators Steamroll Health Concerns as the Global Economy Embraces 5G

By Joel M. Moskowitz | The Washington Spectator — September 18, 2020

In a Washington Post op-ed (June 4, 2020), '5G conspiracy theories threaten the U.S. recovery,' Thomas Johnson Jr., the Federal Communications Commission's general counsel, declared: 'Conjectures about 5G's effect on human health are long on panic and short on science.'

The FCC, however, has been 'short on science' for more than two decades. Along with the World Health Organization, the FCC abdicated its responsibility to protect the public's health from hazards associated with exposure to radiofrequency (RF) radiation. As a result, almost 400 international scientists and doctors have called for a moratorium on deployment of 5G, and 150 community groups have tried to block its rollout in the United States. Environmental Health Trust and Children's Health Defense, along with multiple plaintiffs, sued the FCC over its inadequate RF exposure limits and cell phone testing procedures.

The FCC relies on other agencies, such as the Food and Drug Administration, for health expertise. However, without a comprehensive review of all peer-reviewed science and a formal risk assessment, the FDA in a letter advised the FCC that 'the available scientific evidence to date does not support adverse health effects in humans due to exposures at or under the current limits.' The letter 'concluded that no changes to the current standards are warranted at this time.'

In a Senate Commerce Committee hearing, Senator Blumenthal blasted the FCC and FDA for failing to conduct any research into the safety of 5G technology and deferring to industry.

The FCC reaffirmed its obsolete RF exposure limits, ignoring critical input from more than 50 scientists, hundreds of scientific studies, and hundreds of people who have suffered illness from RF radiation.

Originally adopted in 1996, these limits were based upon a behavioral change in rats and monkeys exposed to microwave radiation and were designed to protect humans only from short-term heating risks.

Since 1996, the preponderance of peer-reviewed research—more than 500 studies—has found harmful biologic or health effects from RF radiation exposure at intensities too low to cause significant heating. Thus stringent exposure limits based on biological effects are needed to protect human health.

Citing this body of research, over 240 scientists who have published peer-reviewed research on the biologic and health effects of nonionizing electromagnetic fields signed the International EMF Scientist Appeal, calling for stronger RF exposure limits.

In 2018, a $30 million study conducted by the U.S. National Toxicology Program reported 'clear evidence' that two years of exposure to cell phone radiation increased cancer in male rats and damaged DNA in rats and mice of both sexes. The Ramazzini Institute replicated the NTP's key finding using much weaker cell phone radiation exposure over the rats' lifespan.

The WHO's International Agency for Research on Cancer classified RF radiation as 'possibly carcinogenic to humans' in 2011. We are seeing increases in head and neck tumors in cancer registries from multiple countries, which may be attributable to the proliferation of wireless device use. These increases are consistent with case-control studies that found increased tumor risk in long-term cell phone users.

Moreover, cancer is not the most common hazard, because there is substantial scientific evidence that RF radiation causes neurological disorders and reproductive harm.

The volume of peer-reviewed scientific evidence on earlier technologies suggests that exposure to microwaves and millimeter waves used in 5G is likely harmful. Should we gamble on our health and invest hundreds of billions of dollars deploying 5G, or should we develop RF exposure standards that fully protect humans and the environment and institute a risk management system based upon a formal risk assessment?

Cellphone Radiation Is Harmful, but Few Want to Believe It

Interview with Joel M. Moskowitz, Ph.D. by Anne Brice | UC Berkeley News — July 1, 2021

Berkeley News: What led you to pursue this research?

Joel Moskowitz: I got into this field by accident. During the past 40 years, the bulk of my research has been focused on tobacco-related disease prevention. I first became interested in cellphone radiation in 2008, when Dr. Seung-Kwon Myung, a physician-scientist with the National Cancer Center of South Korea, came to spend a year at the Center for Family and Community Health. At that time, I was skeptical that cellphone radiation could be harmful. However, I immersed myself in the literature regarding the biological effects of low-intensity microwave radiation. After reading many animal toxicology studies showing that this radiation increases oxidative stress—free radicals, stress proteins, and DNA damage—I became increasingly convinced that what we were observing in human studies was indeed a real risk.

Berkeley News: What did your review of case-control studies find?

Joel Moskowitz: Our 2009 review published in the Journal of Clinical Oncology found that heavy cellphone use was associated with increased brain cancer incidence, especially in studies using higher quality methods and those without telecommunications industry funding. In 2020, we updated our review in the International Journal of Environmental Research and Public Health based on a meta-analysis of 46 case-control studies. Our main takeaway is that approximately 1,000 hours of

lifetime cellphone use—about 17 minutes per day over a 10-year period—is associated with a statistically significant 60% increase in brain cancer.

Berkeley News: How do you respond to controversy surrounding this research?

Joel Moskowitz: A major reason there isn't more research in the U.S. is that the federal government stopped funding it in the 1990s, with the exception of the $30 million rodent study published in 2018 by the National Toxicology Program, which found 'clear evidence' of carcinogenicity. In 1996, the FCC adopted exposure guidelines that limited intensity to prevent tissue heating from short-term exposure, not to protect against long-term exposure to low levels of pulsed radiofrequency radiation. Yet, the preponderance of research published since 1990 finds adverse biologic and health effects from long-term exposure, including DNA damage.

Berkeley News: Why did the government stop funding this research?

Joel Moskowitz: The telecommunications industry holds significant influence over regulatory policy, as documented in Norm Alster's Harvard monograph Captured Agency. The industry spends over $100 million annually lobbying Congress and regulators. There are strong parallels to how the tobacco industry historically delayed public health intervention.

Berkeley News: What specific health effects are associated with long-term exposure to modulated RF radiation?

Joel Moskowitz: Many biologists and EMF scientists believe modulation makes wireless energy biologically active, interfering with cellular mechanisms, opening voltage-gated calcium channels, and allowing excess calcium into cells and mitochondria. This process increases stress proteins, free radicals, DNA damage, and cell death. In 2011, IARC classified RF radiation as 'possibly carcinogenic to humans.' In March 2021, a report by the former director of the CDC’s National Center for Environmental Health concluded there is a 'high probability' that RF radiation emitted by cellphones causes gliomas and acoustic neuromas.

Berkeley News: What changes come with 5G technology?

Joel Moskowitz: 5G utilizes millimeter waves in addition to microwaves. Millimeter waves cannot travel far and are blocked by foliage and structures, requiring an estimated 800,000 new cell antenna sites in the U.S. Millimeter wave radiation is absorbed primarily in the skin, sweat glands, peripheral nerves, eyes, and testes, and can alter immune and circulatory function, harm wildlife, and promote drug-resistant pathogens.

Berkeley News: What practical steps can individuals take to minimize exposure?

Joel Moskowitz: First, minimize direct exposure by using landlines whenever possible. When near a Wi-Fi router, connecting via Wi-Fi typically emits less radiation than transmitting over cellular networks. Second, distance dramatically reduces exposure. Keeping a phone 10 inches away from your body versus 1/10th of an inch results in a 10,000-fold reduction in exposure. Store phones in purses or backpacks, use speakerphone or wired headsets, and do not sleep next to active phones. Third, avoid low-signal use. Cellphones increase power output when signal reception is weak (1–2 bars) or inside metallic enclosures like cars and elevators.

Specific Responses to Questions Posed by USDHHS (Docket HHS-OASH-2026-0397)

Public Experiences and Reported Potential Adverse Health Effects

Question 4: Observations from Clinical Practice, Occupational Settings, or Research

- **4h. Types of Potential Adverse Health Effects Reported:** Numerous peer-reviewed publications demonstrate that EMF affects living organisms at levels well below international guidelines. Observed outcomes include increased cancer risk, cellular stress, elevated free radicals, genetic damage, structural and functional changes to reproductive systems, learning and memory deficits, neurological disorders, and impaired general well-being in humans, as well as adverse impacts on plant and animal life.
- **4j. Characteristics of Populations Involved:** All populations are susceptible to exposure risks, with heightened vulnerability observed in children, pregnant women, individuals with compromised immune systems or electromagnetic hypersensitivity (EHS), individuals of reproductive age, and the elderly.
- **4l. Standardized Methods Used to Assess Exposure & Health Effects:** Standard epidemiologic and toxicologic frameworks utilized include case-control studies, longitudinal cohort studies, cross-sectional population studies, and clinical case studies.

Exposure Standards and Risk Assessment

Question 5: National and International Guidelines for Federal Health Agency Evaluation

Federal health agencies should evaluate and integrate biological exposure limits established by international scientific bodies, including:

- **Council of Europe (Resolution 1815):** Recommends a precautionary exposure limit of 106 μW/m².
- **European EMF Guideline (Belyaev et al., 2016):** Recommends exposure thresholds of 100–10,000 μW/m² for FM radio; 1–100 μW/m² for cellular frequencies; and 0.1–10 μW/m² for Wi-Fi (2400 and 5000 MHz).
- **BioInitiative Report (2012):** Recommends a protective limit of 3–6 μW/m².
- **Building Biology Institute Guidelines (2015):** Recommends <0.1 μW/m² for sleeping environments.

Question 5n: Recommended Scientific, Technical, and Regulatory Changes

- **Adopt Biologically Based Limits:** Implement evidence-based near-field and far-field RF exposure limits that protect human health and the environment based on animal and human data (e.g., Melnick & Moskowitz, 2026).
- **National Exposure Surveillance:** Establish a national monitoring system to measure indoor and outdoor RF-EMF levels and ensure regulatory compliance.
- **Realistic Device Testing Protocols:** Replace SAR models with premarket certification protocols testing devices at 0 mm distance from the body to mirror real-world usage.
- **Post-Market Injury Tracking:** Institute a federal post-market surveillance system for logging adverse health incidents linked to wireless devices and infrastructure.

- **Professional Training Programs:** Provide structured education for clinicians, public health officials, and engineers regarding biological mechanisms and diagnostic indicators of RF exposure.

Question 5o: Research Gaps and Regulatory Readiness

- **Immediate Standard Implementation:** Existing scientific research is sufficient for independent scientists without conflicts of interest to conduct a comprehensive health risk assessment and establish protective standards immediately.
- **Legislative Action:** Congress should enact legislation—modeled on the Cell Phone Right to Know Act (H.R. 6358, 112th Congress)—to fund public health education and research. In the absence of congressional action, the Administration should implement protective measures via executive authority.
- **Reassignment of Agency Authority:** Regulatory oversight of wireless infrastructure should be assigned to the Environmental Protection Agency (EPA), and device regulation should be assigned to the Food and Drug Administration (FDA), removing health policy oversight from the Federal Communications Commission (FCC).

Question 5p: Accounting for Exposure-Related Characteristics

- **Research Programs:** NIH and NIOSH should initiate major intramural and extramural research initiatives evaluating non-thermal biological and health effects across frequencies, signal modulations, pulsing, power densities, duty cycles, beamforming arrays, and multi-frequency cumulative exposures.
- **Comparative Toxicity Studies:** Systematic studies must be conducted to assess how variations in wave signal structures (e.g., peak vs. average intensity, polarization) alter toxicological outcomes.

Existing Evidence and Health Risks

Question 6 & 12: Scientific Evidence of Harm Below Current Federal Limits

Substantial evidence documents adverse biological and health impacts occurring well below current FCC exposure limits. Key research areas documented on Electromagnetic Radiation Safety include:

- Carcinogenicity demonstrated in the National Toxicology Program (NTP) and Ramazzini Institute studies.
- Epidemiological studies linking long-term cellphone and cordless phone use to elevated risks of glioma, acoustic neuroma, meningioma, thyroid cancer, and salivary gland tumors.
- Impairment of male sperm quality, female infertility, and pregnancy complications.
- Neurological dysfunction, blood-brain barrier permeability, oxidative stress, immune system modulation, and Electromagnetic Hypersensitivity (EHS).

Question 13: Cumulative Exposure Patterns Across Specific Technologies

- **5G Infrastructure:** Massive deployment of millimeter waves and microarrays increases total ambient radiofrequency exposure and introduces unstudied signal modulation patterns.
- **Wi-Fi Deployment:** Continuous, multi-device exposure in schools and public facilities elevates cumulative dosage, supporting calls by the Council of Europe to restrict Wi-Fi in classrooms.
- **Autonomous & Electric Vehicles:** Hybrid and electric vehicles create complex internal electromagnetic fields from power electronics and wireless telemetry.

- **Smart Meters:** Transmitting meters create intermittent, non-consensual pulsed RF exposures across residential settings.

Question 14: Adverse Environmental Effects

RF radiation exposure adversely impacts wildlife, avian navigation, insect populations, and broader ecosystems, as demonstrated by environmental monitoring studies showing cell towers as primary contributors to ambient ecosystem radiation.

Exposure Assessment, Measurement, and Public Disclosure

Question 7 & 8: Exposure Assessment Methodologies

- **Current Methods:** Utilize standardized epidemiologic frameworks, field power density mapping, and microenvironment assessment protocols.
- **Methodological Improvements:** Develop personal wearable dosimeters capable of measuring, categorizing, and logging peak exposures, frequency bands, and total cumulative exposures over time.

Question 9: Consumer and Public Information Disclosure

Federal health agencies should mandate public disclosure regarding SAR limitations, distance-dependent exposure mitigation, elevated absorption in children, and precautionary operating guidelines for consumers, schools, healthcare providers, and local governments.

Question 10: Surveillance Systems and Disease Registries

A comprehensive public health framework requires integrating national brain tumor disease registries, occupational exposure registries, ambient environmental monitoring networks, long-term prospective cohorts, adverse event reporting systems, and localized illness cluster investigation protocols.

Question 11: Protection of Sensitive Populations

Exposure limits and risk evaluations must incorporate specific safety margins for children, pregnant women, older adults, individuals with implanted medical electronics, workers with high occupational exposures, and individuals with pre-existing medical conditions or EHS.

Federal Research Priorities and Interagency Coordination

Question 16: Highest Priority Research Gaps

Federal health agencies must prioritize research funding for:

- Biological mechanisms of Electromagnetic Hypersensitivity (EHS).
- Reproductive toxicity, sperm degradation, and pregnancy risks.
- Non-thermal genetic toxicity, DNA strand breaks, and oxidative stress pathways.
- Neurological, cardiovascular, and endocrine system disruption.
- Immune system impacts and blood-brain barrier integrity.
- Synergistic carcinogenic effects of multi-frequency exposures.

Question 17: Federal Agency Roles and Interagency Coordination

- **NIEHS, NIOSH & NTP:** Re-establish and expand federal research initiatives on the toxicological and carcinogenic effects of non-ionizing RF-EMF.

- **FDA:** Conduct formal risk assessments, establish biologically based device exposure standards, oversee premarket safety certifications, and track post-market adverse events.
- **EPA:** Resume environmental surveillance and regulate wireless communication infrastructure radiation limits.
- **NIH:** Direct intramural research and fund extramural scientific grants focused on low-level non-ionizing EMF health impacts, hosting expert consensus conferences.
- **CDC:** Educate health professionals on EHS diagnosis and treatment, launch public awareness campaigns on exposure reduction, and restore evidence-based safety guidance.

Peer-Reviewed Publications on RF-EMF in Scientific Health Journals

- **Myung, S.K., Ju, W., McDonnell, D.D., Lee, H.J., Kazinets, G., Cheng, C-T., Moskowitz, J.M.** Mobile phone use and risk of tumors: A meta-analysis. Journal of Clinical Oncology. 2009; 27(33):5565-5572. DOI: 10.1200/JCO.2008.21.6366
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- **Hardell, L., Moskowitz, J.M.** A critical analysis of the MOBI-Kids study of wireless phone use in childhood and adolescence and brain tumor risk. Reviews on Environmental Health. 2022. DOI: 10.1515/reveh-2022-0040
- **Moskowitz, J.M.** RE: Cellular Telephone Use and the Risk of Brain Tumors: Update of the UK Million Women Study. JNCI: Journal of the National Cancer Institute. 2022; djac109. DOI: 10.1093/jnci/djac109
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- **Frank, J.W., Melnick, R.L, Moskowitz, J.M., on behalf of ICBE-EMF.** A critical appraisal of the WHO 2024 systematic review of the effects of RF-EMF exposure on tinnitus, migraine/headache, and non-specific symptoms. Reviews on Environmental Health. 2024. DOI: 10.1515/reveh-2024-0069
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- **Melnick, R.L, Moskowitz, J.M., on behalf of ICBE-EMF.** Exposure limits to radiofrequency EMF do not account for cancer risk and reproductive toxicity assessed from data in experimental animals. Environmental Health. 2026; 25:42. DOI: 10.1186/s12940-026-01288-6
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- **Mallery-Blythe, E., McCredden, J., Philips, A., Weller, S., Moskowitz, J.M., Frank, J.** Concept analysis of the design of EMF provocation studies. Electromagnetic Biology and Medicine. (Under Review)

Commentary and Invited Presentations on RF-EMF

- **Moskowitz, J.M. (April 28, 2010).** Government must inform us of cell phone risk (Op-ed). San Francisco Chronicle.
- **Moskowitz, J.M. (November 18, 2010).** Cell Phone Use, Brain Tumor Risk, and Public Health Policy (Invited Presentation). The Commonwealth Club, San Francisco, CA.
- **Moskowitz, J.M. (May 31, 2012).** Cell Phone Radiation Risks: Epidemiologic Research and Public Health Policy (Invited Lecture). School of Public Health, University of California, Los Angeles, CA.
- **Moskowitz, J.M. (December 9, 2013).** Recent Human Studies Indicate Wireless Phones Most Likely Cause Brain Cancer – Policy Implications (Invited Forum Presentation). Expert Roundtable: Skeptical about Cell Phones and Health, The Commonwealth Club, San Francisco, CA.
- **Moskowitz, J.M. (October 29, 2014).** Mobile Phone Use and Cancer Risk: Research on a Group 2B Carcinogen (Invited Webinar). CDC Work Group on Cancer Across the Lifespan.
- **Moskowitz, J.M. (May 22, 2016).** Should cell phones have warning labels? (Invited Pro Commentary). The Wall Street Journal.
- **Moskowitz, J.M. (May 9, 2018).** Cell Phones and Public Health Policy (Invited Webinar). Collaborative for Health and the Environment.
- **Moskowitz, J.M. (February 27, 2019).** Cell Phones, Cell Towers, and Wireless Safety (Keynote Presentation). Balancing Technology Series, University Health Services and School of Public Health, University of California, Berkeley.
- **Moskowitz, J.M. (October 17, 2019).** We have no reason to believe 5G is safe (Op-ed). Scientific American.
- **Moskowitz, J.M., Noordegraaf, I.W. (December 6, 2019).** 5G niet uitrollen voordat de gezondheidsrisico's duidelijk zijn (Invited Op-Ed). De Telegraaf (Amsterdam, Netherlands).
- **Moskowitz, J.M. (September 18, 2020).** Regulators Steamroll Health Concerns as the Global Economy Embraces 5G. The Washington Spectator, 46(9):6.
- **Moskowitz, J.M. (September 24, 2020).** Radio Frequency Radiation Health Risks: Implications for 5G (Grand Rounds Presentation). Occupational and Environmental Medicine Grand Rounds, University of California, San Francisco.
- **Moskowitz, J.M. (November 3, 2021).** Health Effects of Cellphone & Cell Tower Radiation: Implications for 5G (Invited Webinar). Center for Occupational and Environmental Health, University of California.
- **Moskowitz, J.M. (September 11, 2023).** Radiofrequency Radiation and Your Health: Is 5G Harmful? (Invited Webinar). Federal Mobility Group.
- **Moskowitz, J.M. (October 1, 2024).** Health Hazards of Wireless Technologies: What do we know now? (Invited Webinar). Collaborative for Health & Environment.
- **Moskowitz, J.M. (September 15, 2026).** How Should We Address Wireless Radiation Health Risks? (Invited Presentation). Online Forum, North Carolina Department of Health and Human Services.

Key Cell Phone Radiation Research Studies

This is not a comprehensive list. I have focused on papers published since 2009 and tried to be parsimonious.

National Toxicology Program cell phone radiation studies

2016 NTP Report of Partial Findings (Rats)
TR-595: NTP Studies of Cell Phone Radiofrequency Radiation (Rats) (Nov. 2018)
TR-596: NTP Studies of Cell Phone Radiofrequency Radiation (Mice) (Nov. 2018)

Also see:
NTP Cell Phone Radiation Study: Final Reports, **National Toxicology Program: Peer & public review**, **National Toxicology Program Finds Cell Phone Radiation Causes Cancer**, **and Ramazzini Institute Cell Phone Radiation Study Replicates NTP Study**

Tumor risk review papers

Myung et al (2009) Mobile phone use and risk of tumors: a meta-analysis. *J Clinical Oncology*. http://bit.ly/2F0ldUS

Khurana et al (2009) Cell phones and brain tumors: a review including long-term epidemiologic data. *Surgical Neurology*. http://bit.ly/2WTQwfk

Levis et al (2011) Mobile phones and head tumours: the discrepancies in cause-effect relationships in the epi studies-how do they arise. *Environ Health*. http://bit.ly/2IsQy4r

Levis et al (2012) Mobile phones and head tumours: a critical analysis of case-control epi studies. *Open Environ Sciences*. http://bit.ly/2EXT5ml

WHO (2013) IARC monographs on the evaluation of carcinogenic risks to humans. Volume 102: Non-ionizing radiation, Part 2: Radiofrequency electromagnetic fields. http://bit.ly/10oIE3o

Morgan et al (2015) Mobile phone radiation causes brain tumors and should be classified as a probable human carcinogen (2A) (Review). *Int J Oncology*. http://bit.ly/2XwgVNa

Wang & Guo (2016) Meta-analysis of association between mobile phone use and glioma risk. *J Cancer Research Therapy* http://bit.ly/2o1dVcn

Bortkiewicz et al (2017) Mobile phone use and risk of intracranial tumors and salivary gland tumors - A meta-analysis. *Int J Occ Med Envir Health*. http://bit.ly/2nVJC5d

Prasad et al (2017) Mobile phone use and risk of brain tumours: a systematic review of association between study quality, source of funding, and research outcomes. *Neurol Sci*. http://bit.ly/2Xxp83P

Yang et al (2017). Mobile phone use and glioma risk: A systematic review and meta-analysis. *PLOS One*. https://doi.org/10.1371/journal.pone.0175136

Carlberg, Hardell (2017) Evaluation of mobile phone and cordless phone use and glioma risk using the Bradford Hill viewpoints from 1965 on association or causation. *Biomed Res Int*. http://bit.ly/2WwBX1K

Miller et al (2018). Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields (Monograph 102). *Environ Res*. http://bit.ly/2rJD7Fu

Choi, Moskowitz, et al (2020). Cellular phone use and risk of tumors: Systematic review and meta-analysis. *Int J Envir Res Public Health*. https://doi.org/10.3390/ijerph17218079.
Moon et al (2024). Relationship between radiofrequency-electromagnetic radiation from cellular phones and brain tumor: meta-analyses using various proxies for RF-EMR exposure-outcome assessment. *Environ Health*. https://doi.org/10.1186/s12940-024-01117-8.
Mevissen et al (2025). Effects of radiofrequency electromagnetic field exposure on cancer in laboratory animal studies, a systematic review. *Environ Intl* https://doi.org/10.1016/j.envint.2025.109482
Kundi, Hutter (2026). Interpretation of Epidemiological Studies on the Relationship Between Mobile Phone Use and Cancer. *Epidemiologia*. https://doi.org/10.3390/epidemiologia7030086

Also see **Long-Term Cell Phone Use Increases Brain Tumor Risk**

Tumor risk studies

Interphone Study Group (2010) Brain tumour risk in relation to mobile phone use: results of the Interphone international case-control study. *Int J Epidemiol*. http://bit.ly/2MzsceR
Interphone Study Group (2011) Acoustic neuroma risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. *Cancer Epidemiol*. http://bit.ly/2Ix7BlQ
Aydin et al (2011) Mobile phone use & brain tumors in children & adolescents: a multi-center case-control study. (CEFALO Study). *JNCI*. http://bit.ly/31j0JBa
Hardell et al (2013) Case-control study of the association between malignant brain tumours diagnosed between 2007 and 2009 and mobile and cordless phone use. *Int J Oncology*. http://bit.ly/2ZaVJg5
Hardell et al (2013) Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997-2003 and 2007-2009 and use of mobile and cordless phones. *Int J Oncology*. http://bit.ly/31gbDaO
Coureau et al (2014) Mobile phone use and brain tumours in the CERENAT case-control study. *Occup Envi Med*. http://bit.ly/1DWgzRi
Grell et al (2016) The intracranial distribution of gliomas in relation to exposure from mobile phones: Analyses from the INTERPHONE Study. *Am J Epidemiol*. http://bit.ly/2ZcawHu

Also see: Acoustic neuroma risk and cell phone use studies and Should Cellphones Have Warning Labels?

Breast cancer

West et al (2013) Multifocal breast cancer in young women with prolonged contact between their breasts and their cellular phones. *Case Rep Med*. http://bit.ly/2WW8n52
Shih et al (2020) The association between smartphone use and breast cancer risk among Taiwanese women: A case-control study. *Cancer Manag Res*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7605549/
Tahmasebi et al (2025) Radiofrequency radiation from mobile phones and the risk of breast cancer: A multicenter case–control study with an additional suspected comparison group. *J Res Medical Sciences*. https://bit.ly/4pwyn15

Brain tumor incidence trends

Inskip et al (2010) Brain cancer incidence trends in relation to cellular telephone use in the United States. *Neuro Oncology*. http://bit.ly/2K6rEuz

Zada et al (2012) Incidence trends in the anatomic location of primary malignant brain tumors in the United States: 1992-2006. World Neurosurg. http://bit.ly/2Wq1Dbm

Hardell & Carlberg (2015) Increasing rates of brain tumours in the Swedish National Inpatient Register & the Causes of Death Register. *Int J Envir Res Public Health*. http://bit.ly/1aDHJm

Devocht (2016) Inferring the 1985–2014 impact of mobile phone use on selected brain cancer subtypes using Bayesian structural time series and synthetic controls. *Environ Int*. http://bit.ly/2jJlbZu corrigendum (2017): http://bit.ly/2Cuq2nU

Hardell & Carlberg (2017) Mobile phones, cordless phones and rates of brain tumors in different age groups in the Swedish National Inpatient Register and the Swedish Cancer Register during 1998-2015. *PLOS One*. http://bit.ly/H-C2017

Philips et al (2018) Brain tumours: Rise in Glioblastoma Multiforme incidence in England 1995-2015 suggests an adverse environmental or lifestyle factor. *J Environ Public Health.* http://bit.ly/2KIY4aI

Also see: Brain Tumor Rates Are Rising in the US: The Role of Cell Phone & Cordless Phone Use

Mechanisms

Ruediger (2009) Genotoxic effects of radiofrequency electromagnetic fields. *Pathophysiology*. http://bit.ly/2EXGaRb

Behari (2010) Biological responses of mobile phone frequency exposure. *Indian J Exp Biology*. http://bit.ly/2Xx0Gzr

Giuliani and Soffritti (2010). Nonthermal effects and mechanisms of interaction between electromagnetic fields and living matter. ICEMS Monograph. Ramazzini Institute. 403 pp. http://bit.ly/2HUnO7R

Juutilainen et al (2011) Review of possible modulation-dependent biological effects of radiofrequency fields. *Bioelectromagnetics*. http://bit.ly/2MAQ7KJ

Volkow et al (2011) Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. *JAMA*. http://bit.ly/2KyjIBT

Pall (2013) EMFs act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. *J Cell Mol Med*. http://bit.ly/2K5yO2e

Calderon et al (2014) Assessment of extremely low frequency magnetic field exposure from GSM mobile phones. *Bioelectromagnetics*. http://bit.ly/2EA1N7e

Dasdag & Akdag (2015) The link between radiofrequencies emitted from wireless technologies & oxidative stress. *J Chem Neuroanat*. http://bit.ly/2EXN88W

Yakymenko et al (2016) Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation. *Electromagnet Biol Med*. http://bit.ly/2qCGM4F

Barnes & Greenenbaum (2016) Some effects of weak magnetic fields on biological systems: RF fields can change radical concentrations and cancer cell growth rates. *IEEE Power Electronics J*. http://bit.ly/1WvQGiY

Tamrin et al (2016) Electromagnetic fields and stem cell fate: When physics meets biology. *Rev Physiol Biochem Pharmacol*. http://bit.ly/2b6Ht3y

Terzi et al (2016) The role of electromagnetic fields in neurological disorders. *J Chem Neuroanat*. https://bit.ly/3j9if6b

Havas (2017) When theory and observation collide: Can non-ionizing radiation cause cancer? *Environ Pollution*. http://bit.ly/2DssMS2

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Hinrikus et al (2018) Understanding physical mechanism of low-level microwave radiation effect. *Int J Radiation Biol*. http://bit.ly/2EwNyoU

Mortazavi et al (2019) Evaluation of the validity of a nonlinear J-shaped dose-response relationship in cancers induced by exposure to radiofrequency electromagnetic fields. *J Biomed Phys Eng*. http://bit.ly/37FlDxP

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Bertagna et al (2021) Effects of electromagnetic fields on neuronal ion channels: a systematic review. *Annals of the New York Academy of Sciences*. https://bit.ly/2R3TigS

Panagopoulos et al (2021) Human-made electromagnetic fields: Ion forced-oscillation and voltage-gated ion channel dysfunction, oxidative stress and DNA damage (Review). *Int J Oncol*. https://www.spandidos-publications.com/ijo/59/5/92

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Leković Ž. Electromagnetic fields and oxidative stress: The link to the development of cancer, neurological diseases, and behavioral disorders. *Electromagn Biol Med*. 2025 Oct 21:1-25. https://doi.org/10.1080/15368378.2025.2567872

Panagopoulos et al (2026). Recording the extremely low frequency pulsations of wireless communication electromagnetic fields. *Electromagn Biol Med*. 2026 Apr 19:1-10. https://www.tandfonline.com/doi/full/10.1080/15368378.2026.2654072

Reproductive Health Effects

LaVignera et al (2011) Effects of the exposure to mobile phones on male reproduction: a review of the literature. *J Andrology*. http://bit.ly/2wL7zRO

Aldad et al (2012) Fetal radiofrequency radiation exposure from 800-1900 Mhz-rated cellular telephones affects neurodevelopment and behavior in mice. *Science Reports*. http://bit.ly/2Z6H45I

Divan et al (2012) Cell phone use and behavioural problems in young children. *J Epidemiol Commun Health*. http://bit.ly/2EV1bw8

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Kim et al (2021) Effects of mobile phone usage on sperm quality – No time-dependent relationship on usage: A systematic review and updated meta-analysis. *Environ Research*. https://bit.ly/3squsu2

Kaur et al (2023) Genotoxic risks to male reproductive health from radiofrequency radiation. *Cells*. https://bit.ly/3PbbIaU

Also see: Effect of Mobile Phones on Sperm Quality and Pregnancy & Wireless Radiation Risks

Electromagnetic Hypersensitivity

See: Electromagnetic Hypersensitivity

Exposure & Exposure Limits

Kelsh et al (2010) Measured radiofrequency exposure during various mobile-phone use scenarios. *J Exposure Sci Environ Epidemiol*. http://bit.ly/2IuYH8s

Gandhi et al (2012) Exposure limits: the underestimation of absorbed cell phone radiation, especially in children. *Electromagnetic Biol Med*. http://bit.ly/2EZilbN

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Schmid & Kuster (2015) The discrepancy between maximum in vitro exposure levels and realistic conservative exposure levels of mobile phones operating at 900/1800 MHz. *Bioelectromagnetics*. http://bit.ly/31j46be

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Also see: Wireless Radiation Exposure Limits
International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF)
Study: Wireless radiation exposure for children should be hundreds of times lower than federal limits (based on NTP study)
What's Wrong with Cell Phone Radiation Exposure Limits? (SAR)
Children are more exposed to cell phone radio-frequency radiation than adults

Genetic Effects

Lai H (2021) Genetic effects of non-ionizing electromagnetic fields. *Electromagnetic Biol Med*. https://www.tandfonline.com/doi/abs/10.1080/15368378.2021.1881866

Weller et al (2025) A scoping review and evidence map of radiofrequency field exposure and genotoxicity: assessing in vivo, in vitro, and epidemiological data. *Front. Public Health.* https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2025.1613353/full

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Blood-Brain Barrier Studies

Effects of Wireless Radiation on the Blood-Brain Barrier

AirPods: Are Apple's New Wireless Earbuds Safe? (Blood-Brain Barrier Effects)

5G and Millimeter Wave Studies

5G Wireless Technology: Is 5G Harmful to Our Health?

5G Wireless Technology: Millimeter Wave Health Effects

Other

Huss et al (2007) Source of funding and results of studies of health effects of mobile phone use: systematic review of experimental studies. *Environ Health Perspec*. http://bit.ly/2wBEmYp

Fragopoulou et al (2010) Scientific panel on electromagnetic field health risks: consensus points, recommendations, and rationales. *Rev Environ Health*. http://bit.ly/2tWiXHP

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Also see:

Effects of Exposure to Electromagnetic Fields (study abstracts published from 1990-2026)
Recent Research on Wireless Radiation and Electromagnetic Fields (3000 abstracts from 2016-2026)

Does long-term exposure to 4G LTE cell phone radiation impair cell phone users' health?
Effects of Cell Phone Use on Adolescents
Hybrid & Electric Cars: Electromagnetic Radiation Risks
Cell Tower Health Effects
Cell Phone Towers are Largest Contributor to Environmental Radiofrequency Radiation
Recent Research on WiFi Effects

Effects of Wireless Radiation on Birds and Other Wildlife
Electromagnetic fields threaten wildlife

International Scientist Appeal on Electromagnetic Fields & Wireless Technology
International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF)
International Agency for Research on Cancer (WHO) Position on Radiofrequency Radiation
WHO Radiofrequency EMF Health Risk Assessment Monograph (EHC series)
ICNIRP's Exposure Guidelines for Radio Frequency Fields

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