Research Gaps on RF/EMF and Public Health

Comment on the HHS Request for Information on EMFs, RF Radiation, and Wireless Radiation Exposure
Docket HHS-OASH-2026-0397
Submitted by Nick Pineault (The EMF Guy), October 2026

Perspective (Question 2)

I am submitting as an individual: a citizen journalist who has spent about 16 years in independent investigative work, the last 10 focused on electromagnetic radiation and health. I am the author of *The Non-Tinfoil Guide to EMFs*, the host of the Smarter Tech podcast, the organizer of the EMF Hazards Summit, and the director of *Body Burden*, a documentary about environmental medicine. Over the past decade I have interviewed more than 100 scientists, physicians and engineers working on this question, and I hear every week from members of the public who believe their health has been affected by wireless exposures.

I am not a scientist. My contribution here is to point to the places where, after a decade of reading the literature and talking with the researchers who produce it, I see the largest unanswered questions. Each section below names the RFI question(s) it responds to.

My perspective is this. Our RF safety standards rest on the wrong assumption, that the only effect worth preventing is tissue heating, and that assumption is one reason these research gaps stay open. Guidelines built on it have created a culture of "no effect" that runs through society, from individuals to government leaders to researchers and regulatory agencies. If the official position is that nothing happens below the heating threshold, there is no reason to fund the study of what happens below it, and this topic was systematically defunded as a result.

The current science carries a great deal of uncertainty, and much of it exists because the studies that would resolve it were never done. The gaps below are areas where human exposure is now nearly universal and where the research is completely inadequate to protect the public. Meanwhile the technology rolls out at a rate that outpaces our ability to study it: 5G, satellite constellations, the Internet of Things and 6G are being deployed faster than any research program could follow, while the research itself is stalling.

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1. Combined exposures and the exposome (Questions 16, 18, 5o)

Nobody is exposed to wireless radiation in isolation. People live with RF exposure alongside heavy metals, pesticides, mold and mycotoxins, plastics, air pollution and pharmaceuticals. In environmental medicine practice, the patients who report symptoms associated with wireless devices (EMR syndrome) are very often the same patients carrying a high body burden of other toxicants. Yet almost all RF research tests one exposure at a time.

Dr. Ronald Kostoff and colleagues have documented this gap directly. Their review of the biomedical literature found a substantial body of studies in which the biological effects of electromagnetic fields were modified when combined with other agents, including chemicals, drugs and other physical stressors (Kostoff & Lau, 2013). Kostoff later argued that safety testing of 5G and earlier wireless technologies does not reflect real-life conditions, because it ignores the combined effects of RF with the other toxic stressors people actually carry (Kostoff et al., 2020).

Research needed:

- Funded studies of combined exposures (RF plus metals, pesticides, mycotoxins or other common toxicants), designed to detect synergistic effects.
- Inclusion of wireless exposure as a standard variable in exposome research. The exposome concept was created to capture the totality of environmental exposures across the lifespan (Wild, 2005). Today, large exposome and environmental health cohorts routinely measure chemical exposures and rarely record ambient RF levels, Wi-Fi in the home, or daily smartphone use and carrying position. A true control group is hard to find, since almost everyone is exposed. That difficulty is a reason to measure exposure gradients carefully. If wireless exposure is left out of the list of factors that environmental health scientists study, any contribution it makes to chronic disease will stay invisible.
- Training and funding for researchers who can work across disciplines (toxicology, bioelectromagnetics, clinical environmental medicine) on multi-system environmental illness.

2. Real-world exposure measurement and compliance (Questions 7, 8, 5n)

The U.S. has no national program that measures the RF exposure people actually experience in homes, schools and hospitals, and no routine verification that deployed devices and antennas stay within the limits they were certified against. The FCC itself has said it “does not have the resources or the personnel to routinely monitor the emissions” of the transmitters under its jurisdiction, and a 2014 Wall Street Journal investigation found that the agency had issued only two citations to carriers since the rules were adopted in 1996, while engineers who examined more than 5,000 cell sites found about one in ten in violation of the rules meant to keep people away from high-exposure zones (Wall Street Journal, 2014). The FCC does not even keep a database of cell sites.

In 2012, the Government Accountability Office found that the FCC’s limit had not been reassessed in light of current research, and that its testing requirements may not identify the maximum exposure, because phones were tested at a distance from the body rather than in the positions people actually use (GAO-12-771). Body-worn SAR testing has allowed separation distances of up to 2.5 cm. When phones are tested in contact with the body, measured SAR can exceed the limit (Gandhi, 2019); French government testing by ANFR reached similar conclusions.

Research needed:

- A federally funded program of independent, real-world RF measurement (personal exposimetry and area surveys) in homes, schools, hospitals and workplaces, published openly.

- Independent post-market SAR testing of phones and wearables in body-contact positions.
- Exposure metrics that capture what the RFI lists in Question 5p: modulation, pulsing, duty cycle, multiple simultaneous frequencies and cumulative time, instead of averaged power alone.

3. Sleep (Questions 12, 16)

Sleep is one of the most consistent places where human experiments have found effects below current limits. Controlled studies have shown that pulse-modulated RF exposure alters the sleep EEG and regional cerebral blood flow (Huber et al., 2002). Sleep disturbance is also among the most common complaints people report about wireless exposure.

There is a more basic problem. Sleep laboratories and sleep clinics, where our reference data on normal and disordered sleep is produced, are themselves full of wireless exposure: Wi-Fi networks, wireless monitoring equipment, cell signals from nearby antennas, and patients' and technicians' phones. Much of the sleep data that medicine relies on was therefore collected under RF exposure that nobody recorded or controlled. The baseline itself may be polluted.

Research needed:

- Sleep clinic and sleep laboratory experiments run with and without wireless exposure (wired equipment, Wi-Fi off, phones removed, shielded rooms), with participants blinded to the condition, to establish whether RF in the testing environment changes sleep measurements.
- Recording of RF levels as a standard variable in sleep studies.
- Studies of children and adolescents, who now sleep next to phones, tablets and Wi-Fi routers every night.
- Studies of chronic nightly exposure to current 4G, 5G and Wi-Fi signals, including effects on melatonin and next-day cognitive outcomes.
- Population studies that record bedroom wireless exposure alongside sleep quality, since sleep loss is itself a driver of many chronic diseases.

4. The microbiome (Question 16)

The gut microbiome is now recognized as central to immune, metabolic and neurological health, yet there is almost no research on how chronic RF exposure affects it. This matters because people now keep transmitting devices very close to the abdomen for hours on end: phones in pockets and waistbands, laptops and tablets on the lap, and phones resting on the belly in bed.

The entire literature consists of a handful of rodent studies from radiation-protection labs. Two studies from one group in Xi'an found that 4.9 GHz and 3.5 GHz (5G band) fields changed the composition of the gut microbiome and shifted hundreds of metabolites in mice; the 3.5 GHz study also reported anxiety-like behavior and inflammatory changes in the hippocampus (Wang et al., 2024; Zhou et al., 2024). A pulsed 2.45 GHz exposure caused depression-like behavior and gut dysbiosis in mice (Luo et al., 2021). In a French study

of juvenile rats exposed around the clock to 900 MHz at an ambient level about a thousand times below the public limit, the gut flora shifted and gut bacteria (*Enterococcus*) were found in the spleen of two thirds of the exposed animals (Collet et al., 2022, preprint). A Kazakh study reported lower gut diversity and a drop in *Bifidobacterium* in rats housed with a Wi-Fi router (Saliev et al., 2023, preprint). Two of these five papers never reached a peer-reviewed journal, the exposures and designs vary widely, and no microbiome research group, to my knowledge, has taken the question on. There are zero human studies.

Research needed:

- Human studies of the gut, oral and skin microbiome in relation to measured RF exposure and device position on the body, including in infants and children, whose microbiome is still developing.
- Independent replication of the rodent findings at everyday exposure levels, with the involvement of microbiome laboratories.
- Studies of the beneficial bacteria (such as *Lactobacillus* and *Bifidobacterium*) that respond to RF in the early research.

5. Antibiotic resistance, tested in hospitals (Question 16)

Antimicrobial resistance is one of the most serious public health threats we face. A series of laboratory studies, conducted over more than a decade, have reported that exposure to Wi-Fi and mobile phone radiation can change bacterial susceptibility to antibiotics, increase biofilm formation and motility, and alter gene expression in pathogens such as *E. coli*, *Listeria*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and carbapenem-resistant *Klebsiella pneumoniae* (Taheri et al., 2017; Said-Salman et al., 2019; reviewed in Said-Salman et al., *J Biomed Phys Eng*). In one study, 2.4 GHz Wi-Fi exposure changed the expression of 101 genes in *E. coli*, including genes linked to efflux pumps and stress responses (Said-Salman et al., 2019, *Scientific Reports*).

Hospitals are where resistant pathogens and dense wireless infrastructure meet: Wi-Fi, wireless charting carts, wireless monitors and staff phones, around the clock. To my knowledge, no one has studied whether that environment influences resistance or biofilm formation in the real world. This is urgent research that almost no one is doing.

Research needed:

- Studies inside hospital settings comparing resistance profiles, biofilm formation and persistence of pathogens under different measured RF environments.
- Replication of the laboratory findings by independent U.S. microbiology labs, with careful temperature control.

6. Pregnancy and prenatal exposure (Question 11b)

Today’s children are the first generation exposed to wireless radiation from conception. Dr. Hugh Taylor, chair of Obstetrics, Gynecology and Reproductive Sciences at Yale, showed that mice exposed in utero to

radiation from a cellular phone developed hyperactivity, increased anxiety and impaired memory, with changes in neuronal function in the prefrontal cortex (Aldad et al., 2012). In humans, analyses of the Danish National Birth Cohort found associations between prenatal and early-childhood phone exposure and later behavioral problems (Divan et al., 2008; 2012). These studies were never followed by the large prospective research they called for.

Research needed:

- Prospective birth cohorts that measure RF exposure during pregnancy (phones carried on the abdomen, laptops on the lap, Wi-Fi at home and work) and follow neurodevelopment, ADHD and behavioral outcomes.
- Animal studies replicating and extending the Yale findings with current 4G, 5G and Wi-Fi signals.
- Clear guidance for pregnant women while the research is done.

7. Fertility and phones carried in pockets (Questions 5p, 9, 11)

Male fertility has declined sharply worldwide, and phone use has been associated with reduced sperm quality in multiple meta-analyses. The largest population study to date, of 2,886 young Swiss men, found that men who used their phone more than 20 times a day had about 21% lower sperm concentration than men who used it once a week or less (Rahban et al., 2023). That study could not settle whether carrying the phone in a trouser pocket matters, because so few men reported carrying their phone away from their body. In other words, almost every young man now carries a transmitting device next to his reproductive organs, and there is no unexposed comparison group left.

Research needed:

- Studies with objective measurement of carrying position and exposure (rather than questionnaires), including female fertility and egg quality, which has received far less attention.
- Disclosure to consumers of the separation distance used in SAR testing, and of what happens to exposure when a phone is carried in a pocket.

8. Cancers in the body regions where phones are now carried (Questions 12, 11a)

If RF radiation is a possible carcinogen when the phone is held to the head (IARC Group 2B, 2011), there is no biological reason the concern stops at the head. Over the past 15 years, phones have moved from the ear to the trouser pocket, the waistband and the bra. Researchers have raised the possibility that this shift is relevant to cancers in those body regions. Dr. De-Kun Li, a senior epidemiologist at Kaiser Permanente, has proposed that phones carried in front and back pockets, near the rectum and distal colon, deserve investigation as a factor in rising early-onset colorectal cancer. Dr. Devra Davis and colleagues have drawn attention to a case series of multifocal breast cancers in young women who habitually carried phones in their bras (Miller et al., 2019).

Meanwhile, early-onset colorectal cancer is rising in adults under 50 (Siegel et al., 2023), gastrointestinal cancers are increasing fastest among younger adults (Koh et al., 2023), and testicular cancer incidence has risen for decades. To my knowledge, no study has examined phone carrying position as a variable in any of these trends.

Research needed:

- Case-control studies of early-onset colorectal, testicular and other cancers of the abdomen and pelvis that record lifetime phone carrying position and duration.
- Inclusion of carrying position in existing cancer cohort questionnaires.

9. Devices worn in the ear and on the head (Questions 13f, 11)

A large share of the population, including children, now wears wireless transmitters in or against the head for hours a day: Bluetooth earbuds such as AirPods, Bluetooth hearing aids, Bluetooth earpieces and headphones, and now smart glasses and virtual reality headsets. These devices transmit at lower power than phones, but they sit in the ear canal or against the skull, close to the brain, for long continuous periods, often in pairs that communicate with each other through the head.

There is essentially no research on their long-term effects. Physicians in environmental medicine have reported seeing young patients with health problems those patients trace to their earbuds. Earlier phone research had already found associations between long-term mobile phone use and tinnitus (Hutter et al., 2010) and parotid gland tumors (Sadetzki et al., 2008).

My specific concerns are tinnitus, enlarged lymph nodes in the neck, and hearing loss. The hearing loss question deserves a careful look. Earbuds already carry two recognized risks: ear infections from a device sitting in the canal, and noise damage from loud sound delivered directly to the eardrum. What has never been examined is whether the RF transmitter in the same earbud changes the equation. RF exposure produces oxidative stress in laboratory studies, and oxidative stress is also one of the mechanisms behind noise-induced hearing loss. So the question is whether a sound that is safe at a given decibel level stays safe when it is delivered alongside a source of oxidative stress sitting in the ear. In other words, does wireless radiation make the damage from loud sound worse? I have not found any literature that crosses these two fields, and hearing experts are the right people to look for it or produce it.

Research needed:

- Review by hearing scientists of the literature on noise-induced hearing loss and on RF-induced oxidative stress, and studies testing whether the safe decibel threshold shifts when sound is combined with RF exposure in the ear.
- Studies of in-ear and head-worn wireless devices and tinnitus, hearing loss, enlarged lymph nodes, cognitive function, headaches, and cancers of the head and neck region.
- Exposure assessment for these devices under real use (both earbuds transmitting, many hours a day, in children).

- Particular attention to hearing aid users, who are often older adults and cannot simply stop wearing their device.

10. Cell towers near schools, hospitals and sensitive populations (Questions 15a, 15b, 11)

Several studies from different countries have reported more symptoms (headaches, sleep problems, fatigue, difficulty concentrating) among people living within a few hundred meters of base stations (Santini et al., 2002; Navarro et al., 2003; Oberfeld et al., 2004), higher cancer mortality near antennas (Dode et al., 2011), DNA damage in residents near base stations (Zothansiama et al., 2017), and cognitive effects in students at schools near towers (Meo et al., 2019). These studies are small and need replication, and that is exactly the problem: in the 30 years since Section 704 of the Telecommunications Act of 1996 barred state and local governments from regulating the placement of wireless facilities on the basis of the environmental effects of RF emissions, the U.S. has not funded the research that would tell communities whether proximity matters.

Other countries have decided not to wait. Chile's 2012 antenna law (Law 20.599) bars towers from "sensitive areas" containing schools, nurseries, hospitals, clinics and nursing homes, and from a buffer of four times the tower height, with a minimum of 50 meters, from their boundary. Switzerland's Ordinance on Non-Ionising Radiation sets an installation limit of 4 to 6 V/m for mobile antennas at "places of sensitive use" (homes, schools, hospitals and workplaces), roughly ten times stricter in field strength than the ICNIRP reference levels the U.S. limits resemble, as a stated precaution. These rules are themselves an opportunity: populations living under different siting regimes could be compared.

Research needed:

- Well-designed U.S. studies, with measured exposure, of children in schools and childcare facilities near towers and small cells, and of residents with antennas close to their homes.
- Cumulative neighborhood exposure mapping as small-cell density increases.

11. Pollinators and insects (Question 14)

To my knowledge, no RF exposure standard anywhere was designed with wildlife in mind. A three-part review of the literature on flora and fauna concluded that "no such standards take wildlife into consideration," that U.S. standards are "human-centric," and that any assumed protection of wildlife "is purely hypothetical at the ecosystem level" (Levitt, Lai & Manville, 2021). The authors recommend recognizing ambient EMF as a novel form of pollution.

Insects are especially relevant. Modeling shows that insects absorb much more RF power as frequencies rise above 6 GHz, the direction in which 5G and future 6G networks are moving (Thielens et al., 2018). Honey bee experiments have reported behavioral responses such as worker piping near active phones (Favre, 2011). Pollinators are essential to the food supply, yet there is almost no controlled field research on how they respond to modern network densities.

Research needed:

- Field studies of honey bees and wild pollinators under measured RF exposure, especially at 5G and future 6G frequencies.
- Assessment of RF as an environmental pollutant in federal environmental reviews of network deployment.

Closing

The people who write to me are not asking for certainty. They are asking why, after decades of rapid growth in wireless exposure, so many basic questions about sleep, pregnancy, fertility, the microbiome, our children's schools and our hospitals have never been studied. A federal research program built around these gaps would serve everyone, including the industry, by replacing uncertainty with data.

But research alone is not the answer, because it is very unlikely that these questions will be settled on a short-term basis, even with a massive effort. That is exactly the situation the precautionary principle was written for. When the science is uncertain and the potential harm is serious, exposure should be minimized now and the public should be given informed consent. Literally hundreds of scientists have asked governments to do this. The International EMF Scientist Appeal, signed by more than 240 scientists who have published peer-reviewed research on non-ionizing EMF, calls for precautionary measures and biologically based exposure limits, and the 5G Appeal, signed by more than 250 scientists and medical doctors, calls for a moratorium on 5G until its effects have been studied.

The opposite has happened. Governments have treated faster wireless deployment as an economic priority, which gives them a financial incentive to be part of this pollution problem and to make it worse. That needs to stop. Further technological development needs guardrails in place before deployment, or the rollout of 6G, the Internet of Things, satellite constellations and every other new source of wireless radiation will create more problems faster than anyone can study them.

Thank you for opening this question to the public.

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