Response to HHS Request for Information on Electromagnetic Fields (EMFs), Radiofrequency Radiation, and Wireless Radiation Exposure

Docket HHS-OASH-2026-0397

Thank you for the opportunity to comment on the scientific evidence concerning electromagnetic fields (EMFs), including radiofrequency electromagnetic fields (RF-EMF), and human health.

In evaluating this literature, I encourage HHS to place greatest weight on well-conducted systematic reviews together with large, well-designed human epidemiologic studies. Individual observational studies, animal experiments, in-vitro studies, and narrative reviews can identify hypotheses and research needs, but should not outweigh high-quality syntheses of human evidence when assessing risks to human health.

Question 5 - Exposure standards and risk assessment

Federal health agencies should consider established national and international exposure frameworks, including the 2020 International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, while evaluating the underlying evidence and research published subsequently.[1]

The European Commission's Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), after reviewing evidence concerning RF frequencies from 100 kHz to 300 GHz, reported that it could not identify moderate or strong evidence of adverse health effects from chronic or acute exposure below the applicable limits. SCHEER recommended technical revision of European standards to incorporate advances in dosimetry and exposure assessment.[2]

A federal assessment should therefore distinguish between two related but scientifically separate questions:

1. whether exposure standards or measurement methods should be technically updated to account for evolving technologies, frequencies, dosimetric quantities, beamforming, pulsed or modulated exposures, localized exposures, and other characteristics; and
2. whether scientific evidence demonstrates adverse human health effects at exposure levels below existing limits.

Modernization of exposure metrics or standards does not by itself establish that exposures permitted under existing standards cause adverse health effects.

Natural versus anthropogenic electromagnetic fields

HHS should also distinguish the source of an electromagnetic field from the physical characteristics of the exposure. An electromagnetic field does not acquire an intrinsic biological property of being harmful simply because it originates from a technological rather than natural source.

Biological interactions must ultimately depend on measurable characteristics of the field and exposure, such as frequency or wavelength, field strength or absorbed dose, polarization, modulation, waveform or temporal structure, spatial distribution, duty cycle, and duration of exposure.

Consequently, comparisons between "natural" and "man-made" EMFs do not by themselves establish either safety or harm. Claims that technologically generated fields produce distinctive biological effects should identify the specific physical characteristic proposed to cause that difference - for example,

modulation, polarization, pulsing, intensity, or exposure pattern - and that characteristic should be experimentally testable.

Terms such as "man-made radiation" or "anthropogenic EMF" can imply a scientifically meaningful category of biological exposure when the relevant question is instead whether particular measurable characteristics of that exposure alter biological or health outcomes.

Questions 6 and 12 - Evidence regarding adverse effects at or below current exposure limits

The strongest recent human evidence does not establish adverse health effects from typical RF exposures below current limits for the outcomes that have been most extensively investigated.

Cancer associated with mobile-phone use is among the most extensively investigated RF-health hypotheses. A 2024 systematic review of human observational studies concluded, with moderate certainty, that near-field RF exposure to the head from mobile-phone use likely does not increase the risk of glioma, meningioma, acoustic neuroma, pituitary tumors, salivary-gland tumors, or pediatric brain tumors. The evidence did not indicate increasing risk with longer duration of mobile-phone use, cumulative call time, or cumulative number of calls.[3]

These findings are supported by the large prospective COSMOS cohort study. Among more than 250,000 participants, cumulative mobile-phone call time was not associated with increased risks of glioma, meningioma, or acoustic neuroma, including among participants with long histories of mobile-phone use.[4]

Recent systematic reviews of other human outcomes similarly emphasize the importance of distinguishing isolated positive findings from reproducible health effects. Reviews addressing self-reported symptoms, cognition, and female reproductive outcomes have generally not established consistent adverse effects attributable to RF exposure. [5-7]

Mechanistic, cellular, and animal evidence

Experimental studies remain useful for identifying possible mechanisms and generating hypotheses. However, evidence that an exposure produces a cellular, biochemical, or animal response is not equivalent to evidence that the exposure causes disease in humans.

HHS should give greatest weight to evidence directly involving humans. Animal and in-vitro findings become more informative when they converge with compatible human epidemiologic evidence, relevant exposure and dose relationships, and a plausible mechanism.

Where such convergence is absent, experimental findings are more appropriately characterized as signals or hypotheses requiring investigation.

The same distinction applies to proposed non-thermal mechanisms. Changes in calcium signaling, reactive oxygen species, gene expression, or other biomarkers may identify biological responses but do not necessarily constitute adverse health effects.

Hypotheses have been proposed in which RF/EMF exposure affects voltage-gated ion channels, intracellular calcium, and oxidative stress. Such hypotheses are scientifically testable. Their evidentiary status, however, should be distinguished from their plausibility as proposed mechanisms.

This is particularly relevant because a 2024 systematic review specifically examining RF-EMF exposure and biomarkers of oxidative stress in experimental studies concluded that the evidence was

inconsistent and of overall very low certainty.[8] Thus, currently available oxidative-stress findings do not provide a strong independent basis for inferring adverse health effects in humans.

Question 16 - Federal research priorities

Federal research priorities should consider not only whether a hypothesis can be investigated further, but also how extensively it has already been tested and whether additional studies are reasonably likely to change scientific understanding or public-health practice.

Avoid repeatedly testing mature hypotheses without a compelling new rationale

Some EMF-health hypotheses have now been investigated for decades. The hypothesis that ordinary mobile-phone use causes the major brain and head tumors most frequently studied is an important example.

Large human studies and recent systematic reviews have not demonstrated increased risks of glioma, meningioma, acoustic neuroma, or several other tumors. For these well-studied exposure-outcome relationships, additional studies that substantially reproduce previous epidemiologic designs should generally be a lower federal research priority. [3,4]

A similar principle applies to extremely-low-frequency (ELF) magnetic fields and childhood leukemia. This association has been investigated for several decades and illustrates the importance of considering not only relative-risk estimates but also exposure prevalence, consistency over time, causality, and potential population impact when setting research priorities.

Earlier pooled analyses reported an association at sustained residential magnetic-field exposures of approximately >=0.3-0.4 microtesla. For example, a 2000 pooled analysis reported an approximately twofold relative risk at >=0.4 microtesla.[9] However, exposure at this level was uncommon: fewer than 1% of children included in those studies were in the >=0.4 microtesla exposure category.[11] Another pooled analysis of studies published after 2000 found that fewer than 0.5% of participating children were exposed at >=0.3 microtesla.[11] These study-population prevalences demonstrate that sustained residential exposure in the range associated with the historical epidemiologic signal is uncommon.

More recent epidemiologic evidence has also weakened the association. A 2022 pooled analysis combined individual-level data from four recent studies comprising 24,994 childhood leukemia cases and 30,769 controls. It found essentially no association at >=0.4 microtesla compared with <0.1 microtesla (OR 1.01). When the three major pooled analyses conducted over time were considered together, the summary OR was 1.45 (95% CI 0.95-2.20), and the investigators noted a declining association over successive generations of studies.[10]

The potential population burden is correspondingly small even under the assumption that the earlier association was causal. A U.S.-focused pooled analysis estimated that approximately 3% of childhood leukemia might have been attributable to residential magnetic-field exposure, but the estimate was highly uncertain (95% CI -2% to 8%) and was explicitly dependent on treating the observed association as causal.[12] Older population-attributable-fraction estimates should not be interpreted as estimates of the number of childhood leukemia cases currently caused by ELF exposure.

It is also important to distinguish measured residential ELF magnetic-field exposure from residence near high-voltage power lines. Magnetic fields arise from multiple components of the electrical system and electrical devices, while distance from a transmission line is an imperfect surrogate for individual magnetic-field exposure. The scientific hypothesis concerns magnetic-field exposure, not high-voltage infrastructure itself.

Taken together these findings indicate that the putative high-exposure category is uncommon, that causality remains unestablished after decades of research, that the association has weakened in more recent studies, and that even earlier estimates implied a relatively small potential population burden. These considerations reduce the likely scientific and public-health return from simply conducting additional conventional observational studies of power-line proximity or residential ELF exposure.

Additional federal investment in this question should therefore preferentially support studies capable of resolving a specific remaining uncertainty rather than adding another broadly similar epidemiologic study to an already extensive literature.

Persistence of public concern should not by itself cause a scientific hypothesis to remain a high research priority indefinitely. Research prioritization should consider:

- the quality and quantity of existing evidence;
- consistency across high-quality human studies;
- prevalence of the exposure and plausible magnitude of population health impact;
- the magnitude and public-health significance of remaining uncertainty;
- whether a new study could realistically resolve that uncertainty;
- whether the proposed exposure differs materially from exposures already studied; and
- the potential consequences if the existing conclusion proves incorrect.

Terms such as "man-made," "wireless radiation," "pulsed," "modulated," "5G," or "6G" should not by themselves be considered sufficient reasons to repeat previously tested health hypotheses. A proposed new exposure characteristic should be physically defined, shown to differ meaningfully from exposures already studied, and supported by a credible rationale for expecting a different biological or health outcome.

Prioritize implementation research for established electromagnetic-radiation hazards

Federal research priorities should also distinguish uncertain or low-probability EMF risks from electromagnetic-radiation hazards for which substantial human evidence already demonstrates preventable disease. Ultraviolet (UV) radiation from the sun and artificial tanning devices is an established cause of skin cancer, and effective preventive measures include reducing excessive UV exposure, using sunscreen together with other sun-protective behaviors such as protective clothing and shade, and avoiding indoor tanning.[13,14] Accordingly, applied and implementation research aimed at increasing adoption and sustained use of effective sun-protection measures, reducing intentional UV exposure and indoor tanning, and identifying interventions that reach populations at greatest risk may offer greater and more immediate public-health benefit. Research agendas addressing the health effects of electromagnetic radiation should therefore consider opportunities to translate well-established causal evidence into measurable reductions in preventable disease.[13,14]

Deprioritize research unlikely to produce actionable public-health benefits

Some exposures may warrant relatively little additional general-population research because they are ubiquitous, minimally modifiable, and unlikely to yield actionable interventions. Ground-level cosmic ionizing radiation is one example. Ordinary ground-level cosmic-radiation exposure is low - averaging about 0.34 mSv per year in the United States - and CDC considers this dose unlikely to affect human health.[15] Geographic or ecological studies are particularly susceptible to confounding by altitude, latitude, socioeconomic, environmental, and population characteristics. Higher exposures experienced by aircrew and astronauts constitute a distinct occupational or space-medicine question. In the absence of a reproducible human health signal at ordinary terrestrial exposure levels, additional studies of small geographic variations in ground-level cosmic radiation represent a low federal research priority, because the exposure is largely unavoidable and opportunities for population-level intervention are

minimal. Research prioritization should consider not merely whether an exposure can be studied, but whether further study has a reasonable prospect of reducing an important and preventable burden of disease.[15]

Areas where additional research may provide greater value

Federal research resources may have greater scientific value when directed toward questions that remain genuinely unresolved or for which technological changes have created materially different exposure conditions. Priorities could include:

1. **Improved exposure assessment.** Prospective human studies should move beyond self-reported device use where feasible and incorporate objective or modeled dosimetry, including frequency, intensity, modulation, duty cycle, distance, localized absorbed dose, and cumulative exposure.
2. **New exposure configurations.** Research on newer technologies should focus on exposure characteristics that are genuinely different from those already studied, rather than assuming that each new generation of wireless technology creates an entirely new biological hazard question.
3. **Long-term prospective human research where meaningful uncertainty remains.** Existing cohorts can be particularly valuable when they allow examination of new exposure patterns or outcomes without recreating research programs addressing questions already studied adequately.
4. **Mechanistic research tied to human evidence.** Mechanistic hypotheses involving ion channels, oxidative stress, membrane effects, modulation, polarization, or other non-thermal interactions should receive greatest priority when there is a reproducible human health signal requiring explanation.
5. **Replication and reproducibility.** Where potentially important findings emerge, confirmatory studies should use accurate dosimetry, appropriate controls, blinding where feasible, prespecified analyses, adequate statistical power, and independent replication.
6. **Evidence synthesis and surveillance.** Periodically updated systematic reviews may sometimes provide greater value than additional small primary studies, particularly in mature research areas with large but heterogeneous literatures.

Question 18 - Additional considerations for evidence evaluation and communication

HHS should explicitly distinguish at least three evidentiary categories when evaluating and communicating RF/EMF evidence:

Established effects: RF energy at sufficiently high intensities can produce adverse effects through tissue heating and related mechanisms. Existing exposure standards are designed in substantial part to protect against established effects.

Unresolved or emerging questions: Particular newer exposure configurations, outcomes with inadequate human data, and specific mechanistic hypotheses may warrant additional investigation when there is a credible scientific rationale.

Claims not supported by strong human evidence: For extensively investigated exposures and outcomes - including ordinary mobile-phone use and the major brain tumors most frequently studied - current human evidence does not establish the claimed causal relationship.

HHS should also consider establishing an explicit evidence-evaluation framework before drawing conclusions from individual submissions to this RFI. Such a framework could specify the relative

evidentiary roles of systematic reviews, prospective cohort studies, case-control studies, controlled human experiments, animal studies, in-vitro experiments, mechanistic studies, and case reports.

For assessments of human health risk, well-designed human evidence should ordinarily receive the greatest weight. Experimental and mechanistic evidence should inform interpretation, particularly when it converges with human findings, but should not automatically be treated as equivalent evidence of human disease.

The framework should also distinguish:

3. Does an exposure produce a measurable biological effect?
4. Does that effect constitute or plausibly lead to an adverse health outcome?
5. Is the adverse outcome demonstrated in humans under relevant exposure conditions?

Finally, federal research agendas should recognize that scientific uncertainty can never be reduced to zero. The appropriate goal is therefore not to continue investigating every proposed association indefinitely, but to allocate finite research resources according to the strength of existing evidence, importance of remaining uncertainty, feasibility of resolving it, and likely public-health value of the resulting information.

This approach would permit continued investigation of genuinely emerging questions while recognizing when decades of research have substantially answered earlier ones.

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