October 21, 2026

Environmental Working Group's comments to the Department of Health and Human Services (HHS) and the Federal Communications Commission (FCC)

Re: HHS Request for Information on Electromagnetic Fields (EMFs), Radiofrequency (RF) Radiation, and Wireless Radiation Exposure (HHS-OASH-2026-0397), and FCC docket 13-84 "Reassessment of human exposure limits to radiofrequency electromagnetic fields"
Submitted electronically to
https://www.fcc.gov/ecfs, and
https://www.regulations.gov/docket/HHS-OASH-2026-0397

EWG urges the Department of Health and Human Services (HHS) and the Federal Communications Commission (FCC) to collaborate on developing updated regulations for radiofrequency (RF) radiation emitted by wireless devices. These standards must protect public health, particularly for children, who face lifetime exposures starting before birth. According to projected technological growth, current and future generations will experience continuous, lifelong exposure to RF emitting devices.

Existing U.S. standards for general public exposure to wireless radiation were established by the FCC in 1996, prior to the widespread adoption of home Wi-Fi routers and smartphones, and before round-the-clock RF radiation exposure became standard for children and youth. The FCC standard relies on outdated data from short-term animal behavioral studies, which do not reflect modern exposure patterns or adequately safeguard children's health. Given extensive research demonstrating adverse health effects from RF radiation including harm to the nervous system, harm to the reproductive system and elevated risk of cancer, a public-health-focused reassessment of exposure limits is essential and urgent.

With this comment letter, EWG emphasizes that federal regulations of electromagnetic fields' emitting devices must be revised so they would (1) adequately protect both children and adults from radiofrequency radiation emitted by consumer products, (2) reflect actual current use patterns, and (3) provide meaningful consumer disclosure without preempting states from requiring additional disclosure. EWG previously submitted these recommendations to the FCC in our prior comment letters, which are attached in the Appendix of this letter.

Current U.S. exposure limits for RF radiation are based on research from the 1970s and 1980s that observed behavioral changes in laboratory animals following brief exposures lasting minutes to hours. Scientific understanding of the health impacts of electromagnetic fields has advanced significantly since the Telecommunications Act of 1996 was enacted, alongside a dramatic increase in everyday exposures to radiofrequency radiation from devices now ubiquitous in homes, schools, and workplaces.

Both epidemiological and animal studies have linked radiofrequency radiation exposure to harmful health effects. These harmful health effects associated with radiofrequency radiation may be caused by changes in the activity of voltage-gated calcium channels, changes in the concentrations of reactive oxygen species and redox homeostasis, changes in intracellular enzymes and gene expression, disruption of the blood-brain barrier and changes in membrane permeability.

Effects on reproduction and development: Research in laboratory animals suggests radiofrequency radiation can increase the risk of abnormal fetal development, affect hormone levels and adversely affect both female and male reproductive systems. Animal studies show exposure can damage the estrogen-producing granulosa cells in the ovaries, endometrial tissue and developing egg cells. Epidemiological research reported changes in fetal heart physiology following prenatal exposure to radiofrequency radiation.

Effects on the nervous system: Radiofrequency radiation exposure can cause changes in electrical activity and biochemical alterations in the nervous system, as well as behavioral and cognitive changes. The changes include alteration in glucose metabolism in the brain and in brain blood flow, as well as in electrical activity in the brain detected by electroencephalography. Radiofrequency radiation exposure has also been linked to changes in behavior, sleep, learning capacity and memory, and an increased risk of headaches.

Increased risk of cancer development: In epidemiological studies, exposure to wireless radiation has been also associated with an increased risk of cancer, including gliomas, parotid gland tumors and thyroid cancers. In 2011, the International Agency for Research on Cancer, or IARC, an agency of the World Health Organization, classified radiofrequency electromagnetic fields as "possibly carcinogenic to humans." IARC's classification was based on the increased risk of malignant brain cancer, glioma, observed among cell phone users.

Detailed citations for these health impacts of radiofrequency radiation are provided in the attached Appendix, including EWG's prior comment letter submitted to the FCC on June 30, 2022.

To support a comprehensive reassessment of federal RF exposure limits, EWG published a peer-reviewed study (Uche & Naidenko, 2021) proposing health-based exposure standards for children and adults (included in the Appendix). EWG's recommendations utilize data from the landmark 2018 National Toxicology Program study, one of the largest long-term laboratory studies on the health effects from radiation exposure.

Applying risk-assessment methodologies developed by the U.S. Environmental Protection Agency for toxic chemical exposures, EWG recommends a whole-body specific absorption rate (SAR) limit of 0.0002 to 0.0004 watts per kilogram (W/kg) for children, which is 200 to 400 times lower than the current federal limit of 0.08 W/kg. For adults, EWG recommends a whole-body SAR limit of 0.002 to 0.004 W/kg, which is 20 to 40 times lower than the current threshold. Under no circumstances should the FCC consider loosening existing protection standards.

In conclusion, EWG urges HHS and the FCC to undertake joint interagency action to update RF radiation exposure regulations. These updated limits must reflect modern scientific evidence to ensure robust protection for everyone in the United States, particularly children, from the adverse impacts of electromagnetic fields emitted by wireless technology.

Respectfully submitted,



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Appendix

1. EWG comment letter submitted to the FCC on June 30, 2022: "Environmental Working Group petitions the FCC to protect children's health by setting strict standards limiting public exposure to radiofrequency radiation."

2. EWG peer-reviewed study: Uche, U. I., & Naidenko, O. V. (2021). Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach. Environmental health : a global access science source, 20(1), 84. https://doi.org/10.1186/s12940-021-00768-1

3. EWG comment letter submitted to the FCC on May 13, 2020: Proposed Rule on Human Exposure to Radiofrequency Electromagnetic Fields (FCC ET Docket No. 19-226).

4. EWG comment letter submitted to the FCC on September 3, 2013: In the Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies (ET Docket No. 13-84) and Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields (ET Docket No. 03-137).

June 30, 2022

The Honorable Jessica Rosenworcel, Chairwoman, Federal Communications Commission

The Honorable Brendan Carr, Commissioner, Federal Communications Commission

The Honorable Geoffrey Starks, Commissioner, Federal Communications Commission

The Honorable Nathan Simington, Commissioner, Federal Communications Commission

Federal Communications Commission, 45 L Street, NE Washington, DC 20554

Environmental Working Group petitions the FCC to protect children's health by setting strict standards limiting public exposure to radiofrequency radiation

To the Federal Communications Commissioners:

The Environmental Working Group, or EWG, a nonprofit research and advocacy organization with headquarters in Washington, D.C., is petitioning the Federal Communications Commission to protect children's health from radiofrequency radiation by setting strict new standards limiting such exposures from wireless communication devices.

Cutting-edge research by EWG and many other scientists and organizations revealed that federal regulation of radiation emitted by wireless devices is woefully outdated and does not protect public health. The FCC set standards for wireless radiation in 1996, before Wi-Fi or smartphones even existed, and before 24-hour daily exposure to radiofrequency radiation became a reality for today's young generation. Since 1996, an ever-growing body of research has raised concerns about the health impacts of radiation from wireless devices, including harm to the nervous system, harm to the reproductive system and elevated risk of cancer.

With this letter, we are submitting the signatures of over 22,000 people who, together with EWG, are asking the FCC to protect public health and develop strict health-based regulation of radiofrequency radiation emitted by wireless devices. Details of EWG's recommendations, supporting information and references to peer-reviewed studies are provided below. The names of signatories to the EWG petition are included with this letter as Appendix B.

1. Since 2013, EWG has urged the FCC to strengthen its radiofrequency radiation standards, so they adequately protect both children and adults

The current FCC standards for exposure to radiofrequency radiation for the general population were set a quarter-century ago, following passage of the 1996 Telecommunications Act. The standards were based on the 1986 recommendations of the National Council on Radiation Protection and Measurements[1] and 1991 recommendations of the Institute of Electrical and Electronics Engineers,[2] which chose an exposure limit based on behavioral changes observed in laboratory animals exposed to radiofrequency radiation for a duration of minutes to hours in studies conducted in the 1970s and 1980s. Considering substantial new research showing that radiofrequency radiation exposure can harm health, even at levels below the current federal limits, the FCC needs to review the latest science and update the allowable exposure limits.

Much has changed since the federal limits were set, including technology and uses of radiofrequency-emitting wireless devices. Most people in the U.S., including children and the developing fetus, are now exposed to radiofrequency radiation. The current federal limits do not consider the impact of radiofrequency radiation on children, even though peer-reviewed studies show the bodies of children absorb more radiofrequency radiation than those of adults, putting children at greater health risk from such exposures.[3]

Between 2013 and 2015, EWG submitted to the FCC multiple comment letters urging the Commission to strengthen its radiofrequency radiation standards. In our earlier letters, EWG noted that federal regulations must be revised so they would (1) adequately protect both children and adults from radiation emitted by wireless communication devices, (2) reflect actual current use patterns, and (3) provide meaningful consumer disclosure without preempting states from requiring additional disclosure. EWG also emphasized that under no circumstances should the FCC consider weakening its existing standards.

Most recently, in response to the court ruling in Environmental Health Trust et al. v. FCC, EWG sent a letter to the FCC, together with the filings submitted by the Environmental Health Trust on November 30, 2021, highlighting the new scientific developments documenting adverse health effects of radiofrequency radiation. In our letter, EWG requested that the FCC reopen Docket 13-84, "Reassessment of FCC Radiofrequency Exposure Limits and Policies," and Docket 03-137, "Proposed Changes to the Commission Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields," to allow robust review and consideration of scientific evidence published in the past two years and in response to the court ruling in the Environmental Health Trust court case. Reopening these two dockets, as well as a new review and consideration of scientific evidence, is essential for the establishment of a much-needed strict exposure standard that would protect children's health from potential adverse effects of radiofrequency radiation.

2. Peer-reviewed research published by EWG scientists supports the need for much lower health-based standards for exposure of both children and adults to radiofrequency radiation

As a step toward advancing a reevaluation of the existing federal limits for radiofrequency radiation exposure, EWG reviewed the latest science and in 2021 published a peer-reviewed study[4] that recommends lower health-based exposure standards for both children and adults. EWG study is included with this letter as Appendix A. EWG recommendation draws on data from the landmark 2018 National Toxicology Program study, one of the largest long-term laboratory studies on the health effects of radiofrequency radiation exposure.[5]

EWG's study applied a methodology similar to the one developed by the U.S. Environmental Protection Agency to assess human health risks from toxic chemical exposures to radiofrequency radiation from wireless devices. EWG recommends a limit of a whole-body specific absorption rate, or SAR, at 0.0002 to 0.0004 watts per kilogram (W/kg) for children, which is 200 to 400 times lower than the current federal whole-body SAR exposure limit of 0.08 W/kg. For adults, EWG recommends a whole-body SAR limit of 0.002 to 0.004 W/kg, 20 to 40 times lower than the federal limit.[4]

3. Epidemiological studies and research in laboratory animals support the need for limiting exposures to radiofrequency radiation

Both epidemiological and animal studies have linked radiofrequency radiation exposure to harmful health effects. These harmful health effects associated with radiofrequency radiation may be caused by changes in the activity of voltage-gated calcium channels,[6] changes in the concentrations of reactive oxygen species and redox homeostasis,[7] changes in intracellular enzymes and gene expression,[8] disruption of the blood-brain barrier[9] and changes in membrane permeability.[10]

Research in laboratory animals suggests radiofrequency radiation can increase the risk of abnormal fetal development, affect hormone levels and decrease ovulation,[11] which may increase the risk for female infertility. Animal studies show exposure can damage the estrogen-producing granulosa cells in the ovaries, endometrial tissue and developing egg cells. Epidemiological research reported changes in fetal heart physiology following prenatal exposure to radiofrequency radiation.[12]

Radiofrequency radiation exposure can harm male fertility by decreasing sperm quality (motility, viability and levels),[13,14,15,16,17,18] changing sperm form and structure,[19,20,21] and changing hormone levels in the testis.[22,23,24,25,26] Radiofrequency radiation exposure can cause changes in electrical activity and biochemical alterations in the nervous system, as well as behavioral and cognitive changes. The changes include alteration in glucose

metabolism in the brain[27] and in brain blood flow,[28] as well as in electrical activity in the brain detected by electroencephalography.[29] Radiofrequency radiation exposure has also been linked to changes in behavior,[30] sleep,[31] learning capacity and memory,[32] and an increased risk of headaches.[33]

Exposure to wireless radiation has been also associated with an increased risk of cancer, including gliomas,[34] parotid gland tumors[35] and thyroid cancers.[36] In 2011, the International Agency for Research on Cancer, or IARC, an agency of the World Health Organization, classified radiofrequency electromagnetic fields as "possibly carcinogenic to humans." IARC's classification was based on the increased risk of malignant brain cancer, glioma, observed among cell phone users.

Conclusion

In closing, the EWG, together with 22,000 signatories to our petition, urge the FCC to develop strict health-based regulation of radiofrequency radiation emitted by wireless devices to protect public health. Given the widespread use of wireless devices, and research showing evidence of harmful effects associated with radiofrequency radiation exposure, scientists and public health advocates are justified in their concerns about the adequacy of the current exposure limits. Today's generation of children is exposed to radiofrequency radiation starting from the fetal development period and will likely experience these exposures for the duration of their lives. A public-health-focused reassessment of exposure limits for radiofrequency radiation is urgent and essential.

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Appendix A: Peer-reviewed study by Uche U.I., Naidenko O.V. Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach. Environ Health. 2021; 20(1):84.

Appendix B: Signatories to EWG's petition to the FCC

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Uche and Naidenko *Environ Health* (2021) 20:84
https://doi.org/10.1186/s12940-021-00768-1

Environmental Health

RESEARCH Open Access

Development of health-based exposure limits for radiofrequency radiation from wireless devices using a benchmark dose approach

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Abstract

Background: Epidemiological studies and research on laboratory animals link radiofrequency radiation (RFR) with impacts on the heart, brain, and other organs. Data from the large-scale animal studies conducted by the U.S. National Toxicology Program (NTP) and the Ramazzini Institute support the need for updated health-based guidelines for general population RFR exposure.

Objectives: The development of RFR exposure limits expressed in whole-body Specific Absorption Rate (SAR), a metric of RFR energy absorbed by biological tissues.

Methods: Using frequentist and Bayesian averaging modeling of non-neoplastic lesion incidence data from the NTP study, we calculated the benchmark doses (BMD) that elicited a 10% response above background (BMD_{10}) and the lower confidence limits on the BMD at 10% extra risk ($BMDL_{10}$). Incidence data for individual neoplasms and combined tumor incidence were modeled for 5% and 10% response above background.

Results: Cardiomyopathy and increased risk of neoplasms in male rats were the most sensitive health outcomes following RFR exposures at 900 MHz frequency with Code Division Multiple Access (CDMA) and Global System for Mobile Communications (GSM) modulations. $BMDL_{10}$ for all sites cardiomyopathy in male rats following 19 weeks of exposure, calculated with Bayesian model averaging, corresponded to 0.27–0.42 W/kg whole-body SAR for CDMA and 0.20–0.29 W/kg for GSM modulation. $BMDL_{10}$ for right ventricle cardiomyopathy in female rats following 2 years of exposure corresponded to 2.7–5.16 W/kg whole-body SAR for CDMA and 1.91–2.18 W/kg for GSM modulation. For multi-site tumor modeling using the multistage cancer model with a 5% extra risk, $BMDL_5$ in male rats corresponded to 0.31 W/kg for CDMA and 0.21 W/kg for GSM modulation.

Conclusion: $BMDL_{10}$ range of 0.2—0.4 W/kg for all sites cardiomyopathy in male rats was selected as a point of departure. Applying two ten-fold safety factors for interspecies and intraspecies variability, we derived a whole-body SAR limit of 2 to 4 mW/kg, an exposure level that is 20–40-fold lower than the legally permissible level of 0.08 W/kg for whole-body SAR under the current U.S. regulations. Use of an additional ten-fold children's health safety factor points to a whole-body SAR limit of 0.2–0.4 mW/kg for young children.

Keywords: Radiofrequency radiation, Specific Absorption Rate, SAR, Exposure guidelines, Benchmark modeling

Introduction

The health risk assessment of non-ionizing electromagnetic radiation generated science and policy debates for decades, particularly around the health effects of radiofrequency radiation (RFR) in the 3 kHz to 300 GHz

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frequency range used for wireless communications [1–4]. Among the reported biological effects of electromagnetic fields are harm to fetal growth and development [5–13], changes in heart rate variability [14, 15], changes in brain activity [16, 17], and elevated risk of several cancers [18–21]. In 2011, the International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as "possibly carcinogenic to humans" based on an increased risk of glioma, a malignant brain cancer, associated with cellular phone use [18].

The mechanisms by which radiofrequency radiation affects cells, tissues, and organisms are not well understood and may include diverse processes such as inhibition of the mitotic spindle apparatus leading to impaired cell division and cell death [22], changes in the activity of voltage-gated calcium channels [23–26], changes in the concentrations of reactive oxygen species and redox homeostasis [25, 27–32], changes in intracellular enzymes and gene expression [33], and changes in membrane permeability [34]. DNA damage following exposure to RFR [35, 36] may be a direct effect or due to secondary mechanisms, such as interference with DNA repair processes [37]. As summarized in a recent review, these biological effects of RFR occur without substantial temperature increases in tissues [27]. Highlighting the complexity of these biological interactions, some forms of electromagnetic fields, described as "tumor treating fields" in the medical research literature, are now explored as a potential therapy for glioblastoma and other cancers [22, 38].

With a continuously growing variety of RFR sources in the everyday environment and drastically increased intensity of daily exposure to RFR from personal wireless devices and from short- and long-range sources such as Wi-Fi routers, cell phone towers, and small cell transmitters, the question of safe exposure levels for the public, especially children, is urgent and important. In the U.S., general population exposure standards for RFR were set by the Federal Communications Commission in 1996 based on studies conducted in the 1970s and 1980s in which behavior changes were observed in laboratory animals exposed to RFR for the duration of minutes to hours [2, 39, 40]. For the frequency range of 100 kHz to 6 GHz, the U.S. standards define the legally allowable exposures in terms of Specific Absorption Rate, or SAR, which refers to the relative amount of energy absorbed by biological tissues. For non-occupational exposures, U.S. regulations allow a SAR of 0.08 W/kg averaged over the whole body and a localized peak spatial SAR of 1.6 W/kg averaged over 1 g of tissue. Localized peak SAR limits apply to wireless device use in immediate contact with the body, for example a cellular phone held near the head.

In the past two decades, epidemiological studies reported an elevated risk of gliomas, acoustic neuromas, parotid gland tumors, and thyroid cancers in regular cellular phone users. The challenge of ascertaining the length, frequency, and intensity of wireless device use and continuously changing communication technologies make it difficult to develop a precise exposure metric from epidemiological research. Recent studies of RFR in laboratory animals provide much-needed information on the specific RFR exposure levels associated with elevated risks of adverse health effects [41]. The results from two long-term, large-scale studies of RFR in laboratory rodents, the study from the U.S. National Toxicology Program (NTP) [42] and the study from the Ramazzini Institute in Italy [7, 43], are especially informative. The NTP study examined the health effects of the RFR exposure of interim duration (19 weeks, including the prenatal period) and long-term exposure (2 years) and reported cardiotoxic, genotoxic, and carcinogenic effects [35, 44–46]. In the Ramazzini Institute study, rats were exposed from prenatal life until natural death, and a statistically significant increase in the incidence of heart schwannomas was reported [7]. Here we model the health effects incidence data from the National Toxicology Program (NTP) to estimate the departure points for exposure guidelines and to open the discussion of exposure limits for wireless devices that would protect the health of vulnerable populations, especially children.

Methods

Lesion incidence data were accessed from the National Toxicology Program (NTP) reports [20, 21]. The NTP examined the effects of RFR with two different modulations, Code Division Multiple Access (CDMA) and Global System for Mobile Communications (GSM), and in two species: rats and mice, exposed to 900 MHz and 1900 MHz radiation, respectively [44, 45]. Animals were exposed every day for the duration of the analysis, and the length of daily RFR exposure totaled 9 h, 10 min per day, achieved via 18 h, 20 min daily exposure in 10-min on–off cycles. The study design for the two species differed with respect to early life exposure. Rats were exposed from the prenatal period, starting on gestation day 5, during the 3-week lactation period, and continuing for the rest of the two-year study duration, with whole-body SAR levels of 1.5, 3, and 6 W/kg [44]. For mice, daily exposure with whole-body SAR levels of 2.5, 5, or 10 W/kg started at 5–6 weeks of age, around the age of puberty in this species [45]. The NTP study reported an increased incidence of cardiomyopathy in female and male rats and increased incidences of various neoplasms in male rats [44]. In contrast, similar effects were not observed in mice [45]. For the analysis here, we focused on the

data from rats because that dataset reflects the potential health impacts of life-long exposure to radiofrequency radiation starting from the prenatal period.

Benchmark dose modeling for non-neoplastic and neoplastic incidence data was conducted using U.S. EPA Benchmark Dose Software (BMDS) version 3.2 (https://www.epa.gov/bmds). For non-neoplastic effects, we used both frequentist and Bayesian model averaging options within the BMDS software. For neoplastic effects, we used the frequentist multistage cancer model (MS Combo) following the U.S. EPA's technical guidance for modeling tumor data [47]. The benchmark approach considers the response at all doses tested in the study and can help fill the data gap regarding the shape of the dose–response curve below the lowest dose tested. As discussed in the benchmark dose modeling research literature [48–50], the best fitting models were selected based on the lowest Akaike Information Criterion, goodness-of-fit p values, scaled residual, and visual inspection of the curve fit.

For benchmark modeling, the choice of the appropriate percentage change in the response above the background depends on the specific dataset [47]. Peer-reviewed literature and guidance documents on BMD modeling published by authoritative agencies have used BMD modeling with 5% or 10% extra risk [47, 48, 50]. Here we applied the standard approach of calculating the benchmark dose (BMD_{10}) at a 10% benchmark response for non-neoplastic incidence data. For neoplastic incidence data, we conducted modeling of both 5% and 10% benchmark response above the background and selected the 5% response rate (BMD_5) as an approach that allowed for successful modeling of the neoplasm incidence data from the NTP study. BMDS software also calculates the 95% lower confidence limit (BMDL) on the exposure level that would produce a response at a selected incidence frequency above the background [47]. BMDL values can be used as a point of departure for the development of health-based guidelines and risk assessment.

Results

Analysis of dose–response patterns for different lesions observed in the NTP study suggests that some health effects associated with RFR exposures exhibit non-monotonic dose–response relationships that may be influenced by gender and RFR modulation. RFR exposure corresponding to whole-body SAR of 1.5 W/kg, the lowest tested level in the NTP study, was associated with an increase in the incidence of various nonneoplastic and neoplastic effects relative to sham-exposed animals, indicating that "No Observed Adverse Effect Level", or NOAEL, was not identified in the NTP study. For some health outcomes, the highest incidence in the RFR-exposed versus control group was observed at 1.5 W/kg exposure, with a decrease in incidence at SAR values of 3 and 6 W/kg.

The findings for cardiomyopathy are particularly compelling. Cardiomyopathy is defined in the NTP report as the "*degeneration and necrosis of myofibers with a mild inflammatory response of macrophages and lymphocytes with occasional neutrophils* [44]*"*. While observed in both males and females and at both RFR modulations, dose–response relationships were distinct for right ventricle versus all sites cardiomyopathy. At 19 weeks of exposure, CDMA-exposed male rats had a lower incidence of right ventricle cardiomyopathy in the 3 and 6 W/kg dose groups compared to the 1.5 W/kg dose group, an effect that was not observed in GSM-exposed male rats at the same time point (Fig. 1A). For all sites cardiomyopathy, male rats in the highest-dose GSM group (SAR 6 W/kg) had lower incidence compared to male rats in the second-highest dose group of 3 W/kg, while for CDMA-exposed male rats all sites cardiomyopathy incidence was the same for the 3 and 6 W/kg groups (Fig. 1B). At 19 weeks, cardiomyopathy incidence in females was lower than in males and did not exhibit a dose–response relationship (Fig. 1). At 2 years, right ventricle cardiomyopathy in both CDMA- and GSM exposed rats exhibited a visible dose–response relationship (Fig. 2A), which was not observed for all sites cardiomyopathy (Fig. 2B). Overall, increased incidence of cardiomyopathy both at the interim examination point of 19 weeks and at the end of the study reinforces the health significance of the findings.

We conducted BMDS modeling for all available cardiomyopathy datasets from the NTP study. Successful model fitting was observed for all sites cardiomyopathy in male rats at 19 weeks of exposure and for right ventricle cardiomyopathy in both male and female rats at the 2-year point (Supplementary Table 1). Figures 3 and 4 illustrate the modeling results for all sites cardiomyopathy in male rats at 19 weeks for CDMA (Fig. 3A) and GSM modulations (Fig. 3B) and right ventricle cardiomyopathy in female rats at 2 years for CDMA (Fig. 4A) and GSM (Fig. 4B). Different BMDS frequentist models resulted in similar or identical BMD values and comparable quality of data fit (Supplementary Table 1). Due to the lack of biological information for determining which mathematical model would be most appropriate for the datasets analyzed here, we used the Bayesian model averaging approach to define the BMD_{10} and $BMDL_{10}$ values. Since the highest variability in the dose–response relationship was observed at the highest SAR exposure dose, we conducted modeling with and without this data point (Supplementary Table 2 and Table 1).

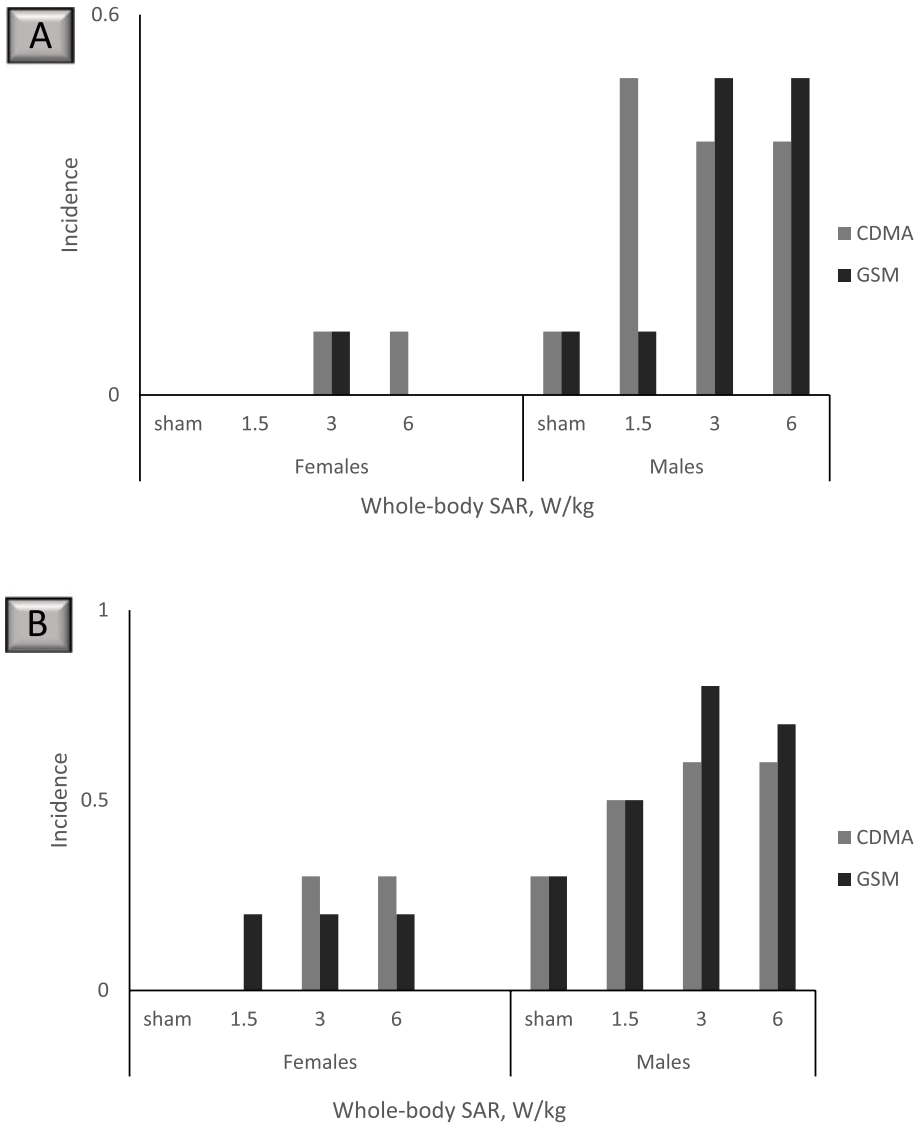


Fig. 1 Cardiomyopathy incidence at 19 weeks. Each experimental group had 10 animals. Where no bar is shown, the specific outcome in question was not observed in the animal group. **A** Right ventricle cardiomyopathy. **B** All sites cardiomyopathy

While BMD modeling of the datasets without the highest dose of 6 W/kg SAR generally resulted in better model fit, overall BMD and BMDL values were comparable for modeling with and without the highest dose (Supplementary Table 1). For male rats at 19 weeks of exposure, the most sensitive responses were observed for GSM, with 0.2–0.29 w/kg $BMDL_{10}$, compared to 0.27–0.42 W/kg $BMDL_{10}$ value for CDMA (Table 1). The range of values reported corresponds to modeling with the highest dose included (0.42 W/kg for CDMA and 0.29 W/kg for GSM) and excluded (0.27 W/kg for CDMA and 0.2 W/kg for GSM).

BMD modeling of right ventricle cardiomyopathy data for female and male rats following a 2-year exposure resulted in consistently lower BMD and BMDL values for males compared to females, indicating greater susceptibility of males to RFR-induced cardiomyopathy (Supplementary Tables 1 and 2). $BMDL_{10}$ for right ventricle cardiomyopathy in females corresponded to 2.7–5.16 W/kg whole-body SAR for CDMA and 1.91–2.18 W/kg for GSM modulation (Table 2). In male rats, the corresponding $BMDL_{10}$ values were 0.7–0.79 W/kg whole-body SAR for CDMA and 0.33–0.42 W/kg for GSM modulation (Table 2).

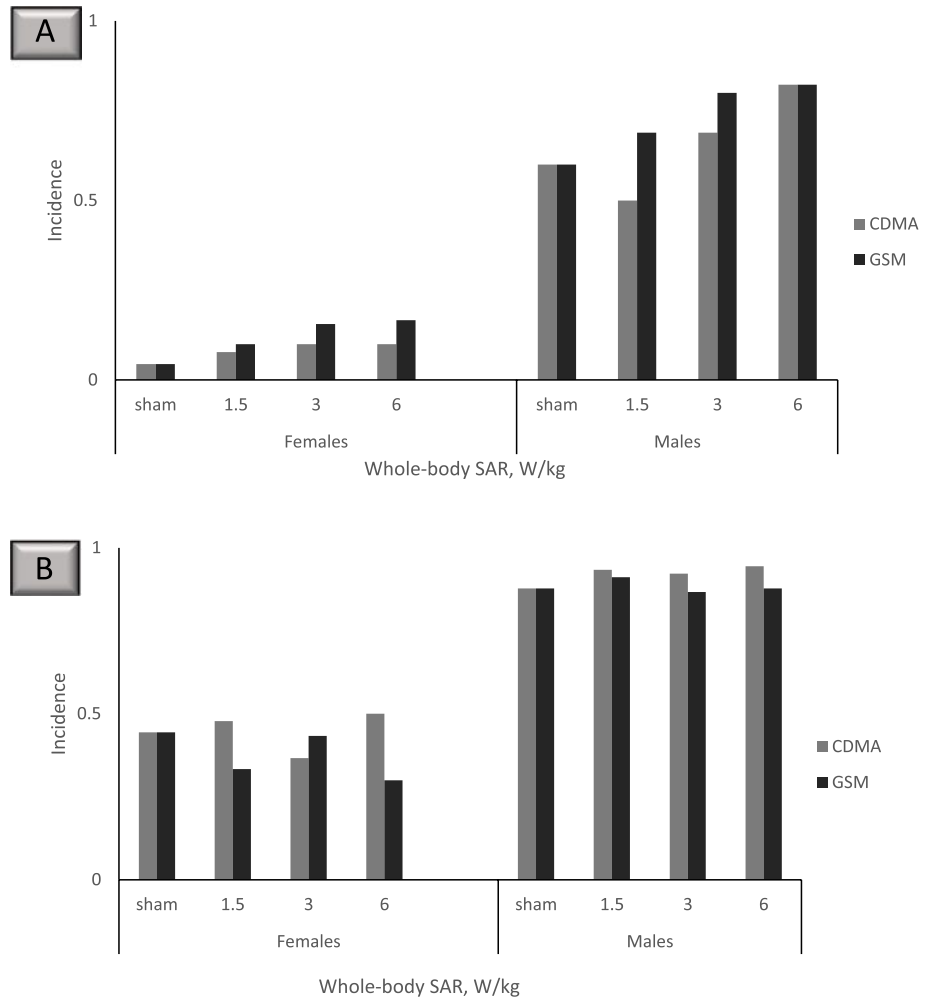


Fig. 2 Cardiomyopathy incidence at 2 years. Each experimental group had 90 animals. **A** Right ventricle cardiomyopathy. **B** All sites cardiomyopathy

Non-monotonic dose–response relationships were also observed in the NTP dataset for hyperplasias (Fig. 5). The incidence of prostate gland hyperplasia in male rats and adrenal medulla effects in female rats increased and decreased along the range of exposure doses tested (Fig. 5). A complex dose–response relationship also was seen for the tumors in the heart, brain, pituitary gland, adrenal medulla, prostate gland, and liver. For certain outcomes, animals in the 6 W/kg exposure group had the highest incidence, such as heart schwannomas in CDMA- and GSM- exposed male rats (Fig. 6A). In contrast, a decrease in incidence in the 6 W/kg groups was observed for several neoplasms, such as adrenal medulla neoplasms in CDMA-exposed female rats (Fig. 5), pituitary gland adenomas in CDMA-exposed male rats (Fig. 6B), and adrenal medulla and prostate gland neoplasms in GSM-exposed male rats (Fig. 6B).

Frequentist modeling of benchmark values for adrenal medulla hyperplasia in female rats and prostate gland epithelium hyperplasia in male rats following a 2-year exposure resulted in BMD_{10} higher than BMD_{10} values for cardiomyopathy (Supplementary Table 3). Most of the modeled $BMDL_{10}$ values for these two health outcomes were in the range of 1–3 W/kg whole-body SAR. Similar to the greater sensitivity of males to RFR-induced cardiomyopathy compared to females, prostate gland epithelium hyperplasia in males was a more sensitive outcome than adrenal medulla hyperplasia in females (Fig. 5, Supplementary Table 3).

Following the approaches recommended by the U.S. EPA BMDS technical guidance [47] and the published methods for tumor data modeling from the California Environmental Protection Agency Office of Environmental Health Hazard Assessment [51], we modeled the benchmark values for specific neoplasms as well as

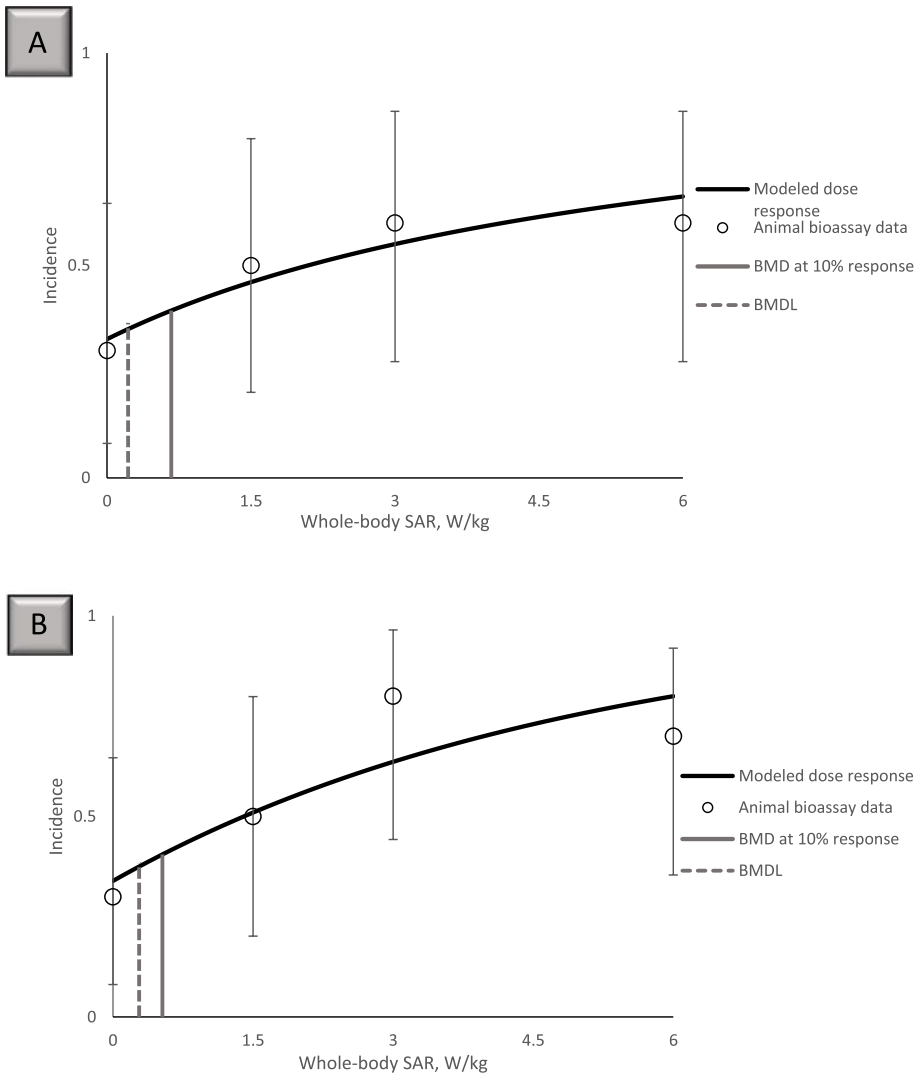


Fig. 3 Benchmark dose modeling of all sites cardiomyopathy in male rats at 19 weeks. **A** Fitting of the data for CDMA exposures to the log-logistic model results in BMD_{10} of 0.67 W/kg and $BMDL_{10}$ of 0.22 W/kg. **B** Fitting of the data for GSM exposures to the Weibull model results in BMD_{10} of 0.54 W/kg and $BMDL_{10}$ of 0.24 W/kg

multi-site tumor incidence in male rats. Neoplasm incidences in female rats could not be modeled. For male rats, the non-monotonic dose–response relationship patterns precluded BMDS modeling of certain tumor outcomes using all exposure dose groups (Supplementary Tables 4 and 5). Using all exposure dose groups, heart schwannoma data for male rats could be modeled for both CDMA and GSM exposures with 5% and 10% change in response rate above background (Table 3). With 10% response modeling for heart schwannoma, calculated BMD_{10} values exceeded the SAR value of 6 W/kg for the highest exposure dose group in the study, suggesting that the 10% response modeling is not practical for some tumor types in this dataset.

The omission the highest exposure dose group and the use of 5% BMR as the modeling approach allowed the modeling of more tumor outcomes, providing an acceptable fit to the remaining dose–response data (Supplementary Table 5 and Table 4). Omission of the highest exposure dose also allowed the modeling of combined incidences of different tumors, which is a modeling option provided in the U.S. EPA BMDS software (Table 4). Modeling of combined tumor outcomes allowed for greater sensitivity and resulted in lower BMD values compared to modeling of individual tumor

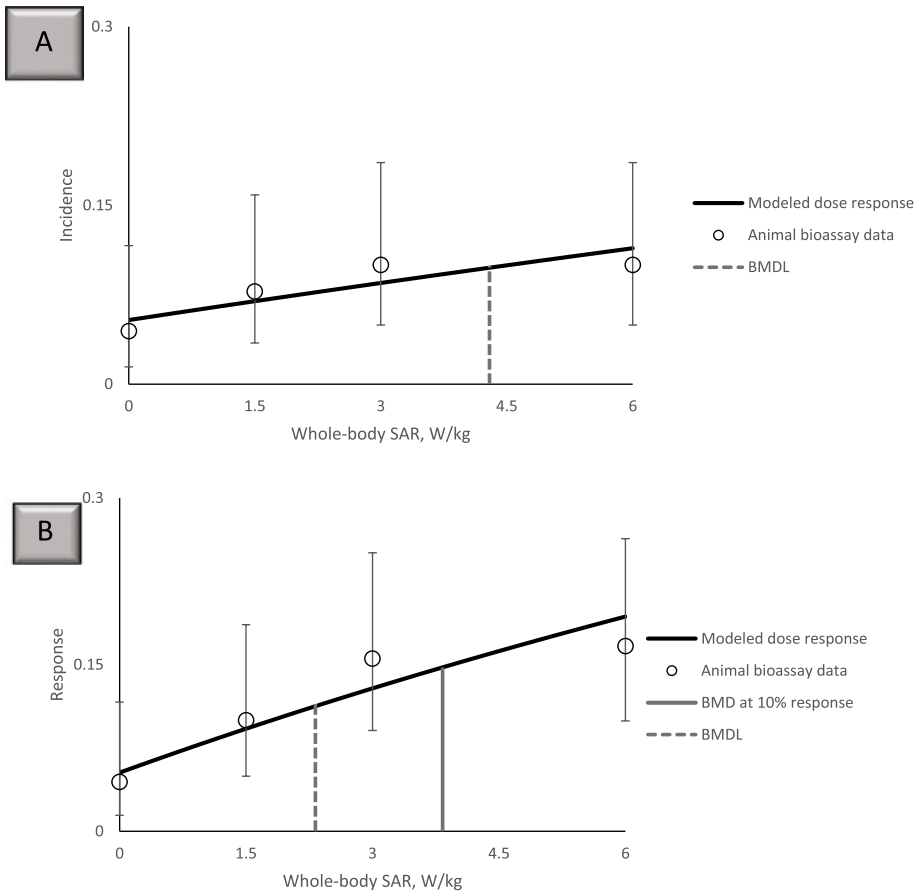


Fig. 4 Benchmark dose modeling of right ventricle cardiomyopathy in female rats at 2 years. **A** Fitting of the data for CDMA exposures to the log-logistic model results in BMD_{10} of 9.80 W/kg (above the highest dose of 6 W/kg tested in the NTP study, and thus not shown in the panel) and $BMDL_{10}$ of 4.30 W/kg. **B** Fitting of the data for GSM exposures to the log-logistic model results in BMD_{10} of 3.83 W/kg and $BMDL_{10}$ of 2.32 W/kg

Table 1 BMD_{10} and $BMDL_{10}$ SAR values calculated with Bayesian model averaging for all sites cardiomyopathy in male rats following 19 weeks of exposure

	CDMA	GSM
BMD_{10}, all doses	1.75 W/kg	0.94 W/kg
$BMDL_{10}$, all doses	0.42 W/kg	0.29 W/kg
BMD_{10}, the highest dose omitted	0.97 W/kg	0.58 W/kg
$BMDL_{10}$, the highest dose omitted	0.27 W/kg	0.20 W/kg

incidences. Even with the omission of the highest dose, BMD_{10} values could not be modeled for heart schwannoma, brain meninges neoplasm, and combined tumors for GSM exposure (Table 4).

The combined neoplasm incidence data could be modeled with a 5% increased incidence above background in the dataset without the highest dose (Table 4). $BMDL_5$ value of 0.31 W/kg whole-body SAR was calculated for combined tumors in CDMA-exposed rats and $BMDL_5$ value of 0.21 W/kg was calculated for GSM. These $BMDL_5$ values for combined tumor incidence are overall comparable to the $BMDL_{10}$ values for cardiomyopathy effects. Of note, throughout our analysis, BMD and BMDL values were consistently lower for GSM-exposed animals relative to CDMA exposures, indicating greater sensitivity to GSM modulation in the NTP study.

Discussion

Radiofrequency radiation can elicit carcinogenic, genotoxic, reproductive, developmental, neurological, and cognitive effects [52–54]. Continuously increasing exposure to radiofrequency radiation from wireless communication devices and sources brings urgency to the question of health-protective limits for such exposures. Here we use benchmark dose modeling as an approach to develop health-based exposure limits for RFR based on animal toxicology data. The lower limit on the modeled benchmark dose, abbreviated as BMDL, offers a

Table 2 BMD_{10} and $BMDL_{10}$ SAR values calculated with Bayesian model averaging for right ventricle cardiomyopathy in male and female rats following a 2-year exposure

	Females CDMA	Females GSM	Males CDMA	Males GSM
BMD_{10}, all doses	10.68 W/kg[a]	4.86 W/kg	1.50 W/kg	0.81 W/kg
$BMDL_{10}$, all doses	5.16 W/kg	2.18 W/kg	0.70 W/kg	0.42 W/kg
BMD_{10}, the highest dose omitted	5.21 W/kg	2.94 W/kg	1.69 W/kg	0.69 W/kg
$BMDL_{10}$, the highest dose omitted	2.70 W/kg	1.91 W/kg	0.79 W/kg	0.33 W/kg

[a] Calculated BMD_{10} value is greater than the 6 W/kg highest SAR exposure dose in the study

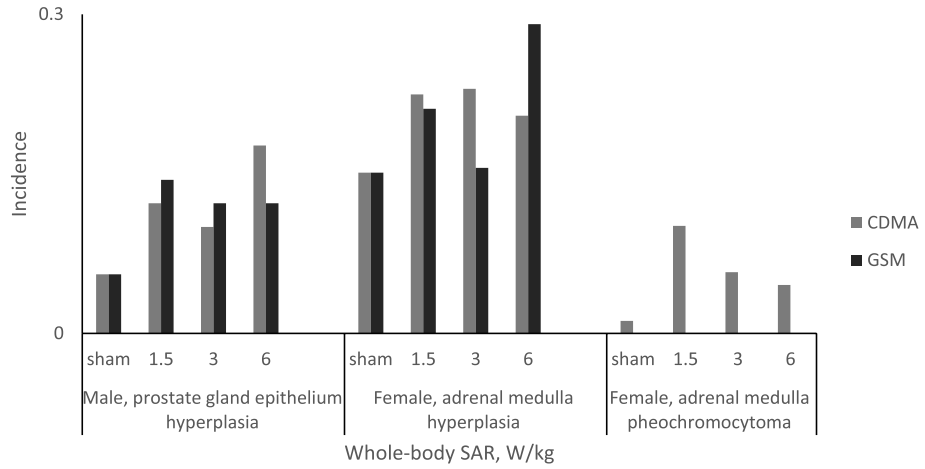


Fig. 5 Prostate gland hyperplasia in male rats and adrenal medulla effects in female rats at 2 years

95% statistical estimate on the exposure dose associated with a 5% or a 10% change in response rate, which can be treated as a point of departure for the development of health-based exposure guidelines. To extrapolate from a point of departure from animal toxicological studies to the exposure level acceptable for the human population, safety factors are commonly used, including a ten-fold factor for differences between species (humans and laboratory animals, in this case) and a second tenfold factor for variability in the potential sensitivity within the human population [55]. The use of these two ten-fold safety factors comes from a decades-old practice in chemical risk assessment. It is possible that the range of variations in sensitivity within the human population and the range of differences between species may not be captured in the conventionally applied ten-fold factors. Further, to protect sensitive populations such as children, an additional safety factor may be necessary, an approach first introduced for pesticide risk assessment to account for susceptibilities during the vulnerable stages of early development [56].

Among the BMDL values calculated in this study, the most sensitive values were $BMDL_{10}$ for all sites cardiomyopathy at 19 weeks of exposure in male rats. The range of $BMDL_{10}$ values 0.2 to 0.4 W/kg, listed in Table 1, offers a point of departure for defining exposure limits. The application of two ten-fold safety factors for interspecies and intraspecies variability (combined 100X factor) to the point of departure suggests a whole-body SAR limit of 2 to 4 mW/kg for adults (Fig. 7). These SAR values are 20- to 40-fold smaller than the current U.S. whole-body SAR limit of 0.08 W/kg. Application of an additional ten-fold safety factor to account for the greater sensitivity of the developing organism points to a whole-body SAR limit of 0.2 to 0.4 mW/kg for the young child.

We note two key differences between the health-based exposure limits presented here and the current U.S. regulations for radiofrequency radiation which set the limits of 0.08 W/kg for the whole-body SAR and the localized spatial peak of 1.6 W/kg SAR as averaged over 1 g of tissue. These differences are in the selection of the point of departure and the application of safety factors. The existing U.S. radiofrequency radiation standards were based on the 1986 recommendations of the U.S. National Council on Radiation Protection and Measurements and

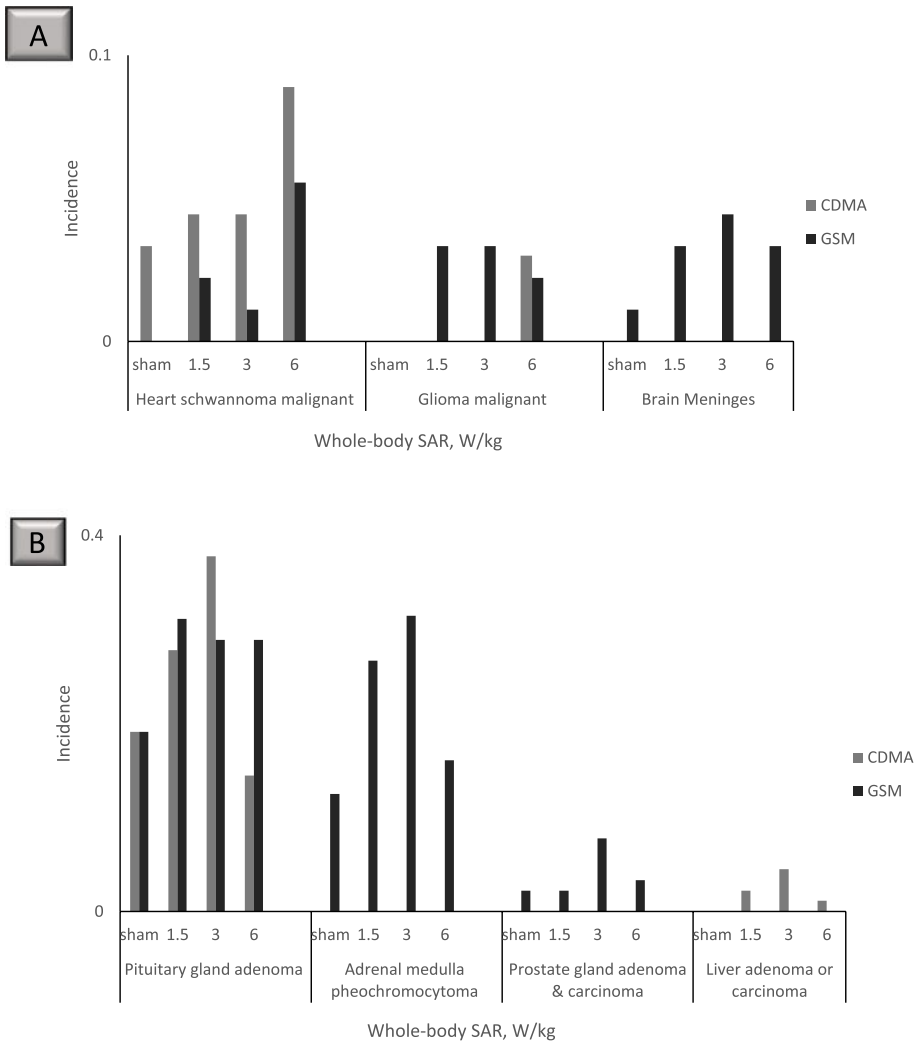


Fig. 6 Neoplasm incidence in male rats at 2 years. Where no bar is shown, the specific outcome in question was not observed in the animal group. **A** Heart and brain tumors. **B** Pituitary gland, adrenal medulla, prostate gland, and liver tumors

Table 3 BMDS modeling of cancer incidence in male rats using the MS Combo model. Neoplasm incidence data analyzed here included all exposure groups

Exposure condition and tumor type	BMD_5	$BMDL_5$	BMD_{10}	$BMDL_{10}$
CDMA, heart schwannoma	4.29	2.71	8.82[a]	5.40
CDMA, pituitary gland adenoma	Could not be modeled			
CDMA, liver adenoma	Could not be modeled			
CDMA, combined heart schwannoma, liver adenoma, and pituitary gland adenoma	**Could not be modeled**			
GSM, heart schwannoma	5.94	3.49	11.82[a]	6.20
GSM, brain malignant glioma	9.00[a]	3.60	Could not be modeled	
GSM, brain meninges neoplasm (benign and malignant)	11.31[a]	3.89	Could not be modeled	
GSM, adrenal medulla pheochromocytoma (benign and malignant)	Could not be modeled			
GSM, pituitary gland adenoma	2.86	1.15	Could not be modeled	
GSM, combined heart schwannoma, brain glioma, and meninges neoplasm, adrenal pheochromocytoma, and pituitary gland adenoma	**Could not be modeled**			

[a] Calculated BMD value is greater than the 6 W/kg highest exposure dose in the NTP study

Table 4 BMDS modeling of cancer incidence in male rats using the MS Combo model. Neoplasm incidence data modeled here did not include the highest exposure dose of 6 W/kg

Exposure condition and tumor type	BMD_5	$BMDL_5$	BMD_{10}	$BMDL_{10}$
CDMA, heart schwannoma	4.09[a]	2.12	8.41[a]	3.50
CDMA, pituitary gland adenoma	0.60	0.37	1.23	0.77
CDMA, liver adenoma	3.37[a]	1.84	6.93[a]	3.78
CDMA, combined heart schwannoma, liver adenoma, and pituitary gland adenoma	**0.45**	**0.31**	**0.93**	**0.63**
GSM, heart schwannoma	6.87[a]	3.01	Could not be modeled	
GSM, brain malignant glioma	3.40[a]	1.86	6.99[a]	3.46
GSM, brain meninges neoplasm (benign and malignant)	4.21[a]	1.90	Could not be modeled	
GSM, adrenal medulla pheochromocytoma (benign and malignant)	0.58	0.38	1.20	0.78
GSM, pituitary gland adenoma	1.06	0.51	2.17	1.06
GSM, combined heart schwannoma, brain glioma, and meninges neoplasm, adrenal pheochromocytoma, and pituitary gland adenoma	**0.30**	**0.21**	**Could not be modeled**	

[a] Calculated BMD value is greater than the 3 W/kg highest exposure dose included in this analysis

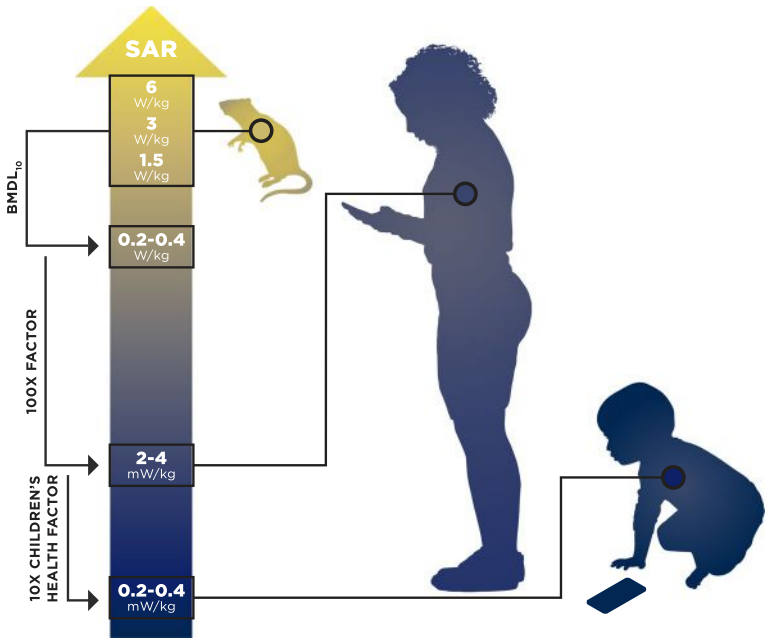


Fig. 7 Summary of health-based exposure limits calculated in this study. Whole-body SAR value of 0.2–0.4 W/kg was selected as a point of departure for calculating health-based exposure guidelines. Applying two ten-fold safety factors for interspecies and intraspecies variability (a total of 100X), a whole-body SAR limit of 2–4 mW/kg is derived for adults. The application of an additional ten-fold (10X) children's health factor suggests a limit of 0.2–0.4 mW/kg whole body SAR for young children

1991 recommendations of the Institute of Electrical and Electronics Engineers [2, 40], which chose SAR value of 4 W/kg as the point of departure based on changes in animal behavior observed in studies conducted in the late 1970s and early 1980s.

The regulatory limit of 0.08 W/kg whole-body SAR was calculated by the application of two factors, a ten-fold factor and a five-fold factor (combined 50X) to the 4 W/kg SAR point of departure. While the first ten-fold factor accounted for the translation from animals to humans, the five-fold factor, proposed in the 1986 report by the U.S. National Council on Radiation Protection and Measurements, related to the difference in duration of work-related occupational exposure versus continuous exposure for the general public and not to health considerations [2]. The legal limit of 0.08 W/kg whole-body SAR did not include safety factors to account for potential variability in the sensitivity within the human

population and greater sensitivity of children. The localized SAR limit of 1.6 W/kg was defined by multiplying the whole-body SAR limit of 0.08 W/kg by a factor of twenty [39, 40]. In the historical context of 1980s discussions of allowable exposure limits for occupational and general public exposures, the concept of a 20-fold increase of peak SAR relative to the whole-body SAR was based on the view that increase in tissue temperature was the main effect of radiofrequency radiation [40].

The epidemiological studies of mobile phone users and the reports of an elevated risk of head tumors on the side of the head where the phone was typically used highlight the toxicological importance of peak exposures in the part of the body closest to the wireless device [18–21, 57]. For example, as reported in a study from Israel, there was a 50–60% increased risk of parotid gland tumors on the ipsilateral side where hand-held mobile devices were used, while on the contralateral side, the risk of parotid gland tumors was not significantly different from controls [19]. Likewise, Hardell and coworkers reported a 90% increased risk of glioma for long-term ipsilateral exposure of mobile phones [57].

In the NTP study, laboratory animals received whole-body exposure to radiofrequency radiation from specially designed reverberation chambers [44, 45]. A dosimetry analysis for the animals in the NTP study reported the ratios between organ and whole-body SAR values [58]. According to that analysis, the peak SAR in the heart of male rats was 2.7 decibels (dB) higher than the whole-body SAR [58]. This difference of 2.7 dB between heart and whole-body SAR is much smaller than the 20-fold difference between localized and whole-body SAR assumed in the 1980s publications [39, 40].

In our view, more research is necessary to define what the acceptable, health-protective localized SAR value should be. An appropriate peak spatial SAR can be determined according to the concept of ALARA, or As Low As Reasonably Achievable, a concept developed for human exposures to ionizing radiation. Technical manuals for wireless devices specify that these products are tested for compliance with the SAR values defined under the U.S. Federal Communications Commission regulations, or under the corresponding regulations set by government authorities in other countries. However, investigative reports found that wireless devices may not comply with these regulatory limits if tested in a real-life scenario where the device touches the body directly [59].

Finally, the methodology used for the development of health-based exposure limits, such as the benchmark dose modeling and the application of safety factors, remains an evolving area of research in risk assessment. The lack of information about the shape of the dose–response curve below the lowest dose tested and the decreased incidence of various lesions observed at the highest dose tested by the NTP [42, 60, 61] pose questions for future research. The point of departure selected from benchmark modeling presented here, $BMDL_{10}$ value of 0.2–0.4 W/kg whole-body SAR, does not correspond to the true "No Adverse Effects Level", which is likely lower. Falcioni and coworkers reported a No Observed Adverse Effects Level of 0.03 W/kg for heart schwannomas in their study [7]. This NOAEL value is between the $BMDL_{10}$ values calculated here and the health-based limit of 2–4 mW/kg for adults that we defined by the application of two ten-fold safety factors. While the use of ten-fold safety factors is an established risk assessment practice in the U.S. and other countries, it is possible that these standard factors either underestimate or overestimate the extent of variability in sensitivity within the human population. Even with the outstanding questions, the NTP and the Ramazzini Institute data on the RFR effects in laboratory animals are a valuable resource for the development of health-based guidelines for RFR exposures in people [41, 42].

Conclusions

The analysis presented here supports a whole-body SAR limit of 2 to 4 mW/kg for adults, an exposure level that is 20- to 40-fold lower than the legally permissible limit of 0.08 W/kg for whole-body SAR under the current U.S. regulations. A ten-fold lower level of 0.2–0.4 mW/kg whole-body SAR may be appropriate for young children. Both technology changes and behavior changes may be necessary to achieve these lower exposure levels. Simple actions, such as keeping the wireless devices farther away from the body, offer an immediate way to decrease RFR exposure for the user.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12940-021-00768-1.

Additional file 1: Supplementary Table 1. Frequentist modeling of cardiomyopathy in male and female rats. Only models with good visual fit were included. Where several models produced identical BMD values, p values, scaled residuals and Akaike Information Criterion, all models giving the same calculated values are listed. **Supplementary Table 2**. 10% BMR estimates for cardiomyopathy calculated with the Bayesian model averaging approach. Model Average values highlighted in bold at the bottom of each row are presented in Tables 1 and 2 of the Results section. **Supplementary Table 3**. Frequentist modeling of hyperplasias in male and female rats following 2 years of exposure. Only models with good visual fit were included. **Supplementary Table 4**. 10% BMR estimates for multistage MS Combo modeling of neoplasm incidence data in male rats at 2 years. Only the datasets that could be modeled are included in this table. **Supplementary Table 5**. 5% BMR estimates for multistage MS Combo modeling of neoplasm incidence data in male rats at 2 years. Only the datasets that could be modeled are included in this table.

Acknowledgements
The authors gratefully acknowledge the help of their colleagues Sydney Evans, Tiffany Follin, and Katie Peacor for their assistance with visualization and graphics. The authors also acknowledge David Andrews, Tasha Stoiber, Sydney Evans, Alexis Temkin and the journal's peer reviewers who provided technical and scientific feedback on the manuscript.

Authors' contributions
Uloma Igara Uche: Conceptualization, Formal Analysis, Writing—Original Draft, Writing—Review & Editing, Visualization Olga V. Naidenko: Conceptualization, Writing—Original Draft, Writing—Review & Editing. The author(s) read and approved the final manuscript.

Funding
This research project was supported by a grant from Jonas Philanthropies.

Availability of data and materials
The datasets analyzed for this study can be found in the published National Toxicology Program technical report https://ntp.niehs.nih.gov/ntp/htdocs/lt_rpts/tr595_508.pdf?utm_source=direct&utm_medium=prod&utm_campaign=ntpgolinks&utm_term=tr595 and on the website of the U.S. National Toxicology Program at https://ntp.niehs.nih.gov/whatwestudy/topics/cellphones/index.html.

Declarations

Competing interests
The authors declare that they have no competing interests.

Received: 3 May 2021 Accepted: 1 July 2021
Published online: 17 July 2021

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Publisher's Note

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May 13, 2020

Environmental Working Groups comments to the Federal Communications Commission proposed rule on Human Exposure to Radiofrequency Electromagnetic Fields, published on April 6, 2020

FCC ET Docket No. 19-226, submitted electronically to https://www.fcc.gov/ecfs

With this letter, the Environmental Working Group objects to the Federal Communications Commission's proposal to apply the outdated, insufficiently protective radiofrequency (RF) radiation exposure limits to 5G technology and to RF emissions above 6 GHz. This proposal, described in the Federal Register publication on April 6, 2020 (85 FR 19117), failed to take into account the significant and growing body of research demonstrating the biological potency of RF emissions and their impacts on cells, tissues and organisms – in this case, people.

EWG is a nonprofit public health research and advocacy organization headquartered in Washington, D.C. EWG has studied the human health effects of cellphone RF radiation since 2009 and has published reviews and research summaries on this topic.[1] Here EWG provides specific comments and links to research studies, which are incorporated in our comments by reference.

EWG's research on the human health impacts of RF emissions draws on the latest studies by U.S. and international scientists, our thorough knowledge of previous research, and our close monitoring of regulatory approaches and recommendations on RF radiation made by government agencies around the world. Based on this analysis, EWG finds that the overall body of science on RF radiation raises justifiable concerns and deserves extensive additional toxicological and epidemiological study and a precautionary attitude.

In 2013 EWG submitted comments to the FCC, urging the commission to review and strengthen its cell phone radiation standards in order to protect both children and adults adequately and to reflect current patterns of use.[2] EWG objects both to the

[1] Environmental Working Group. 2009. EWG's Report on Cell Phone Radiation: Science Review on Cancer Risks and Children's Health. Available at https://static.ewg.org/reports/2009/CellPhoneRadiation_ScienceReview_2009.pdf?_ga=2.229167327.2119036492.1589217181-1390723591.1576602474

[2] Environmental Working Group. 2013. Comments submitted in the Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies (ET Docket No. 13-84) and Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields (ET Docket No. 03-137). Available at https://cdn.ewg.org/sites/default/files/testimony/EWG_FCC_comments_9313.pdf.

FCC's decision to leave the RF exposure limits for the general public unchanged and to the FCC's proposal to extend these outdated limits to a more extensive RF frequency range.

Recognizing the current ubiquity, practicality and economic role of wireless communication technologies and devices, EWG is all the more concerned about ensuring that the technologies and RF emission types deployed today and in the future will be safe for public health. Our special concern is for children, whose developing bodies and brains can absorb greater amounts of RF radiation,[3] and for all vulnerable populations who, due to genetic background, prior health status, RF exposure levels, and/or co-occurring exposures to other physical and chemical factors, may be more susceptible.

Research by the National Toxicology Program, or NTP, which conducted the largest-ever animal study of RF radiation, supports earlier evidence from human studies that long-term exposure to RF radiation can increase the risk of cancer. Specifically, the NTP study found clear evidence of tumors – malignant schwannomas – in the hearts of male rats, as well as some evidence of malignant gliomas in their brains and tumors in their adrenal glands.[4] A study conducted by the Ramazzini Institute, in Italy, obtained similar results showing elevated cancer risk.[5] The NTP study also demonstrated that RF exposure in laboratory animals can cause DNA damage.[6] EWG also highlights an important study from scientists at the National Institute on Drug

[3] Liorni I, Parazzini M, Varsier N, Hadjem A, Ravazzani P, Wiart J. Exposure assessment of one-year-old child to 3G tablet in uplink mode and to 3G femtocell in downlink mode using polynomial chaos decomposition. Phys Med Biol. 2016;61(8):3237‑3257. https://doi.org/10.1088/0031-9155/61/8/3237. Sadetzki S, Langer CE, Bruchim R, et al. The MOBI-Kids Study Protocol: Challenges in Assessing Childhood and Adolescent Exposure to Electromagnetic Fields from Wireless Telecommunication Technologies and Possible Association with Brain Tumor Risk. Front Public Health. 2014; 2:124. https://doi.org/:10.3389/fpubh.2014.00124. Wiart J, Hadjem A, Varsier N, Conil E. Numerical dosimetry dedicated to children RF exposure. Prog Biophys Mol Biol. 2011; 107(3):421‑427. https://doi.org/10.1016/j.pbiomolbio.2011.10.002.

[4] National Toxicology Program. Cell Phone Radio Frequency Radiation. Available at https://ntp.niehs.nih.gov/whatwestudy/topics/cellphones/index.html Page last updated on March 12, 2020.

[5] Falcioni L, Bua L, Tibaldi E, et al. Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. Environ Res. 2018; 165:496‑503. https://doi.org/10.1016/j.envres.2018.01.037.

[6] Smith-Roe SL, Wyde ME, Stout MD, et al. Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure. Environ Mol Mutagen. 2020; 61(2):276‑290. https://doi.org/10.1002/em.22343.

Abuse that in people, exposure to cell phone emissions is associated with changes in brain glucose metabolism in the region closest to the antenna.[7]

As the FCC is aware, the NTP study, and the vast majority of existing studies, have focused on RF frequencies and types used in 2G and 3G wireless communication networks. Given that earlier generation technologies are associated with risks to human health, this information should be taken seriously,[8] and more studies must be done on 5G technology before full-scale rollout.

EWG concludes that the existing RF exposure limits should not be applied to 5G technologies or to RF emissions above the 6 GHz range. We urge the commission to withdraw this proposal and to restart the exposure limits reevaluation process. The epidemiological and toxicological risks of RF exposure deserve thorough study if we are to protect the public health, especially that of our children, from excessive and potentially unsafe levels of exposures to RF emissions.

Submitted on behalf of Environmental Working Group.

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[7] Volkow ND, Tomasi D, Wang GJ, et al. Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. JAMA. 2011;305(8):80‑813. https://doi.org/10.1001/jama.2011.186.
[8] Melnick RL. Commentary on the utility of the National Toxicology Program study on cell phone radiofrequency radiation data for assessing human health risks despite unfounded criticisms aimed at minimizing the findings of adverse health effects. Environ Res. 2019; 168:1 ‑ 6. https://doi.org/10.1016/j.envres.2018.09.010

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies	)	ET Docket No. 13-84
	)	
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	)	ET Docket No. 03-137

COMMENTS OF ENVIRONMENTAL WORKING GROUP

Environmental Working Group respectfully submits its comments on the Commission's First Report And Order, Further Notice of Proposed Rule Making, and Notice Of Inquiry in the aforementioned dockets. EWG is a not-for-profit environmental and public health research and advocacy organization based in Washington D.C. that has raised concerns about the potential long-term health effects associated with exposure to radiofrequency energy (RF) emissions from cell phones.

In our comments, EWG urges the Federal Communications Commission to strengthen its cell phone radiation standards. Specifically, the agency's regulations must be revised so that they will adequately protect both children and adults, reflect actual current use patterns and provide meaningful consumer disclosure without preempting states from requiring additional disclosure.

Moreover, it is imperative that the FCC not weaken its existing standards by altering its testing guidelines to adopt average radiation exposure testing over a larger volume of tissue. This change, proposed by the FCC, would be a step backward, given the unanswered questions about the potential long-term effects of cell phone radiation exposure.

Because of the widespread use of wireless technology, a miscalculation could have potentially severe consequences.

I. INTRODUCTION AND BACKGROUND

The Commission's March 27, 2013, notice of inquiry (NOI) on wireless device safety was long overdue. In the 17 years since the FCC set its standards for radiofrequency energy emissions (RF) from cell phones, wireless technology been revolutionized. The 1996 standards were adopted at a time when cell phone use by children was rare, smart phones did not exist, cell phone cases were virtually unheard of and the FCC assumed that people would often carry the phones in holsters clipped to their belts.

Today, we live in a completely different world. In 2012 there were more than 326 million cell phone subscribers in the U.S. – 10 times as many as in 1997 (CTIA 2013). According to a recent survey, cell phone usage by children is common, and 78 percent of teenagers between the ages of 12 to 17 now own a cell phone (Pew 2013). Almost half of the phones being sold today are smartphones, and cases for these phones have become a multi-million dollar business (CNET 2013a). Wireless-only households now account for 35 percent of all households in the U.S. (CTIA 2013).

Unfortunately, the FCC's standards have not kept up with these changes in the marketplace. They do not account for the fact that children's brains absorb more RF energy than adult brains. They do not consider how phone cases may significantly alter the RF exposure profile of smartphones and other cell phones. They do not provide adequate protection for people who carry their phones next to their bodies rather than in a holster. They do not focus on protecting against potential long-term health effects. To make matters worse, the FCC's standards do not provide consumers who wish to minimize their exposure with sufficient information to make informed purchasing decisions.

These factors provide more than sufficient reason for the FCC to strengthen its standards. Considering the numerous scientific studies published in the last decade that point to potential adverse health effects from cell phone radiation – including childhood and adult cancer, reduced sperm count and reproductive/developmental effects – it becomes imperative for the FCC to act. This is not because there is definitive scientific evidence pointing to harm, but rather because the consequences of a miscalculation could be severe, given the ubiquitous use of wireless technology. It is against this backdrop that we urge the FCC to make the following improvements to its current cell phone standards.

II. FCC STANDARDS MUST BE STRENGTHENED TO PROVIDE ADEQUATE PROTECTION FOR CHILDREN

i. Cell phone use by children is common and increasing

Cell phone use is common and increasing among children and teens. A 2010 survey of 800 teenagers sponsored by the Pew Research Center found that 75 percent of young people ages 12-to-17 own cell phones, compared to 45 percent in 2004 (Lenhart 2010). Another 2010 consumer survey of 4,500 boys and girls reported that 20 percent of children ages 6-11 owned cell phones in 2009, up 68 percent from 2005 (MRI 2010). Cell phones and accessories are now aggressively marketed toward children, as is evident from the wide availability of Disney-themed phones and case covers, and large companies such as Sprint advertise child-friendly models. These trends highlight the need to ensure that children are not being exposed to cell phone radiation at levels that have potential to cause harm.

ii. FCC's standards must be revised to reflect the fact that children's brains absorb significantly more radiation than adult brains

Despite mounting scientific evidence that children are more vulnerable to potentially harmful RF emissions from cell phones, limits on specific absorption rates (SAR) are the same for children and adults. Given the unknowns about the potential long-term effects of exposing

developing brains to cell phone radiation and the increasing number of children and teenagers who own cell phones, it is critical that the FCC revise its standards to be more protective. This is especially important in light of the fact that children will be exposed to cell phone radiation for more years and therefore in greater total amounts than the current generation of adults (NRC 2008a).

Scientists from around the world agree that the head and brain of a child absorb significantly more radiation than those of an adult (de Salles 2006; Gandhi 1996; Kang 2002; Wang 2003). As noted by the International Agency for Research on Cancer, the average RF energy deposition is twice as high in certain regions of children's brains and up to 10 times higher in the bone marrow of children's skulls, compared to energy deposition in adult brains and skulls (IARC 2012; Christ 2010). Research from the wireless industry itself has reached similar conclusions, as evidenced by a 2008 study by France Telecom that found that the maximum SAR in models of children's brains at ages 5-to-8 was twice as high as in models of adult brains (Wiart 2008).

In general, as head size decreases, the percentage of energy absorbed by the brain increases (Martinez-Burdalo 2004). Moreover, children's tissues have higher water and ion content than adult tissues (Peyman 2009). Both factors increase radiation absorption, according to researchers from the U.S., the Finnish cell phone company Nokia, the Institute of Applied Physics in Spain and the U.K. Health Protection Agency (Gandhi 2002; Keshvari 2006; Martinez-Burdalo 2004; Peyman 2009). In addition, children have thinner skulls than adults.

U.S. cell phone emission levels and federal standards are based solely on radiation absorbed by adults and fail to account for children's higher exposures and potentially greater health risks. The FCC's 1.6 W/kg SAR standard is modeled on an adult head, not a child's smaller head with its thinner skull bone and different tissue composition. Assuming a conservative and likely overestimated departure point for health effects based on a SAR value of

4 W/kg, the FCC's 1.6 W/kg exposure standard for the head has only a 2.5-fold safety margin above the level that produced adverse behavioral effects in animals (EWG 2009a).

Furthermore, the FCC did not add any uncertainty (or "safety") factors to its calculations in developing a standard to account for the extra sensitivity of children. This is in stark contrast to the risk management approach practiced by the Environmental Protection Agency (EPA). According to EPA, protective reference values should be derived in a way that accounts for both the uncertainty and the variability in the available data (U.S. EPA 2008). In this framework, variability refers to heterogeneity or diversity in the human population, including differences in vulnerability to a particular physical, chemical or biological agent. Further uncertainty is typically due to a paucity of available information, the need to extrapolate from animal data to humans, assumptions about short-term exposure compared to chronic exposure, and the lack of data regarding all health endpoints that could be affected by exposure (NRC 2008b; U.S. EPA 2002).

To account for uncertainty and variability, default factors (typically tenfold) are used in EPA risk assessments for deriving the operational reference exposure values from experimental data (U.S. EPA 2009). The goal of applying uncertainty/variability factors (UFs) for developing general population exposure standards is to ensure that an adequate margin of safety exists to protect infants, young children and other vulnerable populations. The choice of specific UFs depends on the quality of the studies available and the extent of the research database. EPA has developed certain general principles that apply to most risk assessments (U.S. EPA 2002), to wit:

- The inter-species UF accounts for different sensitivity between humans and laboratory test species; it generally falls between a factor of 3 and 10, but factors higher than 10 may be applied;
- The intra-species UF accounts for variability in response between different individuals; this factor is generally set at 10 and must be higher in order to specifically protect children;

- The sub-chronic-to-chronic duration UF is typically set at a default value of 10 whenever the results of a short term exposure study are used to derive a long-term exposure standard;
- Finally, for certain exposures during vulnerable periods of development, as in the case of young children's exposure to pesticides, an additional safety factor of 10 is typically used (consideration of children's exposure is mandated under Food Quality Protection Act of 1996).

No such uncertainty factors were applied to the FCC standard to account for children's increased exposure to cell phone radiation.

All these data, taken together, suggest that when a child uses a cell phone that complies with the FCC standards, he or she could easily absorb an amount of radiation above the maximum allowed limits defined by the federal guidelines. FCC standards give adults only a slim margin of safety above emission levels that are known to harm animals. For children, the margin is much slimmer – if it exists at all. The FCC's standards must be updated to specifically address the special vulnerability of children and their higher levels of exposure.

iii. Children may face health risks from cell phone RF exposure

An adequately protective standard is particularly important in light of the emerging scientific evidence that children may face particular health risks from RF exposure. Much of the research to date has focused on an association between cell phone use and cancer, which was the subject of a large, multi-center epidemiological study undertaken in Europe, called INTERPHONE. The International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as "possibly carcinogenic to humans (Group 2B)," based on an increased risk of brain glioma observed by the INTERPHONE study (IARC 2012). There is also some evidence that RF may also contribute to acoustic neuroma and parotid malignancy, although the links to glioma are stronger (IARC 2012; Duan 2011; Hardell 2013; Sadetzki 2008; Shoemaker 2005).

Cell phone use by children has not been commonplace long enough for scientists to be able to definitively determine the long-term effects of ongoing exposure to the developing brain. There is also a relative scarcity of information on this question. In response to critical data gaps regarding the effects of RF on children, the World Health Organization Prospective has placed "cohort studies of children and adolescents with outcomes including behavioral and neurological disorders and cancer" on its list of high-priority research needs (WHO 2010).

A few epidemiological studies have been completed or are underway to address these data gaps. A 2012 case-control study that analyzed cancer incidence in Chinese children exposed to RF through mobile base stations found an increased risk of all neoplasms at above-median exposure to RF, and a positive but statistically insignificant association with brain neoplasms and leukemia (Li CY, 2012). Two international epidemiological case-control studies are examining the effects of cell phone radiation exposure in children. Results of the CEFALO study, which involved research centers in four countries, were published in 2011. While there were only weak, statistically insignificant associations between most cell phone use parameters and brain cancer risk, there was a significant association between increasing cancer risk and increasing time since first cell phone use in data provided by network operators (vs. self-reported data that is subject to recall bias) (Aydin 2011). This suggests that increases in brain cancer risk may correspond to duration of cell phone use. The authors also noted that their sample size may not have provided the statistical power to detect smaller increases in brain cancer risk. The second children's study, called Mobi-kids, involves research centers in 16 countries and is seeking to recruit thousands of participants. The FCC should take a precautionary approach and set stricter exposure limits while this important research is completed.

It is important to note that brain tumors have a long latency period of 10 to 15 years (ACS, 2012). Currently available studies may not be reflective of future trends in disease, particularly in those who began using cell phones as children. It is also notable these studies detected *any* increase in risk, given the relatively short time periods involved. The long latency

period of brain cancer creates yet another layer of uncertainty and yet another reason to implement a more stringent standard.

iv. Emerging evidence points to potential links between cell phone radiation and other health effects

Other research suggests that cell phone use could have other adverse effects on children. A Danish study of more than 50,000 children found that the likelihood of developing migraines and headache-related symptoms was higher in children who used cell phones versus those with no exposure (Sudan 2012). The researchers noted that while the study did not demonstrate a causal relationship, the potential health impact would be large if one exists. The same group also reported a weak association between cell phone use and hearing loss in children, but those results were not conclusive (Sudan 2013). Although definitive links between children's cell phone use and health effects have not yet been established, it is best to err on the side of caution.

Some research indicates that prenatal exposure to cell phone radiation may lead to effects later in life. Several studies using laboratory animals have suggested that cell phone radiation might be harmful to the developing fetus. A 2009 study in Turkey found that after pregnant rats were exposed to cell phone radiation for 15 minutes twice a day during the entire gestation period, the female pups had fewer ovarian follicles, indicating the potential for reproductive effects (Gul 2009). Prenatal exposure to cell phone radiation also reduced the number of nerve cells and affected brain structure in rats (Odaci 2008; Sonmez 2010).

A 2012 study by researchers at the Yale University School of Medicine found that mice exposed to cell phone radiation during gestation were hyperactive and had impaired memory (Aldad 2012). There have been similar findings in human studies. UCLA researchers reported that cell phone exposure during pregnancy and after birth was associated with behavioral problems in young children (Divan 2008; Divan 2012).

A proposed mechanism by which electromagnetic radiation may affect the brain is by increasing the permeability of the blood-brain barrier (BBB). The BBB protects the brain from

exposure to substances in circulating blood that could be toxic or disrupt the homeostasis of the brain microenvironment. Exposure to an electromagnetic pulse may increase the permeability of the BBB and perturb proteins that form the tight junctions that maintain its integrity (Ding 2010).

Some experiments using RF of the type emitted by cell phones, including exposures at non-thermal levels, have shown that it can affect BBB permeability in laboratory animals, (reviewed in Nittby 2008). Two studies in humans have reported increased transthyretin in blood, a biomarker of BBB permeability, although the authors made note of confounding factors (Soderquvist 2009a; Soderquvist 2009b).

Additional research has studied other potential health effects, such as childhood obesity, that may be related to prenatal electromagnetic field exposure. A prospective cohort study published in 2012 monitored maternal exposure to magnetic fields during pregnancy and the weight and body mass index (BMI) of 733 children for up for to 13 years. The study reported a relationship between prenatal exposure to magnetic fields and childhood obesity, with the highest exposures associated with the highest risk (Li DK, 2012).

Research on adverse affects associated with prenatal exposure to cell phone radiation is still emerging. A more comprehensive body of data is needed to determine if emissions from cell phones can affect the developing fetus or lead to behavioral or physical effects later in life. The uncertainties surrounding the possibility that children and the fetus may suffer adverse health effects from cell phone radiation strongly argue that the FCC should lower its current public exposure limits to ensure that such populations are protected.

II. FCC STANDARDS MUST BE MODERNIZED TO REFLECT ACTUAL PATTERNS OF CONSUMER USE

i. FCC standards and testing guidelines must assume that consumers will carry their cell phones directly against the body

In its Notice of Inquiry, the FCC acknowledges that there are "circumstances where test configurations may not reflect actual use" because current federal guidelines allow cell phone companies to use a spacer of up to 2.5 centimeters in "body-worn testing configurations." These

guidelines appear to stem from an FCC assumption in 1996 that consumers would be carrying their phones in holsters, rather than directly against the body. Whatever the reason for the agency's earlier decision, it is clear that the FCC must now update its testing guidelines to reflect the reality that many people commonly carry their phones directly against the body, often putting them phones in a pocket or and placing them on the lap – sometimes even placing them in their bras.

Notably, a 2012 Government Accountability Office (GAO) report concluded that consumers who hold a phone directly against the body could receive "*RF energy exposure higher than the FCC limit*" and recommended that the FCC "[r]eassess whether mobile phone testing requirements result in the identification of maximum RF energy exposure in likely usage configurations, particularly when mobile phones are held against the body, and update testing requirements as appropriate."

EWG strongly agrees with this recommendation. Given that holsters and belt clips are not commonly used today, it makes no logical sense to test RF exposure compliance of wireless devices at *any* distance from the body if the agency aims to simulate real-world usage. This is particularly important since at least some testing has indicated that RF exposure from an iPhone 4 would exceed FCC guidelines by a factor of three if tested right next to the body (Pong 2012). The difference is between allowing a 2.5 cm gap and zero spacing is not trivial.

ii. FCC testing guidelines and standards should account for the fact that cell phone cases affect the RF exposure profile of phones significantly

While cell phone holsters and belt clips are no longer common, in the 17 years since the FCC issued its RF standards for cell phones, form-fitting cases have become ubiquitous. Because these cases can alter the RF exposure profile of cell phones considerably, it is important that the FCC incorporate these accessories into its testing guidelines (Pong 2012). Otherwise the FCC standards will continue not to reflect actual consumer use patterns and therefore limit consumer confidence.

At a minimum, the FCC should require testing that indicates whether a cell phone case is likely to increase or decrease RF exposure so that consumers can make informed purchasing decisions. Currently, it is likely that few consumers are aware that using a case on a smartphone could increase (or in some cases decrease) exposure to cell phone radiation significantly.

III. FCC STANDARDS MUST BE REVISED TO PROVIDE MEANINGFUL CONSUMER DISCLOSURE, PROTECT THE PUBLIC'S RIGHT TO KNOW AND GIVE CONSUMERS THE POWER TO MAKE INFORMED DECISIONS WHEN CHOOSING PHONES, CASES AND WIRELESS NETWORKS

i. Consumers should be given sufficient information to be able to reduce their exposure to cell phone radiation

Public concern about RF exposure from cell phones has mounted in recent years as the technology has spread and more scientific evidence linking cell phone radiation to health effects has emerged. Many consumers are interested in reducing their exposure to this inadequately studied possible carcinogen. Exposure reduction could be accomplished via consumer behavior changes such as using a headset or choosing phones and networks that expose them to less RF energy over time.

However, the information currently provided to consumers is highly limited and problematic. It is important for the FCC to develop and mandate the disclosure of real-world SAR values for phones and networks. This information should be made readily accessible in multiple settings, including at the point of sale, and federal laws should not preempt states or municipalities from requiring additional disclosure.

ii. FCC itself has noted that SAR is not an accurate proxy for emissions, yet many consumers seek exposure information

On its website the FCC describes in detail why the maximum Specific Absorption Rate (SAR) – currently the *only* RF exposure metric tested by the FCC and made available to consumers – is not a good predictor of actual exposure to RF energy from cell phones (FCC 2013). The FCC notes, for instance, that "a single SAR value does not provide sufficient

information about the amount of RF exposure under typical usage conditions to reliably compare individual cell phone models" (FCC 2013).

Even with the lack of definitive information on the radiation emissions from particular phone models, consumers have shown high interest in phones that emit lower radiation. For example, for more than four years the technology website CNET has published a data table of cell phone radiation levels based on the maximum SAR value (CNET 2013b). In the 64 hours following the 2009 publication of a EWG database of cell phones SAR values and a science review, 442,000 people accessed these materials on the EWG website, collectively viewing 1.4 million online pages (EWG 2009b).

During those same three days, EWG's findings were reported in 100 news articles and in national and local broadcast news, including The New York Times, NBC Nightly News, WebMD and USA Today. This powerful response from the public and news media outlets reflects consumers' keen interest in the issue of cell phone safety. Consumer demand is also evident in the use of phone-based applications such as a program made by the tawkon company to track RF transmission power in real time, which gives users direct feedback on when the SAR exposure is highest (Tawkon 2013a). According to the Google app store Google play, this application has been installed between 100,000 and 500,000 times (Google 2013).

Clearly, people are eager to know whether cell phones are safe and how they can protect themselves and their families from potential adverse effects of excessive exposure to cell phone radiation.

iii. RF exposure varies by service provider, transmission technology, frequency bands, location and proximity to cell phone towers

Recent studies have indicated that a consumer's choice of wireless network, with its associated frequency bands and transmission encoding, may be a more important factor in cell phone RF exposure than the cell phone model. The technology used in transmitting and encoding cell phone signals has been changing every few years: from GSM to CDMA to WCDMA and

most recently to LTE. The changing antenna design, transmission frequency and encoding have large effects on average RF exposure levels (Shi 2012, Kelsh 2011).

For a given power output to the antenna, the newer 4th generation LTE antenna design produces a SAR value that is 2-to-60 times greater than the 2G and 3G designs (Shi 2012). Research has shown that there was a major reduction in consumer radiation exposure in the shift from 2G to 3G WCDMA transmission technologies. While 2G transmitted at 20-70 percent maximum SAR in average usage, 3G phones generally transmitted at levels below 1 percent of maximum SAR (Gati 2009; Vrijheid 2009). As the technology has evolved, concerns have been raised that LTE transmission technology with multiple-in/multiple-out antenna designs have transmission characteristics similar to 2G technology and that exposure will be a larger fraction of maximum SAR than 3G technology (Shi 2012; Anderson 2011).

Although studies have found marked differences in average SAR levels among cell phone networks, the FCC currently provides consumers with absolutely no information to assist them in choosing a cell phone provider that will expose them to lower cell phone RF energy. This not only inhibits consumer's ability to make informed purchasing decisions, it also deprives the public of its right to know. Because it is now clear that cell phone network technologies affect RF exposure as much as the phone design itself, the FCC-mandated exposure metrics should incorporate both parameters in an expected in-use SAR rating.

iv. Cell phone cases can significantly alter RF exposure profiles

Because cell phone cases can significantly alter the RF exposure profile, FCC testing for maximum SAR as well as expected in-use SAR should be done with and without cases, including non-metal cases. Studies have shown that even non-metal cases, which are used on the vast majority of smartphones sold today, can have a large effect on cell phone signal strength and the related maximum radiation emissions (Pong 2012). Depending on its design and the thickness and type of material used, a case exerts a large net effect on the SAR of a given phone (Cellsafe 2013; Pong 2012). Due to variations in phone design and antenna placement, moreover, the modulation

of the SAR value will be case- and phone-dependent. Currently, however, most consumers are unaware of this. The FCC provides zero information that consumers can use to guide their purchasing decisions.

v. FCC should develop an estimated in-use SAR metric

It is the responsibility of the FCC to develop a metric for phone/network combinations that is representative of the average RF exposure a user would experience. EWG recognizes that this is a complicated endeavor, given that cell phone radiation varies significantly based on location, proximity to towers, transmission frequency, transmission encoding and other factors. Nevertheless, this should not preclude the FCC from developing a metric that would provide real-world SAR value estimates or ranges that would allow reasonable comparison of phone/network combinations.

One option for developing such an in-use SAR metric would be to require phones to record the power output to the antenna and calibrate this to SAR measurements. This would allow real-time SAR reporting and provide much more detailed exposure information that could assist in epidemiological studies of cell phones usage and radiation exposure. The tawkon company provides an application for mobile phones that purports to accomplish this very task of measuring real-time radiation feedback for users and alerts the user when the phone is transmitting at higher power (Tawkon 2013b).

Other federal agencies have attempted to provide consumers with similar real-world metrics to guide purchasing decisions, and these metrics have proven to be highly valuable even when they are acknowledged to be imperfect. Two such metrics are the Department of Energy's and Environmental Protection Agency's Energy Star ratings for household appliances and the miles-per-gallon (MPG) fuel efficiency ratings for automobiles. MPG values are provided even though users may experience wide variability in performance in actual use: the agencies explain that fuel economy can be significantly affected by "driving behavior, driving conditions, vehicle maintenance, fuel characterizes, weather and other factors" (DOE 2013).

In-use SAR values could follow a model similar to the DOE and EPA MPG ratings for city and highway driving scenarios. In addition, the two agencies also maintain a website, www.fueleconomy.gov, where users can track and compare their vehicles fuel use with the government estimates.

vi. FCC risk communication should be updated to reflect current science

In addition to requiring cell phone companies to clearly disclose RF exposure information, the FCC should do a better job of publicly communicating the uncertainties surrounding cell phone use and health risks. The FCC makes the following statement on its website:

> "Some health and safety interest groups have interpreted certain reports to suggest that wireless device use may be linked to cancer and other illnesses, posing potentially greater risks for children than adults. While these assertions have gained increased public attention, currently no scientific evidence establishes a causal link between wireless device use and cancer or other illnesses."

The tone of this statement implies that the concerns raised by public health organizations regarding radiation exposure from cell phone are baseless, when in fact the World Health Organization has determined that RF is a possible human carcinogen (WHO 2011).

While the scientific evidence surrounding cell phone use and health effects is not definitive, there is certainly sufficient research to warrant caution. In addition, there is data suggesting possible mechanisms of action, including oxidative stress and disturbances in the blood-brain barrier, as described here. The FCC should at least acknowledge that there is limited but suggestive scientific evidence that radiation from cell phones may be associated with adverse health effects, while recognizing that the current data is not compelling enough to establish a definitive link.

It is unclear what the next several decades will bring, but if RF exposure from cell phones does in fact cause cancer in even a small percentage of users, the world could be faced with millions of additional cancer cases. The likelihood of this scenario is yet unclear, but it

nevertheless provides a sobering backdrop for the FCC's upcoming decisions on wireless safety standards. We urge the agency to put public health protection and consumers' right to know front and center in its deliberations.

vi. FCC must take action that does not preempt state rights

It is critical that the FCC develop a more reliable exposure metric that is representative of average in-use RF exposure. The in-use exposure value should be comparable across phone/network combinations so that consumers can make informed choices. This exposure information should be disclosed to consumers in cell phone manuals and on Internet websites and be clearly displayed at the point of sale. Just as importantly, any actions by the FCC to enhance consumers' right-to-know must not preempt the right of states to adopt more stringent regulations with respect to exposure disclosure or cell phone RF education at the point of sale or in any other location or form.

IV. FCC MUST NOT WEAKEN ITS EXISTING STANDARDS BY BASING TESTING GUIDELINES ON AVERAGE RADIATION OVER A LARGER VOLUME OF TISSUE

It is imperative that the FCC not weaken its existing standards by altering its testing guidelines for radiation exposure by averaging over a larger volume of tissue.

The FCC currently calculates SAR values based on 1 gram of tissue, but the agency has indicated that it is now considering altering this long-standing method and may move to a system in which SAR values are calculated by averaging over 10 grams of tissue. It is important to note that calculations based on a greater volume of tissue will shrink SAR estimates compared to those based on a smaller tissue mass. Therefore if the FCC changes its calculation methodology and bases SAR values on 10g of tissue, it may underestimate mobile phone RF exposure. Calculations based on 10g of tissue will diffuse RF exposure over a large mass and may mask significantly higher exposures to small portions of the brain. There is also concern that calculating allowable exposure using 10g of tissue rather than 1g over a 6-minute period allows for greater heating in

small areas of the brain, and that such "hot spots" could have adverse effects on brain tissue (Blackman 2009). Research has shown that the SAR 1g calculation can be a better predictor of peak temperature increases and location than the 10g model (Bakker 2011).

A 2006 paper that calculated SAR values in adults and children using a 1g tissue model and a 10g tissue model found substantial differences. SAR values for adults and children using a 1850MHz planar antenna were 52 percent higher using a 1g SAR calculation than with a 10g SAR calculation (de Salles 2006). Calculations using a 850MHz planar antenna were 55 percent higher for adults and 70 percent higher for children using a 1g SAR average (de Salle 2006). This demonstrates that averaging over a larger (10g) tissue mass could significantly underestimate exposure to electromagnetic radiation. Other research shows a similar pattern in which exposure estimates using the 10g model consistently produce lower SAR values than the 1g model (Beard 2006).

Given the unanswered questions about the potential long-term effects of cell phone radiation exposure, increasing the tissue mass used to calculate SAR values, as proposed by the FCC, would be a step backward. Because of the widespread use of wireless technology, a miscalculation could have potentially severe consequences.

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