



Federal Communications Commission
Washington, D.C. 20554

September 29, 2023

VIA ELECTRONIC MAIL

Theodora Scarato
Environmental Health Trust



theodora.scarato@ehtrust.org

RE: FOIA Control Nos. 2023-000281 and 2023-000325

Dear Ms. Scarato,

This letter responds to your Freedom of Information Act (FOIA) requests, FOIA Control No. 2023-000281 and FOIA Control No. 2023-000325. Your request FOIA Control No. 2023-000281 seeks “any and all SAR tests or documentation of SAR tests for any cellphones, including but not limited to the BLU phones, that the FCC tested to determine regulatory compliance for SAR. Please send all SAR Reports, as well as all documentation of the SAR test findings. Please also send the emails and attachments between FCC staff related to the findings of the SAR tests for cell phones. Any SAR tests done by the FCC related to cell phones on the US market January 2017 through April 2020.”¹ Your request FOIA 2023-000325 seeks “all SAR tests, the full reports, the measurements, any images and name of staff person doing tests and date done by [the Office of Engineering and Technology (OET)] (not the manufacturer) on cell phones in the year 2019.”²

As a general matter, you can find SAR testing records in the Equipment Authorization Database on our webpage at <https://apps.fcc.gov/oetcf/eas/reports/GenericSearch.cfm>. If you can identify the FCC ID numbers for the equipment you describe, you can look up the details of the grant. Enter the first three characters of the FCC ID Number as the grantee code and the rest including hyphens as the product code. You can also search by the manufacturer. Enter the manufacturer’s name in the Applicant Name field to populate the results.

Specific to your FOIA requests, OET and the Enforcement Bureau (EB) conducted a search and found 18 records responsive to your request. Many of these records relate to an article published by the *Chicago Tribune* on August 21, 2019, claiming several popular cell phones exceed the FCC’s guidelines for RF exposure. The *Chicago Tribune*, through an independent accredited lab, RF Exposure Lab, LLC, had tested devices manufactured by Apple, BLU Products, Motorola, and Samsung to arrive at the conclusion in the article. Because we take seriously any claims of non-compliance with RF exposure standards, the FCC tested the same device models at our Lab. The FCC’s tests confirm that all tested sample devices comply with the FCC’s strict RF exposure guidelines.

¹ FOIA Control No. 2023-000281 (submitted January 30, 2023).

² FOIA Control No. 2023-000325 (submitted February 8, 2023).

We did not have access to the actual phones tested by the test lab used by the *Chicago Tribune*. The FCC Lab, therefore, obtained the same makes and models of these phones (where available), both from suppliers and on the open market. We tested the devices manufactured by Apple, BLU Products, Motorola, and Samsung at a 5mm separation distance, consistent with our published guidance.³ These tests were conducted consistent with the FCC Lab normal practices and the RF exposure compliance report for each phone that is publicly available in the application for certification in the Equipment Authorization System. These devices all complied with the FCC limits for RF exposure, limits that have a significant safety margin. With this letter, we release the test results.

Separately, and only for purposes of comparison with the *Chicago Tribune* results, the FCC Lab tested the devices with a separation distance at which the *Chicago Tribune* tested its devices, i.e., at 2 mm separation distance. We observed that at a 2 mm separation distance, the FCC RF exposure limits were exceeded, and found that the *Chicago Tribune* results at the 2 mm separation distance were even higher than what we observed. With this letter, we release our 2 mm separation distance test results with the caveat that the 2 mm separation distance test results are inconsistent with FCC practice,⁴ and are misleading because they reflect extreme conditions. Notwithstanding the foregoing, given that the RF exposure limit includes a significant safety margin, none of the results suggest there is any RF safety issue with the devices tested.

We also stress that cell phones operate under the control of the wireless networks to which they are connected. We believe that the *Chicago Tribune* tests did not use the appropriate wireless network control codes to set the phone in the proper modes for operation for the U.S. This may have disabled the various sensors or caused the network simulator to not control the phone's transmitters properly for operation in the U.S.

With that explanation, in response to your FOIA requests, out of the 18 documents located, we are releasing 11 records in full with no redactions. We are withholding the remaining seven records in full under FOIA Exemption 5. Exemption 5 protects certain inter-agency and intra-agency records that are normally considered privileged in the civil discovery context.⁵ Exemption 5 encompasses a deliberative process privilege intended to “prevent injury to the quality of agency decisions.”⁶ To fall within the scope of this privilege the agency records must be both pre-decisional and deliberative.⁷ Pre-decisional records must have been “prepared in order to assist an agency decision maker in arriving at his decision.”⁸

³ KDB 447498 D01 General RF Exposure Guidance v06 specifies the 5 mm minimum test separation distance. https://apps.fcc.gov/kdb/GetAttachment.html?id=f8IQgJxTTL5y0oRi0cpAuA%3D%3D&desc=447498%20D01%20General%20RF%20Exposure%20Guidance%20v06&tracking_number=20676 at 11 (“Devices that are designed to operate on the body of users ... without requiring additional body-worn accessories must be tested for SAR compliance using a conservative minimum *test separation distance* ≤ 5 mm to support compliance” (emphasis in original); see also KDB 648474 D04 Handset SAR v01r03, at 3, https://apps.fcc.gov/kdb/GetAttachment.html?id=zCDu9bDcV8fcsumpj%2Bef3w%3D%3D&desc=648474%20D04%20Handset%20SAR%20v01r03&tracking_number=33853 (citing KDB 447498 D01 General RF Exposure Guidance v06).

⁴ See, e.g., KDB 447498 D01 General RF Exposure Guidance v06, *supra* note 3.

⁵ 5 U.S.C. § 552(b)(5).

⁶ *NLRB v. Sears Roebuck & Co.*, 421 U.S. 132, 151 (1975).

⁷ *Id.* at 151-52.

⁸ *Formaldehyde Inst. v. Dep't of Health and Human Servs.*, 889 F.2d 1118, 1122 (D.C. Cir. 1989); see also *Coastal States Gas Corp. v. Dep't of Energy*, 617 F.2d 854, 866 (D.C. Cir. 1980) (“In deciding whether a document should

Deliberative records must be such that their disclosure “would expose an agency’s decision-making process in such a way as to discourage candid discussion within the agency and thereby undermine the agency’s ability to perform its functions.”⁹

The records withheld under Exemption 5, constituting internal documents and emails, contain pre-decisional internal deliberations among Commission staff. These records include staff summaries, pre-decisional discussion of the merits of information provided by third parties, preliminary thoughts of agency staff regarding policy, and general discussion of internal staff questions and viewpoints. Particularly, the withheld records implicate sensitive matters that require particular candor in the advice given to decision makers, which would be discouraged by the public release of the advice. We have determined that it is reasonably foreseeable that disclosure would harm the Commission’s deliberative processes, which Exemption 5 is intended to protect. Release of this information would chill deliberations within the Commission and impede the candid exchange of ideas.

We are required by both the FOIA and the Commission’s own rules to charge requesters certain fees associated with the costs of searching for, reviewing, and duplicating the sought-after information.¹⁰ To calculate the appropriate fee, requesters are classified as: (1) commercial use requesters; (2) educational requesters, non-commercial scientific organizations, or representatives of the news media; or (3) all other requesters.¹¹

Pursuant to section 0.466(a)(5)-(7) of the Commission’s rules, you have been classified as category (2), “educational requesters, non-commercial scientific organizations, or representatives of the news media.”¹² As an “educational requester, non-commercial scientific organization, or representative of the news media,” the Commission assesses charges to recover the cost of reproducing the records requested, excluding the cost of reproducing the first 100 pages. The production in response to your request did not involve more than 100 pages of duplication and is being provided in electronic form. Therefore, you will not be charged any fees.

If you consider this to be a denial of your FOIA request, you may seek review by filing an application for review with the Office of General Counsel. An application for review must be *received* by the Commission within 90 calendar days of the date of this letter.¹³ You may file an application for review by mailing the application to Federal Communications Commission, Office of General Counsel, 45 L Street NE, Washington, DC 20554, or you may file your application for review electronically by e-mailing it to FOIA-Appeal@fcc.gov. Please caption the envelope (or subject line, if via e-mail) and the application itself as “Review of Freedom of Information Action.”

be protected by the privilege we look to whether the document is . . . generated before the adoption of an agency policy and whether . . . it reflects the give-and-take of the consultative process. The exemption thus covers recommendations, draft documents, proposals, suggestions, and other subjective documents . . .”).

⁹ *Formaldehyde Inst.*, 889 F.2d at 1122 (quoting *Dudman Commc’ns Corp. v. Dep’t of the Air Force*, 815 F.2d 1565, 1568 (D.C. Cir. 1987)).

¹⁰ See 5 U.S.C. § 552(a)(4)(A); 47 CFR § 0.470.

¹¹ 47 CFR § 0.470.

¹² 47 CFR § 0.466(a)(5)-(7).

¹³ 47 CFR §§ 0.461(j), 1.7 (documents are considered filed with the Commission upon their receipt at the location designated by the Commission).

If you would like to discuss this response before filing an application for review to attempt to resolve your dispute without going through the appeals process, you may contact the Commission's FOIA Public Liaison for assistance at:

FOIA Public Liaison
Federal Communications Commission
Office of the Managing Director
Performance Evaluation and Records Management
45 L Street NE, Washington, DC 20554
202-418-0440
FOIA-Public-Liaison@fcc.gov

If you are unable to resolve your FOIA dispute through the Commission's FOIA Public Liaison, the Office of Government Information Services (OGIS), the Federal FOIA Ombudsman's office, offers mediation services to help resolve disputes between FOIA requesters and Federal agencies. The contact information for OGIS is:

Office of Government Information Services
National Archives and Records Administration
8601 Adelphi Road-OGIS
College Park, MD 20740-6001
202-741-5770
877-684-6448
ogis@nara.gov
<https://www.archives.gov/ogis>

Sincerely,



Ronald T. Repasi
Chief
Office of Engineering & Technology

Attachments

cc: FOIA Office, EB

FCC cell phone radiation SAR limit is **1.6 W/kg**

Environmental Health Trust FOIA Documents

Released by FCC Under FOIA

This is a screenshot from the FCC's spreadsheet on the FCC's Cell Phone Radiation SAR Tests done with a separation distance of 2 mm between the phone and the body.

FCC ID	Manufacturer	Description	Sample Type	SAR Configuration	FCC Lab Measured SAR Value (W/kg)	Serial Number
BCG-E3091A	Apple	iPhone 7 Portable Handset	Provided by Manufacturer	WCDMA Band 4, RMC, 12.2 kbps, Ch 1513, Body, Bottom, 2 mm	1.440	C6K6HD69HG7N
BCG-E3161A	Apple	iPhone X Portable Handset	Provided by Manufacturer	WCDMA Band 2, RMC, 12.2 kbps, Ch 9262, Body, Bottom, 2 mm GPRS 1900, GMSK, 2 Tx Slots, Ch 512, Body, Bottom, 2 mm	1.350 0.727	C39VF007JH2Q
BCG-E3218A	Apple	iPhone XS Portable Handset	Purchased by FCC	GPRS 1900, GMSK, 2 Tx Slots, Ch 661, Body, Back, 2 mm GPRS 1900, GMSK, 2 Tx Slots, Ch 661, Body, Bottom, 2 mm	2.340 1.990	GONZ50M7KPFR
A3LSMG960U	Samsung	Galaxy S9 Portable Handset	Provided by Manufacturer	CDMA BC1, RC3, TDSO 32, Ch 600, Body, Back, 2 mm, Connect then Position	4.520	R38K609SMYL
A3LSMG960U	Samsung	Galaxy S9 Portable Handset	Purchased by FCC	CDMA BC1, RC3, TDSO 32, Ch 600, Body, Back, 2 mm, Position then Connect	4.380	R3M706TT9A
A3LSMJ337A	Samsung	Galaxy J3 Portable Handset	Provided by Manufacturer	WCDMA Band 4, RMC, 12.2 kbps, Ch 1312, Body, Back, 2 mm, Connect then Position	5.200	RF8KA1J3X6E
IHDT56XC4	Motorola	Moto e5 play Portable Handset	Provided by Manufacturer	WCDMA Band 4, RMC, 12.2 kbps, Ch 1312, Body, Back, 2 mm, Position then Connect	1.390 1.360	359524090350295
IHDT56XB1	Motorola	Moto g6 Play Portable Handset	Provided by Manufacturer	WCDMA Band 2, RMC, 12.2 kbps, Ch 9262, Body, Back, 2 mm, Connect then Position	1.980	351864090034178
IHDT56XB1	Motorola	Moto g6 Play Portable Handset	Purchased by FCC	WCDMA Band 5, RMC, 12.2 kbps, Ch 4132, Body, Front, 2 mm, Position then Connect	1.980	3518643090300620
YHLBLUVIV05MN	BLU	Vivo 5 Mini Portable Handset	Provided by Manufacturer	WCDMA Band 5, RMC, 12.2 kbps, Ch 4132, Body, Front, 2 mm, Connect then Position	1.080	1080021018057240
YHLBLUVIV05MN	BLU	Vivo 5 Mini Portable Handset	Purchased by FCC	WCDMA Band 5, RMC, 12.2 kbps, Ch 4132, Body, Front, 2 mm, Position then Connect	1.090	1080021018069900
				GPRS 850, GMSK, 4 Tx Slots, Ch 128, Body, Back, 2 mm	2.200	
				GPRS 850, GMSK, 4 Tx Slots, Ch 128, Body, Back, 2 mm	2.750	

Freedom of Information Act Appeal

December 28, 2023

Office of General Counsel
Federal Communications Commission
45 L St. NE
Washington, DC 20554
FOIA-Appeal@fcc.gov,

Appeal RE: FOIA Control Nos. 2023-000281 and 2023-000325

This letter constitutes an appeal of the Federal Communications Commission (“FCC”) determination granting in part and denying in part Theodora Scarato’s request under the Freedom of Information Act (“FOIA”) on behalf of the Environmental Health Trust (FOIA Control Nos. 2023-000281 and 2023-000325). The Environmental Health Trust (“EHT”) appeals all aspects of the FCC’s denial, including the withholding of all or part of the requested records.

BACKGROUND

On January 3, 2023 and February 8, 2023, Theodora Scarato of the Environmental Health Trust initially requested records related to cell phone radiation tests performed by the FCC from January 2017 through April 2020. On September 29, 2023, she received 11 of 18 documents in response, along with a letter signed by Ronald T. Repasi Chief, Office of Engineering & Technology at the FCC.

In regards to the seven documents the FCC withheld from the FOIA response, the FCC stated, “The records withheld under Exemption 5, constituting internal documents and emails, contain pre-decisional internal deliberations among Commission staff. These records include staff summaries, pre-decisional discussion of the merits of information provided by third parties, preliminary thoughts of agency staff regarding policy, and general discussion of internal staff questions and viewpoints. Particularly, the withheld records implicate sensitive matters that require particular candor in the advice given to decision makers, which would be discouraged by the public release of the advice. We have determined that it is reasonably foreseeable that disclosure would harm the

Commission's deliberative processes, which Exemption 5 is intended to protect. Release of this information would chill deliberations within the Commission and impede the candid exchange of ideas."

The 11 records released on September 29, 2023 revealed that FCC had tested several popular cell phones (Apple, Samsung, Motorola, Blu models) for cell phone radiofrequency (RF) radiation SAR levels in positions mimicking the phone in the pocket, specifically at 2 mm distance between the phone and the body phantom. The FCC's findings showed RF radiation SAR level measurements that violated FCC limits when tested in this position. This is the first known public release of these records.

These records further state: "We observed that at a 2 mm separation distance, the FCC radiofrequency (RF) exposure limits were exceeded". The FOIA records released by the FCC document cell phone radiation SAR levels as high as 5.2 W/kg --more than 3 times the current SAR limit of 1.6 W/kg.

The FCC's tests were conducted in response to an August 21, 2019, [Chicago Tribune investigation](#) that reported that phones tested in close body contact (at 2 mm) exceeded FCC's SAR radiation limits several-fold. The Tribune chose the 2 mm distance to mimic real world cell phone use with a phone in a tight pants pocket.

Soon after the report made headlines, the FCC issued a [December 19, 2019 report](#) stating that they had tested the same phone models and that the phones met FCC limits. However, this report only included the FCC's cell phone radiation SAR test findings done with the phone distanced from the body at 5 mm to 15 mm. The [December 19, 2019 report](#) did not include findings from the FCC tests done at 2 mm from the body that found cell phone radiation SAR levels over 300% of the FCC limit.

At the time, the agency also had an [open rule-making](#) followed by a court challenge ([EHT v. FCC](#)) regarding its 1996 limits and regulations for human exposure to cell phone radiation. A central issue involved the FCC's premarket cell phone compliance tests that do not require phones to be tested in body contact positions. The FCC withheld this data from the Inquiry and it was not included in any court filings. Further, the Inquiry addressed the adequacy of the FCC's human exposure limits as the limits were designed to only protect for short term exposure, not long-term exposure.

The materials provided in response to the EHT FOIA noted that the FCC cell phone radiation SAR radiation testing commenced August 30, 2019 and concluded on

September 23, 2019. Yet on December 4, 2019, [the FCC issued a decision](#) in its 7 year inquiry that omitted both (i) public opportunity to comment on and (ii) possibly full FCC personnel access to the FCC's 2 mm cell phone tests data. The FCC stated that "Even though some parties claim that the RF exposure evaluation procedures for phones should require testing with a "zero" spacing – against the body – this is unnecessary."

DISCUSSION

The FCC Should Not Withhold Documents Based on Exemption 5

The FCC withheld certain documents from EHT based on the FOIA exemption in 5 U.S.C. § 552(b)(5) (shielding certain inter-agency or intra-agency documents from disclosure). To begin with, EHT challenges the application of 5 U.S.C. § 552(b)(5) to the records requested. However, because the FCC has not provided any sufficient description of any of the records withheld (apart from what can be gleaned from the claimed exemption), the EHT lacks the ability to make any document-by-document arguments at this time.

Exemption 5, the deliberative process privilege, has been interpreted for the general purpose to "prevent injury to the quality of agency decisions." *NLRB v. Sears, Roebuck & Co.*, 421 U.S. 132, 151 (1975). Specifically, three policy purposes consistently have been held to constitute the bases for this privilege: (1) to encourage open, frank discussions on matters of policy between subordinates and superiors; (2) to protect against premature disclosure of proposed policies before they are finally adopted; and (3) to protect against public confusion that might result from disclosure of reasons and rationales that were not in fact ultimately the grounds for an agency's action. See, e.g., *Russell v. Dep't of the Air Force*, 682 F.2d 1045, 1048 (D.C. Cir. 1982); *Coastal States Gas Corp. v. Dep't of Energy*, 617 F.2d 854, 866 (D.C. Cir. 1980); *Jordan v. United States Dep't of Justice*, 591 F.2d 753, 772-73 (D.C. Cir. 1978) (en banc); *Heggstad v. United States Dep't of Justice*, 182 F. Supp. 2d 1, 12 (D.D.C. 2000). Despite the breadth of the goal of protecting such information from disclosure, this exemption is not a cover-all that applies merely because it is invoked.

Traditionally, the courts have established two fundamental requirements, both of which must be met, for the deliberative process privilege to be invoked. See *Mapother v. Dep't of Justice*, 3 F.3d 1533, 1537 (D.C. Cir. 1993) ("The deliberative process privilege protects materials that are both predecisional and deliberative." (citing Petroleum Info.

Corp. v. United States Dep't of the Interior, 976 F.2d 1429, 1434 (D.C. Cir. 1992))). First, the communication must be predecisional, i.e., "antecedent to the adoption of an agency policy." *Jordan*, 591 F.2d at 774. Second, the communication must be deliberative, i.e., "a direct part of the deliberative process in that it makes recommendations or expresses opinions on legal or policy matters." *Vaughn v. Rosen*, 523 F.2d 1136, 1143-44 (D.C. Cir. 1975). The burden is upon the agency to show that the information in question satisfies both requirements. See *Coastal States*, 617 F.2d at 866. Finally, even if a document is clearly protected from disclosure by the deliberative process privilege, it may lose this protection if a final decisionmaker "chooses expressly to adopt or incorporate [it] by reference." *Niemeier v. Watergate Special Prosecution Force*, 565 F.2d 967, 973 (7th Cir. 1977); *Bhd. of Locomotive Eng'rs v. Surface Transp. Bd.*, No. 96-1153, 1997 WL 446261, at **4-5 (D.D.C. July 31, 1997) (finding that staff recommendation was adopted in both written decision and commission vote); *Burkins v. United States*, 865 F. Supp. 1480, 1501 (D. Colo. 1994) (holding that final report's statement that findings are same as those of underlying memorandum constituted adoption of that document); *Atkin v. EEOC*, No. 91-2508, slip op. at 23-24 (D.N.J. July 14, 1993) (holding recommendation to close file not protectible where it was contained in agency's actual decision to close file).

In an effort to obtain sufficient information to make this document-by-document assessment, on October 7, 2023, Theodora Scarato sent an email to the David Duarte, FCC Spectrum Allocations Analyst, OET/ Policy & Rules Division requesting the Vaughn list for the redacted documents from the FCC including the date of document; originator; originating component, the author, and the recipient; subject/title of document; total number of pages reviewed; number of pages of reasonably segregable information released; number of pages denied; exemption(s) claimed; justification for withholding. In response, Scarato received an email on October 16, 2023 from Duarte stating that, "We are happy, to the extent we are able, to answer any specific questions you may have regarding the material that may have been withheld in our response to your two requests. That said, however, agencies are not required to provide FOIA requesters with a Vaughn Index to complement an administrative FOIA response and we will not do so in this instance which is consistent with agency practice." On October 16, 2023, Theodora Scarato emailed David Duarte requesting the: date of document, author and recipient; Subject/title of document; total number of pages for each document and exemption(s) claimed for each document. On November 8, 2023, David Duarte emailed Theodora Scarato that, "This request is the equivalent of a Vaughn's Index. As stated before, we are not required to provide one with an administrative FOIA response and

will not be providing one for these FOIA requests. Please let us know if you have any further questions regarding your requests.”

The FCC Must Still Provide Documents that Contain Non-Exempt Materials

Even assuming that 5 U.S.C. § 552(b)(5) applies, the FCC is obligated to provide segregable, non-exempt portions of such records. For example, even when an agency document embodies pre-litigation deliberations that would normally be exempt under (b)(5), the factual content underlying those deliberations must still be produced. See *Ryan v. DOJ*, 617 F.2d 781, 790-91 (D.C. Cir. 1980); *Mead Data Cent., Inc., v. Department of the Air Force*, 566 F.2d, 242, 260 (D.C. Cir. 1977); *EPA v. Mink*, 410 U.S. 73, 91 (1973) (refusing to extend deliberative process privilege protection to "factual material otherwise available on discovery merely [on the basis that] it was placed in a memorandum with matters of law, policy, or opinion"); *Coastal States*, 617 F.2d at 867 (citing *Mink*, 410 U.S. at 93); *Bilbrey v. United States Dep't of the Air Force*, No. 00-0539, slip op. at 10-11 (W.D. Mo. Jan. 30, 2001) (holding privilege inapplicable to factual statements underlying predecisional recommendations), *aff'd*, No. 01-1789, 2001 WL 1222471, at *1 (8th Cir. Oct. 16, 2001) (unpublished table decision); *Sw. Ctr. for Biological Diversity*, 170 F. Supp. 2d at 941 (concluding that release of "raw research data" would not expose agency's deliberative process, on grounds that such data were not recommendations, not subject to alteration upon further agency review, and not "selective" in character).

The FCC failed to provide segregable portions of documents that it claims are exempt under 5 U.S.C. § 552(b)(5). Even if the exemption does apply, portions of those documents should be disclosed to the EHT.

The FCC Should Provide the Documents Based on the Extreme Interest to Public Health

Finally, we request that you release the withheld documents notwithstanding their purported exempt status based on the critical nature of the information and the heightened public interest. The public interest in their release outweighs the public interest in withholding them because most of the American public uses cell phones with the phone pressed to their body. If there is a balance to be weighed between protecting deliberative privilege and the notification of the public of harmful interference the balance should be on side of transparency and public health.

Real world use of phones often occurs with phones 2mm from the body or even in direct skin contact (0 mm). If phones are exceeding the regulatory limit in positions of real-world use, the public has a right to be informed. Nearly every child and adult in the United States uses a cell phone in direct body contact, i.e. phones in the pocket, held up to the chest or on lap. Parents use phones pressed against the body of their infants unaware that the phones even emit radiation. The public is not aware that phones exceed radiation limits when the phone is used in body contact as the FCC's 2 mm tests reveal. There is no clear consumer information informing users to distance their body from the phone despite the FCC stating that no additional consumer information is necessary.

The public health implications of continuing the withhold this information are far reaching. Scientific research has found adverse effects from cell phone radiation exposure at levels well below FCC limits with study findings that include [cancer](#), the induction of [oxidative stress](#), [epigenetic effects](#), impacts to [neurotransmitters](#), [memory](#), [brain development](#) and damage to the [immune](#), [endocrine](#), [hematological](#) and [reproductive system](#) ([Alkayyali et al 2021](#), [Panagopoulos et al. 2021](#), [Lai 2021](#), [Smith-Roe et al. 2020](#), [Cantu et al 2023](#), [Davis et al 2023](#), [ICBE-EMF 2022](#), [Gautam et al 2023](#), [Lai and Levitt 2022](#), [Hardell and Carlberg 2017](#), [Miller et al. 2018](#), [Belpomme et al 2018](#), [Directorate-General for Parliamentary Research Services European Parliament 2021](#)).

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