20-1025 (Lead); 20-1138 (Consolidated)

UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

ENVIRONMENTAL HEALTH TRUST; CONSUMERS FOR SAFE CELL PHONES; ELIZABETH BARRIS; THEODORA SCARATO

CHILDREN'S HEALTH DEFENSE; MICHELE HERTZ; PETRA BROKKEN; DR. DAVID O. CARPENTER; DR. PAUL DART; DR. TORIL H. JELTER; DR. ANN LEE; VIRGINIA FARVER, JENNIFER BARAN; PAUL STANLEY, M.Ed.
Petitioners

v.

FEDERAL COMMUNICATIONS COMMISSION;
UNITED STATES OF AMERICA
Respondents

Petition for Review of Order Issued by the
Federal Communications Commission

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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 WT Docket No. 03-137
	)	
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	)))	

COMMENTS OF CTIA – THE WIRELESS ASSOCIATION

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September 3, 2013

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COMMENTS OF CTIA – THE WIRELESS ASSOCIATION®

I. INTRODUCTION AND SUMMARY

CTIA – The Wireless Association® ("CTIA") respectfully submits these comments in response to the Commission's *Notice of Inquiry* in the above-captioned proceedings.[1]

CTIA is an international nonprofit membership organization that represents the wireless communications industry. Since its formation in 1984, it has supported the industry's voluntary efforts to promote the safe, responsible use of wireless products and services. For example, it has backed efforts to encourage wireless device recycling, to discourage texting while driving, and to increase wireless access for individuals with disabilities. It has also provided millions of dollars in funding for research into the safety of radiofrequency ("RF") emissions, for example funding recent research conducted by the Food and Drug Administration ("FDA"),[2] and partnering with the National Academy of Sciences to conduct a symposium on RF safety.[3]

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[1] *Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies*, First Report and Order, Further Notice of Proposed Rulemaking and Notice of Inquiry, ET Docket Nos. 13-84, 03-137 (rel. Mar. 29, 2013) ("*NOI*").

[2] *See, e.g.*, FDA, *Radiation-Emitting Products – Cooperative Research and Development Agreement (CRADA)*, http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/Ce

CTIA commends the Commission for its ongoing oversight of RF issues and its decision to conduct a comprehensive review of developments since it adopted the existing RF emission regulations in 1996. The consensus view of international standard-setting bodies and federal and international health agencies is that the safety standards reflected in those regulations continue to protect public health and safety. Indeed, as the Government Accountability Office ("GAO") recently explained in its review of the latest research, the consensus view is that those standards are *overly* protective and should be harmonized with more recent international standards.[4]

When the Commission adopted its 1996 regulations, it grounded them in the weight of scientific evidence as then expressed in the work of international standard-setting bodies and federal health and safety agencies. Backed by scientific evidence and set at a level 50 times below the threshold at which biological impacts are observed, the current standards appropriately balance public safety with the need to allow wireless services to address ever-growing marketplace demands.[5] CTIA urges the Commission to continue its science-based approach to RF emission standards and testing methodologies, and to continue to eschew any requirements that are not supported by the science but are putatively "precautionary" in nature. The Commission should: (1) apply its science-based approach to its review of the exposure standard and confirm that its current RF emission standards adequately protect public health and safety; (2) refrain from requiring RF safety disclosures or warnings or from encouraging methods for

llPhones/ucm116340.htm (last updated May 5, 2009) (referencing FDA and CTIA's cooperative research and development agreement regarding wireless devices and potential health effects).

[3] *See id.*

[4] United States Government Accountability Office, Report to Congressional Requesters, *TELECOMMUNICATIONS: Exposure and Testing for Mobile Phones Should Be Reassessed,* GAO-12-771 (July 2012) ("*GAO Report*").

[5] *See NOI*, ¶ 236; *In re Procedures for Reviewing Request for Relief from State and Local Regulations*, Order, 12 FCC Rcd 13494, 13496 (¶ 2) (1997) ("*RF Order II*").

limiting exposure to RF emissions or taking other precautionary measures, which would not be supported by science and could cause confusion and alarm; (3) remain open to alternative means of compliance evaluation while continuing to endorse the specific anthropomorphic method of testing and knowledge database bulletins; and (4) continue to rely on existing proximity restrictions for body-worn specific absorption rate ("SAR") issues.

II. BACKGROUND: STATE OF THE INDUSTRY AND FEDERAL REGULATION

A. The Wireless Revolution Has Been Aided By The FCC's Nationwide, Uniform, and Careful RF Regulation.

By continuing a pro-competitive, deregulatory environment for wireless service and directing the FCC to promulgate uniform RF emission standards, the 1996 Telecommunications Act codified the policy goals underlying the Commission's current RF regime.[6] When adopting the current standards, the Commission noted that it sought to balance public safety with the goal of fostering wireless deployment,[7] thus reflecting the directives of the 1996 Act. The growth of the wireless industry since 1996 attests to the Commission's success in striking the right balance.

The Commission's current RF standards were carefully designed to establish safe, effective, and practical emissions thresholds and testing protocols that are, first and foremost, grounded in science. These national standards were developed with significant input from the federal health and safety agencies[8] and in collaboration with expert private organizations. The

[6] Pub. L. No. 104–104, 110 Stat. 56.

[7] *RF Order II*, ¶ 29.

[8] *See In re Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, Release No. 96-326, 11 FCC Rcd. 15123, 15124 (¶ 2) (1996) ("*RF Order I*") (stating standards represent a "consensus view of the federal agencies responsible for matters relating to the public safety and health"; *id.* ¶¶ 15-20 (citing comments from EPA, FDA, NIOSH, and OSHA); *RF Order II*, ¶ 19 (noting "careful consideration" of the views of federal health and safety agencies, "notably the U.S. Environmental Protection Agency (EPA) and the U.S. Food and Drug Administration (FDA)").

Commission adopted them pursuant to its authority over radio communications under the 1934 Communications Act, Congress's directive in the 1996 Telecommunications Act to promulgate standards, and its obligations under the National Environmental Policy Act ("NEPA").[9]

The Commission's inquiry into the potential biological impact of RF emissions from Commission-licensed devices began in 1979.[10] In 1985, it adopted emission standards based on the recommendations of the American National Standards Institute ("ANSI").[11] It subsequently determined that low-powered communications devices (less than 7 W), including wireless telephones, would be exempt from "routine environmental evaluation with respect to RF radiation."[12] In 1993, the Commission initiated a proceeding to revise the 1985 standards following ANSI's 1992 update to its standards.[13] Three years later, with action pending before the Commission, Congress directed the Commission to "complete action" to "prescribe and make effective rules regarding the environmental effects of radio frequency emissions."[14] This directive was motivated by Congress's recognition that "uniform, consistent requirements, with

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[9] 42 U.S.C. § 4322(2)(C) (obligating all federal agencies to consider and identify the environmental impact of "major" agency action that "significantly impacts the human environment); Pub. L. No. 104–104, § 704(b), 110 Stat. 56 (directing the Commission "to prescribe and make effective rules regarding the environmental effects of radio frequency emissions."); *In re Responsibility of the FCC to Consider the Biological Effects of RF*, Report and Order, 100 FCC 2d 543 (1985) (citing Sections 4(i), 4(j) and 303(r) of the Communications Act of 1934).

[10] *See id.*

[11] *RF Order I*, ¶ 6.

[12] *In re Responsibility of the FCC to Consider Biological Effects of Radiofrequency Radiation When Authorizing the Use of Radiofrequency Devices*, Second Report and Order, 2 FCC Rcd 2064 (¶ 16) (1987).

[13] *RF Order I*, ¶ 10 (citing *In re Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation*, Notice of Proposed Rulemaking, 8 FCC Rcd 2849 (1993)).

[14] Pub. L. No. 104-104, § 704(b), 110 Stat. 56 (1996).

adequate safeguards of the public health and safety" were in the national interest.[15] The Commission revised its RF emission standards in 1996, adopting limits based on guidelines from the National Council on Radiation Protection and Measurements (NCRP) and the 1992 ANSI/IEEE C95.1 standard.[16]

The standards adopted in 1996 remain in effect today.[17] Those standards were designed to "provide a proper balance between the need to protect the public and workers from exposure to excessive RF electromagnetic fields and the need to allow communications services to readily address growing marketplace demands."[18] They include two tiers of emission standards, one for the general public (general population/uncontrolled exposure) and a less restrictive tier of limits for workers exposed to RF as a consequence of their employment (occupational/controlled exposure).[19] Though low-power devices such as cell phones had previously been categorically exempt from routine evaluation, the 1996 rulemaking applied the limits to low-power devices.[20] Thus, cell phones had to comply with the SAR limit of 1.6 Watts/kg over 1 gram of tissue.[21]

Before a cell phone may be marketed or sold in the United States, it must be tested for compliance with the Commission's SAR limit.[22] The Commission's approved testing protocols

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15 H.R. Rep. No. 104-204(I), at 94 (1995).

16 *RF Order I*, ¶ 28.

17 *NOI*, ¶ 205.

18 *RF Order II*, ¶ 29.

19 *In re Proposed Changes in the Communications Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields*, 18 FCC Rcd 13187, 13201 (¶ 36) (2003). This distinction rested on the premise that individuals exposed to RF as a consequence of their employment "can exercise control over their exposure." *RF Order I*, ¶ 43.

20 *RF Order I*, ¶ 7.

21 47 C.F.R. § 2.1093(d)(2).

22 47 C.F.R. § 2.803(a)(1).

are set forth in the rules and technical bulletins.[23] Pre-market testing is carried out by testing laboratories whose work is reviewed by authorized certification bodies[24] and is a required element of the authorization process.[25] Since 2002, the Commission's sole pre-approved method for testing has been through the IEEE-recommended specific anthropomorphic mannequin (SAM).[26]

The surge of wireless services and usage since 1996 attests to the FCC's success in balancing public safety with fostering wireless deployment when setting its RF emission standards and overseeing compliance testing. Over the past two decades, wireless service has transformed and improved everyday life. Once "voice-centric," wireless service is now "data-centric."[27] Compared to the first wireless phones offered to the public, today's devices are smaller, "smarter," and cheaper.[28] Consumers have rapidly adopted data-capable mobile

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23 *See, e.g.*, 47 C.F.R. § 2.1093(d)(3); Supplement C to OET Bulletin 65 (now rescinded); FCC KDB 447498, "General RF Exposure Guidance" (last updated May 28, 2013) ("FCC KDB 447498").

24 *See* 47 C.F.R. § 2.960; FCC KDB 447498 at 3.

25 47 C.F.R. § 2.803 (requiring equipment authorization before marketing of RF devices); *id.* § 2.901 *et seq*. (setting forth equipment authorization procedures); *id*. § 2.960 *et seq*. (setting forth rules applicable to Telecommunication Certification Bodies).

26 *See Office of Engineering and Technology Announces Release of Revised Supplement C to OET Bulletin 65*, Public Notice, DA 02-1438 (Jun. 29, 2001). The Commission's current testing protocols are published in the Commission's KDBs, and the SAM phantom remains the sole-approved device for SAR testing of mobile communications devices. *See* FCC KDB 447498.

27 *In re Implementation of Section 6002(B) of the Omnibus Budget Reconciliation Act of 1993*, Sixteenth Report, 28 FCC Rcd 3700, 3711 (2013) ("*Sixteenth Wireless Competition Report*").

28 Of course, the "pro-competitive, de-regulatory framework for wireless service prescribed by Congress and implemented by the FCC" has played a large role in the success and innovation of the wireless industry. *See* Brief of the Federal Communications Commission as Amicus Curiae at 8, Murray v. Motorola, C.A. No. 01-8479, 2007 5694816 (D.C. Sup. Aug. 24, 2007); *see also* FCC National Broadband Plan at 21, *available at* http://broadband.gov/download-plan/ (noting that limited regulation has driven progress in broadband technology). But this "hands-

devices, which send emails, instant messages, text messages, pictures and videos; take pictures and videos; play mp3s and stream music and movies through the Internet; and access news and social media.[29] As a result, the total number of mobile wireless connections now exceeds the total population,[30] and mobile data traffic continues to increase dramatically.[31]

The public's demand for wireless services has spurred significant innovation in both the wireless industry and the broader U.S. economy. Wireless service providers offer a wide variety of service plans: prepaid, postpaid, shared data plans, family plans.[32] Fierce competition among device manufacturers has led to an ever-growing array of smartphones and improved features.[33] The "app" economy, which was virtually non-existent five years ago, now offers more than 2.7

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off" approach to price and service regulation has been paired with centralized federal regulatory authority over the technical aspects of radio communications, including RF emissions, which has led to nationally uniform technical and operational standards. *See, e.g.*, *FRC v. Nelson Bros. Bond & Mortg. Co.*, 289 U.S. 266, 279 (1933); 47 U.S.C. §§ 301, 303(c)-(e). The importance of these uniform technical rules in creating an efficient nationwide wireless network and a stable environment for investment and innovation has been recognized by both Congress and the FCC. *See* H.R. Rep. No. 104-204(I), at 94 (1995); *Farina v. Nokia*, 625 F.3d 97, 105-06 (3d Cir. 2010) (citing *In re An Inquiry Into the Use of the Bands 825-845 MHz and 870-895 MHz for Cellular Communications Systems*, 86 FCC 2d 469, 504-05 (1981)).

[29] *Sixteenth Wireless Competition Report*, ¶ 249.

[30] *Id.* ¶ 244.

[31] CTIA, *Year-End 2012 Top-Line Survey Results*, at 9, *available at* http://files.ctia.org/pdf/CTIA_Survey_YE_2012_Graphics-FINAL.pdf.

[32] *See, e.g.*, Reply Comments of CTIA-The Wireless Association at 17-20, WT Docket No. 13-135 (Jul. 25, 2013) ("CTIA Reply Comments, *Seventeenth Wireless Competition Report*"); Julien Blin, "Shared data plans to Experience Innovation, Price Wars," Fierce Wireless (Mar. 19, 2013), http://www.fiercewireless.com/story/blin-shared-data-plans-experience-innovation-price-wars/2013-03-19.

[33] *See* CTIA Reply Comments, *Seventeenth Wireless Competition Report* at 11-12; Eric Pfanner, "Chipping Away at the Smartphone Leaders," N.Y. Times (Jul. 27, 2010), http://www.nytimes.com/2013/07/27/business/global/chipping-away-at-the-smartphone-leaders.html?hp ("For several years, [Apple and Samsung] have dominated the mobile phone-making business, successively one-upping each other with ever sleeker, more technologically sophisticated iPhones and Galaxy handsets that left would-be rivals grasping. But now the competition is stirring, and consumers are giving another look to brands they once ignored.").

million apps[34] and is projected to generate as much as $46 billion in 2016.[35] And the growth of mobile cloud computing forecasts continued innovation in retail, education and other sectors of the economy.[36] The wireless industry's innovation and growth have been critical to the U.S. economy.[37] The industry directly and indirectly employs more than 3.8 million Americans, accounting for approximately 2.6 percent of all U.S. employment.[38]

The rise of wireless communications has had a profound impact on public safety and healthcare as well. Wireless devices are rightly regarded as "life-saving tool[s],"[39] not only because they provide immediate access to 911 dispatchers, but also because they provide immediate information about public safety threats. The Wireless Emergency Alert ("WEA") system delivers geographically-targeted, text-like messages alerting customers owning certain

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34 CTIA, *50 Wireless Quick Facts,* http://www.ctia.org/advocacy/research/index.cfm/aid/10377 (last updated May 2013) (citing internal CTIA research; Nielsenwire, State of the Appnation - A Year of Change and Growth in U.S. Smartphones, May 16, 2012).

35 Press Release, CTIA, *App Economy Created 519,000 Jobs Across the U.S.* (Oct. 4, 2012) http://www.ctia.org/media/press/body.cfm/prid/2212.

36 *See ,e.g.,* Lowell McAdam, *How the U.S. Got Broadband Right*, N.Y. Times, (Jun. 20, 2013) ("We are just beginning to see the potential of innovative cloud-based services, smartphones and tablets to transform education and job training."); Preston A. Cox, *Mobile Cloud Computing,* IBM, Mar. 11, 2011, *available at* http://www.ibm.com/developerworks/cloud/library/cl-mobilecloudcomputing/ (discussing how mobile cloud computing can disrupt retail operations);

37 *See, e.g.*, President Barack Obama, Presidential Memorandum: Unleashing the Wireless Broadband Revolution, Memorandum for the Heads of Executive Departments and Agencies (Jun. 28, 2010) ("The resurgence of American productivity growth that started in the 1990s largely reflects investments by American companies, the public sector, and citizens in the new communications technologies that are what we know today as the Internet.").

38 *50 Wireless Quick Facts*, *supra* note 34 (citing Roger Entner, Recon Analytics, The Wireless Industry: The Essential Engine of US Economic Growth (2012)).

39 Jane L. Levere, *FEMA Promotes Its Wireless Emergency Alert System*, N.Y. Times (May 28, 2013), http://www.nytimes.com/2013/05/29/business/media/fema-promotes-its-wireless-emergency-alert-system.html (quoting W. Craig Fugate, administrator of FEMA).

mobile devices to imminent threats to safety in their area.[40] The alerts cover those issued by the President, alerts involving imminent threats to safety or life, and AMBER Alerts for missing children.[41] Recent AMBER Alerts deployed through the WEA system have been instrumental in rescuing missing children.[42] Recent innovations have also improved access to and accuracy of emergency services, through the wireless industry's voluntary efforts to provide text-to-911 service[43] and compliance with the Commission's E911 location accuracy rules.[44] Congress's creation of the First Responder Network Authority, now under the stewardship of NTIA, will further ensure that Americans can take full advantage of the public safety benefits that wireless communications can offer.[45] Wireless service has also provided "dramatic benefits … to the healthcare industry, including improving the capacity for telemedicine, and facilitating the exchange of medical data and opinions."[46] Indeed, the Commission recently announced its

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40 FCC, *Wireless Emergency Alerts*, http://www.fcc.gov/guides/wireless-emergency-alerts-wea.

41 *Id.*; *see also* Comments of CTIA-The Wireless Association at 49, WT Docket No. 13-135 (Jun. 17 2013) ("CTIA Comments, *Seventeenth Wireless Competition Report*").

42 *See* National Center for Missing & Exploited Children, *AMBER Alert Success Stories*, http://www.missingkids.com/amber/success (crediting the rescue of an 8-year old boy in Ohio after individuals received the AMBER alert via the WEA system); *Don't Turn Off Cell Phone Amber Alerts, California Officials Say*, Sacramento Bee (Aug. 12, 2013), http://blogs.sacbee.com/capitolalertlatest/2013/08/dont-turn-off-cell-phone-amber-alerts-california-officials-say.html (crediting rescue of missing California teenager to Amber Alert deployed through the WEA system).

43 CTIA Comments, *Seventeenth Wireless Competition Report* at 49.

44 *See In re Wireless E911 Location Accuracy Requirements*, Second Report and Order, 25 FCC Rcd 18909 (2010).

45 *See* Pub. L. No. 112–96, 126 Stat. 156, § 6101 (reallocating spectrum for use by public safety entities); NTIA, *FirstNet*, http://www.ntia.doc.gov/category/firstnet.

46 *In re Fostering Innovation and Investment in the Wireless Communications Market*, Notice of Inquiry, 24 FCC Rcd 11322, 11324 (¶ 16) (2009).

intention to act on the mHealth Task Force's report and recommendations on wireless health technology.[47]

While the proliferation of wireless service makes clear that the FCC struck the right balance when setting its RF emission standards, one question that should guide the Commission's efforts in this proceeding is whether the current standards strike a balance that will continue to promote growth and innovation in the decades to come. As the GAO recognized, using a standard that differs from that used more broadly around the world carries costs[48] – costs that may hold back competition and innovation. Accordingly, as discussed further below, the Commission may wish to consider harmonizing its emission standards with the most recent recommendations of the Institute for Electrical and Electronics Engineers ("IEEE") and the International Commission on Non-Ionizing Radiation Protection ("ICNIRP") to ensure the U.S. wireless industry remains at the forefront of wireless innovation and competition.

B. The Commission's RF Regime Is Grounded In The Scientific Consensus As Evaluated By International Standard-Setting Bodies And Federal Health And Safety Agencies.

The Commission's RF standards have consistently been guided by scientific consensus[49] and grounded in scientific validity.[50] When adopting the current limits, the Commission took

47 *See* FCC Fact Sheet, *mHealth Task Force Recommendations, available at* http://www.fcc.gov/document/fact-sheet-mhealth-task-force-recommendations (last visited August 21, 2013).

48 *See GAO Report* at 27.

49 *See In re Responsibility of the FCC to Consider the Biological Effects of RF*, Report and Order, 100 FCC 2d 543, 551 (¶ 23) (1985) ("[W]e believe that the Commission can rely on existing exposure guidelines as long as they are technically sound and scientifically supportable.").

50 *See RF Order I*, ¶ 4; *In re EMR Network Petition for Inquiry To Consider Amendment of Parts 1 and 2 Regarding Environmental Effects of Radiofrequency Radiation*, Order, 18 FCC Rcd 16822, 16825 (¶ 8) (2003) ("[T]his Commission has carefully and assiduously developed

careful account of both the most recent scientific knowledge[51] and the views of federal health and safety agencies.[52] FDA, EPA, NIOSH and OSHA all urged the Commission to take a more conservative approach to its RF guidelines than that advocated by the 1992 ANSI/IEEE guidelines, based on the data and technical knowledge available at the time.[53] The Commission followed their recommendations.[54] The FDA further recommended that the Commission closely monitor new research concerning long-term use of portable devices.[55] The Commission agreed,

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RF guidelines to protect the public according to the best science available, as interpreted by the agencies most expert in the pertinent fields.").

[51] *See RF Order I*, ¶ 168 ("We believe that the regulations that we are adopting herein represent the best scientific thought"); *id.* ¶ 169 ("[The guidelines] provide assurance that recent scientific knowledge is taken into account").

[52] *Id.* ¶ 2 (basing regulations "substantially" on the recommendations of health and safety agencies); *id.* ¶ 28 ("We continue to believe that we must place special emphasis on the recommendations and comments of Federal health and safety agencies because of their expertise and their responsibilities with regard to health and safety matters."); *see also* Brief for Respondents United States and FCC, Cellular Phone Taskforce v. FCC, No. 00-393, 2000 WL 33999532 at *16-17 (U.S. Dec. 4, 2000) ("FCC Cellular Phone Br.") (noting the Commission's emission standards "were formulated by expert scientific groups that reviewed exhaustive studies and were supported by every federal health and safety agency").

[53] *See* FDA Comments, ET Docket No. 93-62, at 1 (Nov. 17, 1995) (arguing against the Commission's adoption of a low-power exclusion clause with respect to cell phones based on "data from technical publications and other sources"); OSHA Comments, ET Docket No. 93-62, at 2 (Jan. 12, 1994) ("The more 'conservative approach' . . . is appropriate, particularly with respect to general public exposure); NIOSH Comments, ET Docket No. 93-62, at 1 (Oct. 11, 1993) (urging the Commission to differentiate its limits between exposed workers and the general public as this would be "the conservative public health approach"); EPA Comments, ET Docket No. 93-62, at 4 (Nov. 9, 1993) (supporting the Commission's proposal to differentiate between workers and the public as this would be "more conservative" and to apply "more restrictive exposure limits to any transmitters and facilities" in unrestricted areas);.

[54] *RF Order II*, ¶ 5 (noting limits "were crafted to address concerns about ANSI/IEEE C95.1-1992 that had been raised by several agencies of the Federal Government with responsibility for health and safety."); *id.* ¶ 111 ("Our guidelines adopt the most conservative aspects of the ANSI/IEEE and the NCRP recommended exposure criteria and have been recommended by all of the relevant health and safety agencies.").

[55] FDA Comments, ET Docket No. 93-62, at 1-2 (Nov. 17, 1995).

and in *RF Order II* committed to monitor the science and potentially adjust its standards should the scientific consensus change.[56]

The Commission incorporated a fifty-fold safety factor for RF emissions to provide further assurance that its standards were sufficiently protective.[57] The safety factor accounts for a "variety of variables such as different physical characteristics and individual sensitivities – and even the potential for exposures to occur in excess of our limits without posing a health hazard to humans."[58] By doing so, it "both protects the public based on scientific consensus and allows for efficient and practical implementation of wireless services."[59]

The RF standards' solid scientific grounding has appropriately allowed the Commission to successfully defend its regime against challenges alleging that the standards are not sufficiently protective. Though some petitioners seeking reconsideration of the standards urged the Commission to adopt stricter limits to address controversial and unsubstantiated claims of "non-thermal" effects and groups "sensitive" to RF emissions,[60] the Commission, like ANSI, IEEE, virtually all of U.S. and international health agencies and the scientific community generally, determined that the scientific literature does not support the existence of such "non-thermal effects.[61] It concluded that its regime, which imposed very restrictive limits supported

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56 *RF Order II*, ¶ 32.

57 *See NOI*, ¶ 236.

58 *Id.*

59 *Id.*

60 *See, e.g.*, *RF Order II*, ¶¶ 26-28 (considering comments urging regulation to protect against non-thermal effects, protection for electro-sensitive individuals and different limits for different members of the public).

61 *Id.* ¶ 31 ("It would be impracticable for us to independently evaluate the significance of studies purporting to show biological effects, determine if such effects constitute a safety hazard, and then adopt stricter standards than those advocated by federal health and safety agencies.

by a conservative evaluation of the science, struck the proper regulatory balance of the dual interests in protecting human health and encouraging investment and innovation.[62] Two different courts of appeal rejected petitions for review arguing that the adopted standards did not adequately protect the public.[63] These challenges were animated by the same arguments that the Commission rejected in the 1996 rulemaking – that the rules allegedly do not account for children, "electro-sensitive" individuals, low frequency modulation effects and scientific uncertainty.[64] The Second Circuit found that such claims were not justified.[65] The FCC's RF standards, which are based on the ANSI/IEEE and NCRP recommendations, account for non-thermal effects. In promulgating their standards, both ANSI and NCRP considered non-thermal

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This is especially true for such controversial issues as non-thermal effects and whether certain individuals might be 'hypersensitive' or 'electrosensitive.'").

62 *Id.* ¶ 5 ("We believe that the limits adopted in [*RF Order I*] provide a proper balance between the need to protect the public and workers from exposure to excessive RF electromagnetic fields and the need to allow communications services to readily address growing marketplace demands.").

63 *EMR Network v. FCC*, 391 F.3d 269 (D.C. Cir. 2004) (upholding Commission's decision not to regulate on the basis of non-thermal effects); *Cellular Phone Taskforce v. FCC*, 205 F.3d 82 (2d Cir. 2000) (upholding Commission guidelines against claims that they were arbitrary and capricious for failure to account for non-thermal effects and extremely-low frequency waves).

64 In other cases challenging the RF standards through tort actions, courts have agreed with the Commission that such claims are not judicially cognizable. *See, e.g., Farina*, 625 F.3d at 122 (preempting claims that marketing of cell phones as safe for use without headsets violated state law because "[i]n order for Farina to succeed, he necessarily must establish that cell phones abiding by the FCC's SAR guidelines . . . are inadequate – that they are insufficiently protective of public health and safety."); *Murray v. Motorola*, 982 A.2d 764, 776-77 (D.C. 2009) ("verdicts that would hold defendants liable for damages for bodily injuries caused by cell phones that met the FCC RF radiation limit would necessarily upset [the] balance [the agency struck] and . . . contravene the policy judgments of the FCC") (quotations omitted); *Bennett v. T-Mobile USA, Inc.*, 597 F. Supp. 2d 1050, 1053 (C.D. Cal. 2008) (finding plaintiffs' allegations that the RF levels emitted from cell phones are unsafe "are a collateral attack on the FCC regulations themselves. Allowing such claims would be to second-guess the balance reached by the FCC in setting RF emission standards under its delegated authority.").

65 *Cellular Phone Taskforce*, 205 F.3d at 90-91.

effects but determined the scientific data on this point was unreliable.[66] Both organizations also concluded that the existence of modulation effects was unclear, an assessment shared by the EPA.[67] Reliance on consensus-driven, science-based standards has thus provided the Commission with a sound policy basis for the current RF standards.

III. DISCUSSION

CTIA applauds the Commission for refreshing the record in support of its RF standards. In response to the issues raised by the *Notice of Inquiry*, CTIA offers the following comments:

First, the overwhelming weight of scientific evidence supports the Commission's existing RF standards.[68] Indeed, the GAO's recent review of the science confirmed that those standards are, if anything, *overly* conservative. Scientific validity has been and should continue to be the touchstone of RF regulation. The Commission has always looked to the weight of scientific evidence as expressed in the work of standard-setting bodies like the IEEE and NCRP, and to the advice of the federal health and safety agencies.[69] But it has always viewed their recommendations and requirements through the lens of scientific validity,[70] and by doing so has ensured that its RF regime enjoys broad support and is defensible on appeal if challenged. Setting the standard at an overly conservative level would have the opposite effect, and could also have the perverse effect of increasing public anxiety. Moreover, such an approach would be unlikely to meet the objections of its advocates. Indeed, many of these groups profess that *no*

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66 *Id*. at 90.

67 *Id*. at 91.

68 *See infra* Section III.A. CTIA notes that ICNIRP may soon revise its standard, *NOI*, ¶ 213, and reserves the right to comment on its revised standard if it does.

69 *NOI*, ¶ 215 (noting reliance on the federal health and safety agencies).

70 *Id*. (seeking comment on the "appropriate consideration of evaluations of research conducted by international organizations or by activities in other countries").

level of RF emissions would be satisfactory, and that cell phones are unsafe regardless of the SAR level. Adopting a limit untethered to science would simply encourage additional requests that the level be set at ever lower "precautionary" levels.

Second, the Commission should carefully review the current recommendations of the IEEE and ICNIRP.[71] Both organizations now recommend limiting RF emissions to 2.0 watts per kilogram, averaged over 10 grams of tissue, while the Commission's current rules limit emissions to 1.6 watts per kilogram averaged over 1 gram of tissue.[72] The available science indicates that the IEEE and ICNIRP standard adopted in Europe and elsewhere presents no known danger to human health and might have certain public interest benefits when compared with the more restrictive standard in the United States.[73] The 2.0 W/kg standard makes possible improved network efficiency and coverage, particularly in rural and underserved areas, by allowing phones to operate at a higher power level when needed. Thus, like the current Commission standard, it is entirely consistent with the Commission's goal of "protect[ing] the public without imposing an undue burden on industry."[74]

Third, without any scientific evidence that the current rules pose any danger to human health, there is no need for additional regulation in the area of consumer "disclosures" or encouraging consumers to limit their exposure to RF emissions. Ample information is already available from government and industry, and industry is voluntarily working on additional

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[71] *See infra* Section III.B.

[72] *See GAO Report* at 16-17.

[73] *See infra* Section III.B.

[74] *NOI*, ¶ 209 ("In considering whether there is a need for changes to our RF exposure limit rules, our intent is to adequately protect the public without imposing an undue burden on industry.").

information offerings to consumers.[75] Neither a mandatory disclosure nor encouragement to take precautionary measures is necessary. In light of the limited utility of SAR as a consumer metric and the current state of science, the Commission has rightly refused to endorse comparative SAR disclosures[76] or encourage exposure reduction measures.[77] Such initiatives would not make consumers safer, and could make them *less* safe by discouraging them from using portable devices.[78] Moreover, without any evidence that the current RF standards pose a danger to human health, mandatory warnings or disclosures would be problematic from a First Amendment standpoint.[79]

Fourth, while CTIA shares the Commission's interest in identifying compliance evaluation alternatives to the SAM model, it believes that the Commission should continue to embrace SAM as a safe harbor.[80] In contrast to SAR measurement and modeling methods that are still being developed, the SAM method is a scientifically accepted, time-tested and reliable means of evaluating compliance that has been widely embraced by the scientific community and

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75 *See infra* Section III.C.1 (discussing RF information available from government agencies, carriers and manufacturers).

76 *See infra* Sections III.C.1, III.C.2.

77 *NOI*, ¶ 242 (noting the Commission "does not endorse the need for nor set a target value for exposure reduction").

78 *See infra* Section III.C.1.

79 *See infra* Section III.C.1; *see, e.g., CTIA–The Wireless Ass'n v. The City and County of San Francisco*, 494 F. App'x 752, 753 (9th Cir. 2012) (affirming preliminary injunction against fact sheet and ordinance mandating disclosures on RF because such disclosures were misleading and controversial); *Video Software Dealers Ass'n v. Schwarzenegger*, 556 F.3d 950 (9th Cir. 2009) (finding state law restricting sale and requiring age labeling of "violent" video games violated the First Amendment where state failed to demonstrate a scientific basis for psychological or neurological harm to children from the video games at issue).

80 *See infra* Section III.D.1; Letter from Austin C. Schlick, General Counsel, FCC to Tony West, Assistant Attorney General, DOJ, at 2-3 (Sept. 13, 2010) (filed in *Dahlgren v. Audiovox Communications Corp*., No. 2002 CA 007884B) *("Dahlgren Letter")* ("[I]t is the FCC's position that any claims that depend on a judicial finding that the Commission's compliance procedures fail to ensure that wireless phones are safe are also preempted.").

industry. CTIA also supports and encourages the continuation of the Commission's flexible approach to knowledge database bulletins ("KDBs'), which allows for more efficient modification in response to changes in technology or the scientific consensus.[81]

Fifth, CTIA agrees that there is no evidence that body-worn usage is a safety issue.[82] Because the Commission's RF standards are premised on the assumption that users have neither knowledge of nor the ability to control RF emissions, the general population emission standards and evaluation criteria have been viewed, and should continue to be viewed, as addressing all reasonable usage scenarios. CTIA supports the existing proximity restriction and does not believe a zero-spacing measurement requirement would accurately mimic real usage or increase safety.

Overall, the Commission must bear in mind that the scientific consensus continues to be that existing RF rules protect public health[83] and that consumers have benefitted tremendously from (and are more safe because of) a wireless industry that has flourished over the last two decades. Indeed, the success of the Commission's regime has led other countries to consider the Commission's standards when promulgating their own regulations. With respect to balancing

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81 *See infra* Section III.D.2.

82 *See infra* Section III.E.

83 *See, e.g.*, *NOI*, ¶ 210 (citing NCRP commentary in support of the existing emissions standards); National Council on Radiation Protection and Measurements (NCRP), *Letter Report on Wireless Telecommunications Radiofrequency Safety Issues for Building Owners and Managers*, Scientific Committee 89-6 (Dec. 20, 2002) ("Available evidence and research to date indicate that adherence to the FCC guidelines will avoid adverse effects of RF exposure . . . the available evidence indicates that exposure to RF fields at levels in compliance with FCC guidelines does not lead to additional risk for cancer or adverse effects on potentially sensitive tissues . . . ."); *see also* WHO, *Electromagnetic fields and public health: Mobile Phones*, (June 2011), http://www.who.int/mediacentre/factsheets/fs193/en/index.html ("WHO EMF Fact Sheet") ("A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use.")

"the need to protect the public and workers from exposure to excessive RF electromagnetic fields and the need to allow communications services to readily address growing marketplace demands,"[84] the standards adopted in 1996 have been a success. A very heavy burden indeed should be upon those who seek to alter the Commission's approach to these issues with controversial science, changes to the testing standard, or opinionated and alarmist messaging premised on familiar but still unsubstantiated theories of harm.

A. The Weight Of Scientific Evidence Compels The Conclusion That The Commission's Existing Exposure Standards Are More Than Adequate.

CTIA encourages the Commission to continue its science-based approach to regulation and to confirm—as it has in the past—that its existing emission standards are more than adequate to protect the public.[85] This is because the science continues to support its conclusion that cell phones operating within its guidelines are safe. In short, CTIA encourages the Commission to continue its history of regulating based on facts and science.

1. The Commission's Emission Standards were Safe When Established and Experts Agree They Remain Safe Today.

In response to the Commission's request for comment "generally" on whether current emission standards "should be modified in any way,"[86] CTIA agrees that the consensus in the scientific community continues to be that the Commission's standards protect human health.[87]

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84 *RF Order II*, ¶ 29.

85 *NOI*, ¶ 210 ("The purpose of this *Inquiry* is to open a science-based examination of the efficacy, currency, and adequacy of the Commission's exposure limits for RF electromagnetic fields.").

86 *Id.* ¶ 219.

87 *Id.* ¶ 210 ("[C]ontinued use of our present exposure limits is currently supported by . . . significant qualified expert organizations and governmental entities") (citing to the NCRP's 2003 commentary on the standards); *see also id.* ¶ 216 ("[W]e continue to have confidence in our exposure limits.").

Although those standards were established in 1996,[88] the scientific evidence, as evaluated by federal agencies, international standard-setting bodies and other reputable entities, continues to show that they are appropriate.[89] Indeed, a recent GAO report that reviewed the available science concluded that they may be *overly* conservative, and stated that "research to date has not demonstrated adverse human health effects from RF energy from mobile phone use."[90] A 2012 report from the UK Health Protection Agency Advisory Group on Non-ionizing Radiation similarly concluded that "[t]he accumulating evidence on cancer risks [associated with cell phones] is increasingly in the direction of no material effect of exposure."[91]

Both the FDA and the Commission have echoed these same conclusions in recent years. For example, as of the date of this filing, it is the FDA's opinion that "[t]he scientific evidence does not show a danger to any users of cell phones from RF exposure."[92] And, when asked for

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[88] In developing its emission standards, which "represent[ed] the best scientific thought," the Commission considered submissions from over 100 interested parties including federal agencies with particular expertise in environmental, health, and safety issues. *RF Order I*, ¶¶ 46-61.

[89] *See, e.g.,* WHO EMF Fact Sheet ("A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use."); *GAO Report* at 6 ("In 2001, we reported that FDA and others had concluded that research had not shown RF energy emissions from mobile phones to have adverse health effects . . . . Following another decade of scientific research and hundreds of studies examining health effects of RF energy exposure from mobile phone use, FDA maintains this conclusion.").

[90] *GAO Report* at 6, 16-19.

[91] UK Health Protection Agency Advisory Group on Non-Ionising Radiation, *Health Effects from Radiofrequency Electromagnetic Fields*, (2012), *available at* http://www.hpa.-org.uk/webc/HPAwebFile/HPAweb_C/1317133827077 ("UK AGNIR 2012 Report"); *see also id.* at 172 (concluding that "[t]aken together, [recent] studies have produced no compelling evidence that RF fields are genotoxic or cause robust carcinogenic effects with exposures below [the 2.0 w/kg] guideline values.").

[92] FDA, Radiation-Emitting Products, Children and Cell Phones (Mar. 10, 2009), *available at* http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116331.htm (last visited Aug. 3, 2013) ("FDA Children and Cell Phones").

comment on emission standards for the July 2012 GAO report, the FDA confirmed that "the overall body of research has not demonstrated adverse health effects."[93] As for the Commission, it advises consumers that "[t]here is no scientific evidence that proves that wireless phone usage can lead to cancer."[94] It goes on to say that its "RF exposure standard [is] set at a level well below that at which laboratory testing indicates, and medical and biological experts generally agree, adverse health effects could occur."[95] CTIA is unaware of any governmental authority in the world that has taken the position that the Commission's existing emission standards are insufficient to protect the public. On the contrary, those authorities that have commented on them have consistently upheld them as appropriately protective of human health.[96]

A wide range of studies, conducted in a variety of scientific disciplines using data from a number of different countries, have reached the same conclusion: Cell phones are not associated with increased health risks.[97] For example, as the WHO and the Commission have both noted,

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[93] *GAO Report* at 6.

[94] FCC, *FAQs: Wireless Phones*, *available at* http://www.fcc.gov/encyclopedia/faqs-wireless-phones#evidence (last visited Aug. 6, 2013). *See also* Brief of the United States and the FCC as Amicus Curiae, Murray v. Motorola, Nos. 07-cv-1074-79, 2008 WL 7825518 at *15-16 (D.C. Apr. 8, 2008) ("FCC Murray Br.") ("The FCC has determined that wireless phones that do comply with its RF standards are safe for use by the general public."); *Farina*, 625 F.3d at 126 ("[T]he FCC considers all phones in compliance with its standards to be safe.").

[95] FCC, *Specific Absorption Rate (SAR) For Cell Phones: What It Means For You*, *available at* http://www.fcc.gov/cgb/consumerfacts/sar.html (last viewed Aug. 6, 2013) ("FCC SAR Factsheet").

[96] *See, e.g.*, Institute of Electrical and Electronics Engineers, Inc. (IEEE), *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*, IEEE Std C95.1-2005, at 2 (2006) ("IEEE Std C95.1-2005") ("A lack of credible scientific and medical reports showing adverse health effects for RF exposures at or below similar exposure limits in past standards [including the 1996 IEEE recommendation of 1.6 watts/kg over 1 gram of tissue] supports the protective nature of the exposure limits.").

[97] *See* WHO, *What Are Electromagnetic Fields?*, http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html ("In the area of biological effects and medical applications of non-ionizing radiation approximately 25,000 articles have been published over the past 30 years. . . Based on a recent in-depth review of the scientific literature, the WHO

the 2010 Interphone study, which drew on data from 13 participating countries, found no overall increased risk of glioma, meningioma or acoustic neuroma with mobile phone use of more than 10 years.[98] The Interphone study is the largest case-control study conducted to date. Similarly, a large cohort study following cell phone users in Denmark from 2001 to 2011 has found no association between cell phone use and glioma, meningioma or acoustic neuroma.[99] And the most recent cohort study in the peer-reviewed literature to examine this issue, the 2013 UK Million Women Study, confirms these findings. That study found no association between glioma or meningioma and daily use of a cell phone or use of a cell phone for more than ten years.[100]

Studies conducted in the United States have reached similar results. In 2000, researchers conducting a hospital-based case-control study in the United States found no evidence of increased risk of brain cancer and cell phone use.[101] In 2001, another U.S.-based study also reported no increased risk of brain cancer associated with use of wireless phones.[102] More recently, a 2010 study published by the NIH found no increase in the incidence of brain or other

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concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields.").

[98] *See* WHO EMF Fact Sheet; OET RF Safety.

[99] *See* Patrizia Frei, et al., *Use of mobile phones and risk of brain tumours: update of Danish Cohort study*, 343 BMJ d6387 (2011); Joachim Schuz, et al., *Cellular telephone use and cancer risk: update of a nationwide Danish cohort.*, 98 J. Nat'l Cancer Inst. 1707 (2006).

[100] *See* V.S. Benson, et al., *Mobile phone use and risk of brain neoplasms and other cancers: prospective study*, Int. J. Epidemiol. (2013). The Benson publication, which drew on the 2013 UK Million Women Study, was published in June 2013. While the study noted an association for acoustic neuroma in a subset of the 800,000 women studied, the authors noted the finding could be a result of confounding. *Id*. at 8.

[101] J.E. Muscat, et al., *Handheld cellular telephone use and risk of brain cancer,* 284 J. Am. Med. Assoc. 3001 (2000).

[102] P.D. Inskip, et al., *Cellular-telephone use and brain tumors,* 344 N. Engl. J. Med. Vol. 79 (2001).

central nervous system cancers between 1996 and 2006.[103] And an independent analysis by the National Cancer Institute "has turned up no evidence to support a link between cell phone use and brain cancer in the United States."[104]

Perhaps most tellingly, while cell phone use has increased dramatically all over the world, there has not been any corresponding rise in the incidence of brain cancer. In fact, brain tumor rates have remained flat or even fallen slightly here in the United States.[105] Researchers comparing actual incidence with rates predicted by those who believe RF emissions cause brain cancer have found that actual incidence rates are at least 40 percent lower than such predictions.[106] The same is true in European countries where cell phones were adopted relatively early in comparison to the United States. After studying brain cancer incidence in Sweden, Finland, Denmark and Norway from 1979-2008, IARC researchers and authorities in these countries found incidence rates to be generally stable over the entire period.[107]

A small minority may comment here and argue in favor of more stringent standards based on a few stray observations in the Interphone study and a handful of studies by Dr. Lennart Hardell, as support for the proposition that RF emissions may cause adverse health effects.

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103 *See* P.D. Inskip, et al., *Brain Cancer Incidence Trends in Relation to Cellular Telephone Use in the United States*, 12 Neuro-Oncology 1147 (2010).

104 National Cancer Institute, *Cancer Research Highlights* (July 2010), *available at* http://www.cancer.gov/ncicancerbulletin/072710/page3#d.

105 M.P. Little, et al., *Mobile phone use and glioma risk: comparison of epidemiological study results with incidence trends in the United States*, 344 BMJ e1147 (2012).

106 *Id.*

107 I. Deltour, et al. *Mobile phone use and incidence of glioma in the Nordic countries 1979-2008: consistency check*, 23 Epidemiology 301 (2012).

Government agencies and other reputable entities, however, have concluded that it is impossible to draw conclusions from these flawed, outlier findings.[108]

In summary, the Commission should continue to be guided by the consensus in the scientific community and should regularly review that consensus through organizations like IEEE and ICNIRP.[109] To date, the vast weight of the scientific evidence supports the conclusion that current standards are appropriate and conservative, and no qualified expert organizations or governmental entities have suggested adopting more restrictive standards.

2. The IARC Monograph Confirms and Does Not Change the State of the Science.

The IARC monograph on RF fields, which was released after the *Notice of Inquiry* was issued, confirms rather than changes the state of the science.[110] CTIA respects IARC's conclusions but emphasizes they are limited and easily misinterpreted. Accordingly, the Commission should view IARC's classification of RF energy as a 2B agent in its proper context and should not be unduly swayed by the classification.

The IARC Working Group classifies agents as falling in one of five categories, specifically categories 1 ("carcinogenic to humans"), 2A ("probably carcinogenic to humans"), 2B ("possibly carcinogenic to humans"), 3 ("not classifiable as to its carcinogenicity") and 4 ("probably not carcinogenic to humans"). It assigned RF fields to category 2B, which includes

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108 *See, e.g., GAO Report* at 8-10 (discussing the Interphone study as inconclusive and the limitations associated with epidemiological studies like Interphone); FDA, *No Evidence Linking Cell Phone Use to Risk of Brain Tumors* (Apr. 11, 2013), *available at* http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm212273.htm; ICNIRP SCI REVIEW: *Epidemiologic Evidence on Mobile Phones and Tumor Risk: A Review*, 20 Epidemiology 639 (2009) (criticizing Hardell's studies).

109 *NOI*, ¶¶ 211-15.

110 *Id.* ¶ 219 ("We invite parties to comment on th[e IARC] monograph if it is released during the comment period established for this Inquiry.").

"agents for which there *is limited evidence of carcinogenicity* in humans and less than *sufficient evidence of carcinogenicity* in experimental animals."[111] In doing so, it concluded that there is limited evidence of carcinogenicity in both humans *and* animals,[112] and acknowledged it could not rule out chance, bias, or confounding with reasonable confidence.[113]

Under the IARC rubric, the Working Group concluded that there was not enough experimental or epidemiological evidence to label RF fields as even "probably carcinogenic"—let alone "carcinogenic."[114] In so doing, IARC—as many have done before it—rejected the notion that sufficient scientific evidence links cell phones and cancer in either humans or animals. It is true that the majority of the Working Group was unwilling to categorize RF energy as "not classifiable as to its carcinogenicity" (category 3) or "probably not carcinogenic to humans" (category 4).[115] But that should not be surprising, as only *one* of the nearly 1,000 (968)

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111 International Agency for Research on Cancer *Monograph, Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic fields*, Vol. 102 at 30 (2013) (hereinafter "*IARC Monograph*").

112 *IARC Monograph* at 419. Notably, IARC determined there was *limited*, as opposed to less than *sufficient*, evidence of carcinogenicity in animals, thereby likely placing RF emissions "lower" in the 2B category than many other agents. *See id.* at 27.

113 *IARC Monograph* at 27, 407, 412.

114 As the District Court for the Northern District of California explained in *CTIA-The Wireless Ass'n v. City & Cnty. of San Francisco*, "the 'possible' group is a weaker group than the 'probably carcinogenic' group and weaker still than the 'carcinogenic' group; it does not take much to list something as 'possible.'" 827 F. Supp. 2d 1054, 1060 (N.D. Cal. 2011), *aff'd*, 494 F. App'x 752 (9th Cir. 2012). Indeed, IARC uses a very literal definition of the term "possible." *See IARC Monograph* at 30 (defining "possibly carcinogenic" as having "no quantitative significance" but being used "simply as descriptors of different levels of evidence of human carcinogenicity, with *probably carcinogenic* signifying a higher level of evidence than *possibly carcinogenic*.") (emphasis in original).

115 A minority opinion found that "current evidence in humans was *inadequate*, therefore permitting no conclusion about a causal association. This minority saw inconsistency between the two case-control studies and a lack of exposure-response relationship in the INTERPHONE study. The minority also pointed to the fact that no increase in rates of glioma or acoustic neuroma was seen in a nationwide Danish cohort study, and that up to now, reported time trends

agents classified by the IARC Working Group has been deemed "probably not carcinogenic." The 2B category itself includes 285 agents, including RF fields alongside other "possibly carcinogenic" agents like coffee and picked vegetables.[116] Moreover, the IARC Monograph "does not specifically or exclusively consider mobile phones" or RF emissions that comply with the RF standards of either the Commission or the international community.[117] Rather, it considers RF emissions at any level from any source, including medical devices, aviation radar systems, and whole-body security scanners, among others.[118]

The 2B classification does not represent a sea change—or indeed any change—in either the state of the science or the international consensus regarding RF emissions and human health. It is simply an acknowledgement that there is no scientific basis on which to conclude that RF emissions from wireless devices pose a risk to human health, but also no scientific basis on which to absolutely rule out any possibility of such a risk.[119] In other words, it simply reinforces the input the Commission previously received from the international scientific community.

Notably, the IARC's naming scheme is particularly vulnerable to distortion by alarmists. The description "possibly carcinogenic" is oftentimes misunderstood, misused and misstated by consumers and advocates alike.[120] Part of the confusion stems from the meaning of the word "possible." In the IARC context, the term "possible" means "being something that may or may

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in incidence rates of glioma have not shown a trend parallel to time trends in mobile-phone use." *IARC Monograph* at 419.

116 WHO, *Agents Classified By the IARC Monographs, Volumes 1-108*, http://monographs.iarc.fr/ENG/Classification/.

117 *IARC Monograph* at 33.

118 *Id.* at 64-67.

119 *See also CTIA*, 827 F. Supp. at 1060 (stating that a "possible carcinogen" means "no one yet knows if the agent (RF radiation) is actually harmful (or not).")

120 *See infra* notes 194-198 and accompanying text.

not occur or be true."[121] In other words, "possible" simply means not *impossible*. As the Chief of the National Cancer Institute's Radiation Epidemiology Branch succinctly explained: possible in the IARC context just means "maybe."[122] The American Cancer Society has also recognized the potential for confusion and distortion, explaining that "[i]t is critical that [IARC's] findings be interpreted with great care [and put] into perspective" given the meaning of the 2B classification and the agents designated therein.[123]

In summary, the IARC Monograph's classification does not alter the scientific landscape. On the contrary, it confirms the Commission's conclusion that there is no scientific basis on which to regulate RF emissions beyond the heat-based limits that were and still are supported by the consensus of the international scientific community.

3. Current Emission Standards and Testing Procedures are Safe and Appropriate for Children.

The Commission has also inquired as to whether its existing emission standards are appropriately protective of children.[124] The scientific consensus also supports the Commission's existing emission standards on this point. The Commission, as well as the expert agencies on which it relies for guidance, reached this conclusion when developing those standards. No change in the state of the science warrants reconsidering them.

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[121] Merriam Webster Dictionary, "Possible," http://www.merriam-webster.com/dictionary/possible.

[122] National Cancer Institute, *NCI Cancer Bulletin* (June 28, 2011), *available at* http://www.cancer.gov/ncicancerbulletin/062811/page4.

[123] American Cancer Society, *Otis Brawley responds to IARC Classification of Cell Phones as Possibly Carcinogenic*, *available at* http://pressroom.cancer.org/index.php?s=43&item=312.

[124] *NOI*, ¶ 219 (seeking comment as to whether its existing emission standards are appropriate as they relate to device use by children).

The Commission has previously considered and rejected claims that its RF emission standards do not adequately protect children.[125] The Commission's 1996 and 1997 RF Orders, which established the current federal safety standards for RF emissions, determined that its standards "represented the best scientific thought" on the limits necessary to protect all members of the public, including children.[126] Research into this area has continued and has confirmed that existing standards are safe for children. The UK Health Protection Agency Advisory Group on Non-Ionizing Radiation concluded in a comprehensive 2012 review and evaluation of the science that, "although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes health effects in . . . children."[127] Significantly, this report applied the ICNIRP and IEEE's 2.0 W/kg SAR standard (a more permissive standard than the current U.S. standard) and still found that cell phones were safe.

Since the Commission established its current emission standards, it and other agencies have similarly stated that the existing standards are safe for children. In 2001, EMR Network, a non-profit group that advocates for greater regulation of RF emissions, sought to reopen the RF

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[125] *RF Order II*, ¶ 26 (noting the Cellular Phone Taskforce sought revision of the limits "to allow for different rates of absorption among members of the public," including children); *see also* Cellular Phone Taskforce Petition for Reconsideration at 1-8, ET Docket No. 93-62 (Sept. 3, 1996); Ad-hoc Association of Parties Concerned About the FCC's Radiofrequency Health and Safety Rules Petition for Reconsideration, ET Docket No. 93-62 (Sept. 9, 1996).

[126] *RF Order I*, ¶ 158; *see also id.* ¶ 62. As far back as 1991, when it developed the exposure standard of 1.6 W/kg, IEEE stated that: "The members of Subcommittee 4 believe the recommended exposure levels should be safe for all, and submit as support for this conclusion the observation that no reliable scientific data exist" that, among other things, "certain subgroups (e.g., infants, the aged, the ill and disabled) of the population are more at risk than others." IEEE, *IEEE Standard for Safety Levels With Respect to Human Exposure to Radiofrequency Electromagnetic Fields, 3 KHz to 300 GHz*, at 23 (1991) ("IEEE C.95.1-1991").

[127] UK AGNIR 2012 Report at 4.

rulemaking by alleging, *inter alia*, that the standards did not protect children.[128] EMR Network maintained that children and the sick "are more susceptible to RF exposures," and as such, a "multi-tiered standard, applicable only to those populations," should be considered.[129] The Office of Engineering and Technology ("OET") denied EMR Network's petition, and on appeal the full Commission affirmed OET's denial.[130] In addition, in its fact sheet on the issue of wireless devices and health concerns, the Commission states that, with respect to children, "currently no scientific evidence establishes a causal link between wireless device use and cancer or other illnesses."[131] The FDA has also concluded that "[t]he scientific evidence does not show a danger to any users of cell phones from RF exposure, including children and teenagers."[132]

The conservative nature of the Commission's current emission standards and testing regime ensures that children are appropriately protected. The emission standard's fifty-fold safety factor "accommodates a variety of variables such as different physical characteristics,"[133] thereby accounting for adults and children alike. While a publication two years ago by Dr. Om Gandhi claimed that using SAM for SAR testing understates SAR, particularly in children,[134]

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128 EMR Network Petition for Inquiry, *In re Environmental Effects of Radiofrequency Radiation: Petition for Inquiry to Consider Amendment of Rules in Parts 1 and 2* (Sept. 25, 2001).

129 *Id.* at 12.

130 *In re EMR Network Petition for Inquiry To Consider Amendment of Parts 1 and 2 Regarding Environmental Effects of Radiofrequency Radiation*, Order, 18 FCC Rcd 16822, 16825 (2003).

131 *See* FCC, *Wireless Devices and Health Concerns*, available at http://www.fcc.gov/guides/wireless-devices-and-health-concerns (last visited Aug. 6, 2013) ("FCC Wireless Devices and Health Concerns").

132 *See* FDA Children and Cell Phones.

133 *NOI*, ¶ 236.

134 Gandhi et al., *Exposure Limits: The underestimation of absorbed cell phone radiation, especially in children*, Electromagnetic Biology and Medicine, Early Online, 1-18 (2011).

this publication is at odds with the weight of studies that have confirmed that SAR testing results are conservative for the general population, including children.[135] One study conducted by an international task force of experts lead by Dr. Brian Beard of the FDA compared numerical computation of SAR using SAM- and MRI-based models of normal adults and found that "SAM produced a higher SAR in the head than the anatomically correct head models. Also the larger (adult) head produced a statistically significant higher peak SAR . . . than did the smaller (child) head for all conditions of frequency and position."[136] Thus, not only is SAM conservative compared to other models, but SAR values based on SAM may be *more* conservative for children than adults. Thus, there are no science-based reasons to tighten either the emission standards for, or the testing methodology associated with, children.

B. The Best Available Science Indicates that the IEEE and ICNIRP 2.0 W/kg Standard Also Adequately Protects Human Health.

In response to the Commission's request for comment on the emission standards recently adopted by other national and international standard-setting organizations,[137] including the IEEE and ICNIRP, CTIA notes that the GAO has concluded that the current RF emission standards "may not reflect the latest evidence on the thermal effects of RF energy exposure."[138] The

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135 *See, e.g.*, A. Hadjem et al., *Analysis of Power Absorbed by Children's Head as a Result of New Usages of Mobile Phone*, 52 IEEE Trans. Electromagn. Compat., 812-19 (2010); A. Peyman et al., *Dielectric properties of tissues; variation with age and their relevance in exposure of children to electromagnetic fields; stage of knowledge*, Prog Biophys Mol Bio. (2011); Christ et al., *Age-dependent tissue-specific exposure of cell phone users*, 55 Phys Med Biol. 1767 (2010).

136 Beard et al., *Comparisons of computed mobile phone induced SAR in the SAM phantom to that in anatomically correct models of the human head*, 48 IEEE Trans. Electromagn. Compat. 397 (May 2006).

137 *NOI*, ¶ 219 ("[W]e solicit comment from national and international standards organizations (specifically including NCRP and IEEE) on the currency of their exposure limits and supporting documents in light of recent research....").

138 *GAO Report* at 27.

Commission developed those regulations and standards in 1996 based on input from federal health and safety agencies as well as the recommendations of IEEE, which at that time proposed a 1.6 W/kg SAR standard.[139] In 2006, however, IEEE published an updated recommendation that emissions be limited to 2.0 W/kg. According to IEEE, "improved RF energy research and a better understanding of the thermal effects of RF energy exposure on animals and humans, as well as a review of the available scientific research, led to the change in recommended RF energy exposure limit."[140] IEEE's new recommended limit brought it into harmony with ICNIRP's 1998 recommendations, which have been adopted by more than 115 countries and territories in the European Union and elsewhere.[141] Both of these recommendations call for a limit of 2.0 W/kg averaged over 10 grams of tissue, which according to IEEE "represents a scientific consensus on RF energy exposure limits."[142] While the updated IEEE and ICNIRP recommendations are somewhat less restrictive than the Commission's current standards,[143] the organizations that have "expertise in the health field" have not suggested that there is a science-

139 *See RF Order I*, ¶ 28; *see also* Section II.B, *supra*.

140 *GAO Report* at 17.

141 J. Rowley at al., *Radiofrequency exposure policies relevant to mobile communication devices and antenna sites*., BioEM (June 10-14, 2013), Thessaloniki, Greece. Countries following the ICNIRP standard include Australia, Austria, Brazil, Czech Republic, Croatia, Denmark, Estonia, France, Greece, Hungary, Ireland, Latvia, Luxemburg, Malta, Netherlands, New Zealand, Norway, Portugal, Singapore, South Africa, South Korea, Spain, Sweden, Taiwan, United Kingdom, and Venezuela. *See* Power Point: Shaiela Kandel, ELF Policies Worldwide – Protection of General Public, at the WHO Workshop, "Developing and Implementing Protective Measures for ELF EMF" (Jun. 20-21, 2007) *available at* http://www.who.int/peh-emf/meetings/elf_emf_workshop_2007/en/index1.html.

142 *GAO Report* at 17. *See also* IEEE Std C95.1-2005 at 86 ("[T]he widespread adoption of the ICNIRP guidelines as recommended by the World Health Organization demonstrates scientific consensus on RF safety limits. In summary, the scientific judgment of this committee [is] in agreement with the views of other independent expert groups.").

143 *See id*. at 79 ("This revision of IEEE Std C95.1 maintains many of the characteristics of the previous standard but also contains a number of differences from earlier editions that address new dosimetry findings and that simplify the use and application of the standard.").

based reason for changing the IEEE and ICNIRP standards.[144] Accordingly, the Commission has solicited comments on "the scientific basis for such changes as well as the advantages and disadvantages . . . of doing so,"[145] including the "potential for international harmonization."[146]

Harmonizing the existing emission standards would be advantageous for a number of reasons. To begin, harmonization would be consistent with the longstanding federal mandate that agencies apply "voluntary consensus standards in lieu of government-unique standards except where inconsistent with law or otherwise impractical."[147] The Office of Management and Budget has determined that harmonizing domestic standards with foreign standards generally tends to "decrease the cost of goods,"[148] "decrease . . . the burden of complying with agency regulation,"[149] "encourage long-term growth for U.S. enterprises,"[150] and "promote efficiency

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144 *NOI*, ¶ 219 ("[O]rganizations with expertise in the health field such as the FDA have not suggested that there is a basis for changing our standards or similar standards applied in other parts of the world.").

145 *Id.* ¶ 219; *see also id.* ¶ 213 ("We seek to examine the bases for these determinations by other qualified and responsible expert bodies and ensure that there is a justification for our differing conclusions or adjust those conclusions accordingly.").

146 *Id.* ¶ 214 ("In the event that the Commission may propose to adopt new exposure limits in this proceeding, we seek comment on the preference, costs, and benefits of adopting any of the present or future standards being developed by IEEE, ICNIRP, or possibly by NCRP, keeping in mind the potential for international harmonization, the adequacy of supporting documentation, the differences in process and openness in development, and the technical completeness of each standard.").

147 United States Office of Management and Budget, *Circular A-119 Revised* § 1 (Feb. 10, 1998), *available at* http://www.whitehouse.gov/omb/circulars_a119 (last visited Aug. 3, 2013); *see also id.* § 6 ("All federal agencies must use voluntary consensus standards in lieu of government-unique standards in their procurement and regulatory activities, except where inconsistent with law or otherwise impractical. . . . 'Impractical' includes circumstances in which such use would fail to serve the agency's program needs; would be infeasible; would be inadequate, ineffectual, inefficient, or inconsistent with agency mission; or would impose more burdens, or would be less useful, than the use of another standard.").

148 *Id.* § 2(a).

149 *Id.*

150 *Id.* § 2(c).

and economic competition."[151] Moreover, applying voluntary consensus standards "can increase productivity and efficiency in Government and industry, expand opportunities for international trade, conserve resources, improve health and safety, and protect the environment."[152]

These benefits of harmonization are particularly apt in the current context. For example, the GAO has noted that maintaining separate emission standards may "result in additional costs" and "affect phone design in a way that could limit performance and functionality."[153] And, because many manufacturers' phones are sold in multiple countries, "manufacturers have to develop and test phones based on different exposure limits, which can require additional resources and slow the time it takes to get new phones into the market."[154] Moreover, bringing Commission limits into line with those of the majority of the world would reduce unwarranted fears and "controversy connected with RF fields."[155] Indeed, the WHO's International EMF Project advocates "harmonization of … standards worldwide" because it is in large part the "disparities in EMF standards" themselves that have caused "increasing public anxiety…."[156]

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151 *Id.*

152 *Id.* § 6(e).

153 *GAO Report* at 19; *see also id.* at 27 (noting that more restrictive RF emission standards in the United States imposes "additional costs on manufacturers and limitations on mobile phone design").

154 *Id.*; *see also* WHO, *Framework for Developing Health-Based EMF Standards*, at 7, *available at* http://www.who.int/peh-emf/standards/EMF_standards_framework%5b1%5d.pdf (last visited Aug. 6, 2013) ("WHO Framework for EMF Standards") ("[D]isparities between national limits and international guidelines can . . . provide a challenge to manufacturers and operators of communications systems who need to tailor their products to each market.").

155 Kenneth R. Foster, *Exposure Limits for Radiofrequency Energy: Three Models*, *available at* http://www.who.int/peh-emf/meetings/day2Varna_Foster.pdf (also noting that harmonization would "provide a consistent level of health protection to different people around the world [and] also minimize some practical problems [associated with implementation].").

156 WHO International EMF Project, *Electromagnetic Fields – Standards & Guidelines*, *available at* http://www.who.int/peh-emf/standards/en/ (last visited Aug. 3, 2013) ("Because disparities in EMF standards around the world has caused increasing public anxiety about EMF

"[L]arge disparities between national limits and international guidelines" not only "increase public anxiety," but also "foster confusion for regulators and policy makers."[157] What is more, harmonization would facilitate global research efforts[158] and cooperation in the field.[159] The International EMF Project's model legislation and regulations recommend adoption of the currently-applicable ICNIRP standards, which includes the 2.0 watts/kg over 10 g of tissue standard for the general population exposure to RF emitted from mobile phones.[160]

Harmonizing existing science-based RF emission standards would not be "impractical," let alone "inconsistent with law."[161] To the contrary, there is a clear consensus in the scientific community that "exposures below the limits recommended in the ICNIRP international

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exposures from the introduction of new technologies, WHO commenced a process of harmonization of [EMF] standards worldwide. With 54 participating countries and 8 international organizations involved …, it provides a unique opportunity to bring countries together to develop a framework for harmonization of EMF standards and to encourage the development of exposure limits and other control measures that provide the same level of health protection to all people.").

157 WHO Framework for EMF Standards at 7.

158 As the WHO has acknowledged, "[i]f a common EMF exposure were found to cause a disease, it would likely be a rare one. Demonstrating such a relationship would require complex population studies" from across the globe. WHO, *EMF Project Strategy for Dealing with EMF Risk Brochure*, *available at*, http://www.who.int/peh-emf/about/emf_brochure_webversion.pdf.

159 "Some of the disparities in EMF standards around the world have arisen from the use of only national databases, different criteria for accepting or assessing individual studies, varying interpretations of the scientific data or different philosophies for public health standards development. Such differences in EMF exposure guidelines might reflect, in part, deficiencies in communications among scientists between different regions as well as certain social difference. . . . These factors [among others] have motivated the World Health Organization ("WHO") to build a Framework for developing health-based EMF exposure standards using a rational scientifically-driven process." WHO Framework for EMF Standards at 7

160 WHO, *Model Legislation for Electromagnetic Protection*, http://www.who.int/peh-emf/standards/EMF_model_legislation_2007.pdf

161 United States Office of Management and Budget, *Circular A-119 Revised* § 6 (Feb. 10, 1998), *available at* http://www.whitehouse.gov/omb/circulars_a119 (last visited Aug. 3, 2013).

guidelines do not appear to have any known consequence on health."[162] Like the current Commission standard, the ICNIRP-recommended emission standard for the general population is set at 50 times below the level at which biological impacts are observed, thus providing a significant safety margin.[163]

C. Requiring Mandatory Disclosures Or Warnings Regarding RF Safety Or Encouraging Consumers To Limit Exposure To RF Emissions Would Be Unnecessary.

Given the lack of scientific evidence establishing a causal link between cell phone use and harm to human health, and the information already available to consumers,[164] there is no basis for requiring disclosures or warnings on RF safety, or encouraging consumers to limit their exposure to RF emissions. As the Commission considers whether to do so,[165] it should consider the potential for misleading consumers into believing that mobile devices are unsafe, which would contradict its position that they are safe, and the experiences of the state and local governments that have tried to do so, which forecasts the scientific, public policy and legal issues that the Commission would face.

1. Information Already Available to Consumers Is Accurate and Adequate.

A wide variety of information on the issue of RF safety is already available to consumers. As the *Notice of Inquiry* itself notes, the Commission has "continually provided information to the public regarding radiofrequency electromagnetic fields, including OET Bulletins, CGB

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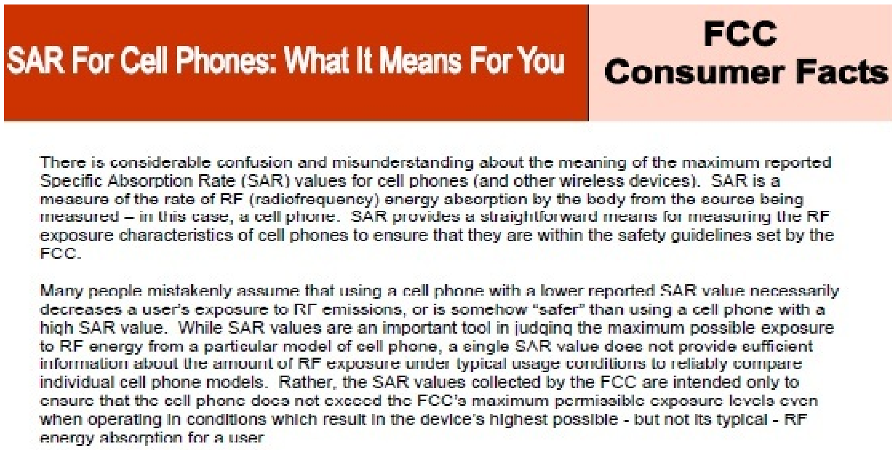
162 WHO International EMF Project, *Electromagnetic Fields – Standards & Guidelines*, *available at* http://www.who.int/peh-emf/standards/en/ (last visited Aug. 6, 2013).

163 *See* WHO, *What Are Electromagnetic Fields?*, http://www.who.int/peh-emf/about/WhatisEMF/en/index4.html ("ICNIRP applies a safety factor of 10 to derive occupational exposure limits, and a factor of 50 to obtain the guideline value for the general public.")

164 *NOI*, ¶ 216.

165 *Id.* ¶¶ 234, 238.

Consumer Guides and *The Local Official's Guide*."[166] For example, the Commission's SAR Consumer Guide explains what SAR means and how it can be misinterpreted; how SAR testing is conducted and how results are reported; and what SAR does not show.[167]

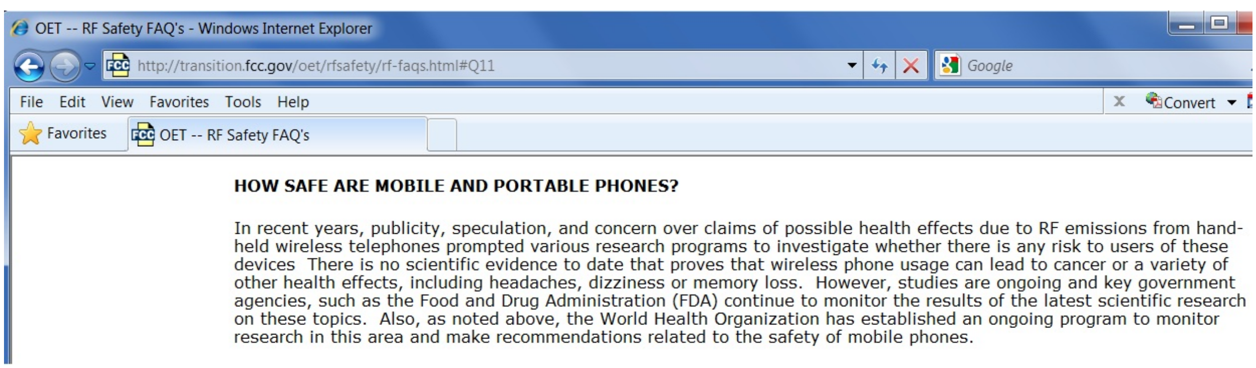

SAR For Cell Phones: What It Means For You

FCC Consumer Facts

There is considerable confusion and misunderstanding about the meaning of the maximum reported Specific Absorption Rate (SAR) values for cell phones (and other wireless devices). SAR is a measure of the rate of RF (radiofrequency) energy absorption by the body from the source being measured – in this case, a cell phone. SAR provides a straightforward means for measuring the RF exposure characteristics of cell phones to ensure that they are within the safety guidelines set by the FCC.

Many people mistakenly assume that using a cell phone with a lower reported SAR value necessarily decreases a user's exposure to RF emissions, or is somehow "safer" than using a cell phone with a high SAR value. While SAR values are an important tool in judging the maximum possible exposure to RF energy from a particular model of cell phone, 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. Rather, the SAR values collected by the FCC are intended only to ensure that the cell phone does not exceed the FCC's maximum permissible exposure levels even when operating in conditions which result in the device's highest possible - but not its typical - RF energy absorption for a user

OET's RF Safety FAQs further explain that "[t]here is no scientific evidence to date that proves that wireless phone usage can lead to cancer or a variety of other health effects, including headaches, dizziness or memory loss."[168]



HOW SAFE ARE MOBILE AND PORTABLE PHONES?

In recent years, publicity, speculation, and concern over claims of possible health effects due to RF emissions from hand-held wireless telephones prompted various research programs to investigate whether there is any risk to users of these devices There is no scientific evidence to date that proves that wireless phone usage can lead to cancer or a variety of other health effects, including headaches, dizziness or memory loss. However, studies are ongoing and key government agencies, such as the Food and Drug Administration (FDA) continue to monitor the results of the latest scientific research on these topics. Also, as noted above, the World Health Organization has established an ongoing program to monitor research in this area and make recommendations related to the safety of mobile phones.

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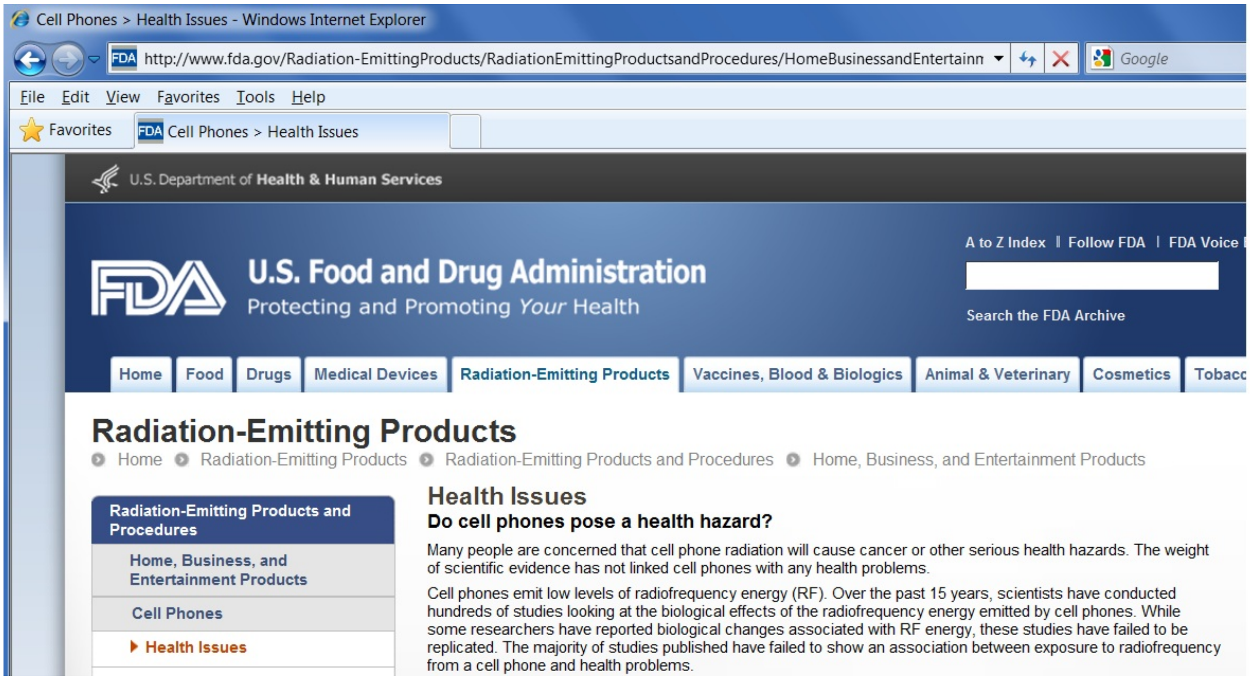
166 *Id.* ¶ 231.

167 *See* FCC SAR Factsheet.

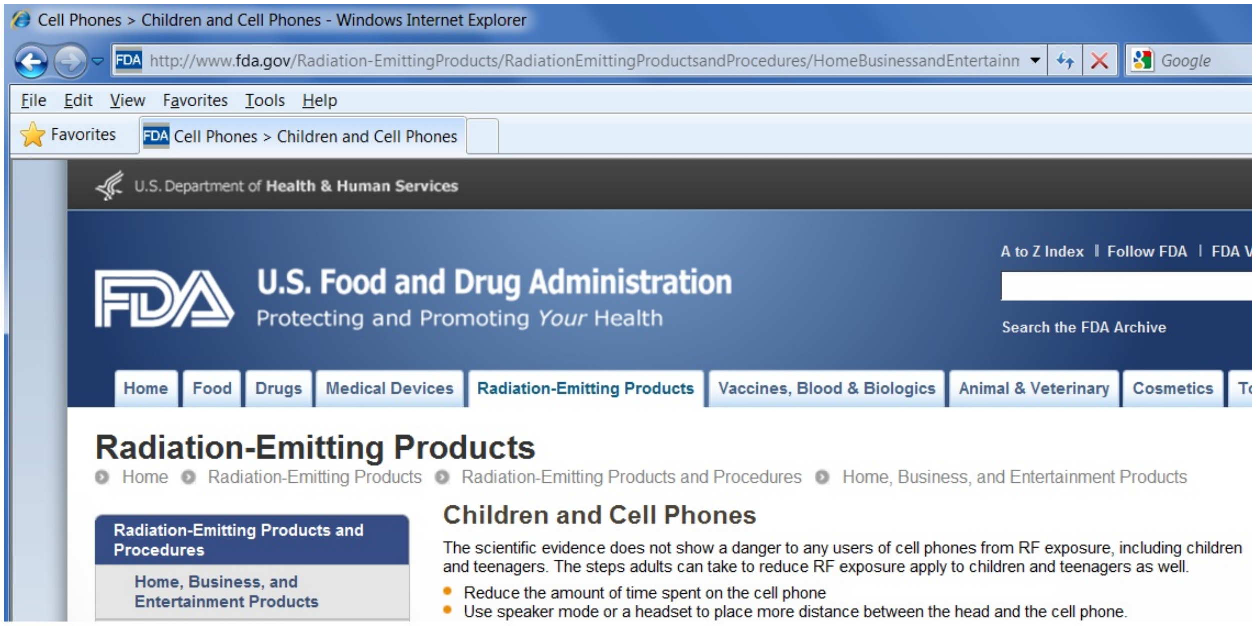
168 FCC OET, *Radio Frequency Safety*, http://transition.fcc.gov/oet/rfsafety/rf-faqs.html#Q11 (last viewed July 22, 2013) ("OET RF Safety").

The FDA also provides resources explaining that "the weight of scientific evidence has not linked cell phones with any health problems,"[169] and that "scientific evidence does not show a danger to any users of cell phones from RF exposure, including children and teenagers."[170]



169 FDA, *Radiation-Emitting Products, Health Issues: Do Cell Phones Pose a Health Hazard?*, http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116282.htm (last viewed July 22, 2013).

170 FDA Children and Cell Phones.



Consistent with the free marketplace of ideas and the competition that characterizes the wireless market, carriers and manufacturers voluntarily offer information in their own voices.[171] The four major wireless carriers all provide RF information on their websites and elsewhere. Verizon Wireless provides information on what experts say about cell phone safety and RF emissions, summarizing and linking to resources from the FDA, the Commission, the National Cancer Institute, and the WHO.[172] AT&T also cites the FDA and the Commission, provides information from the Commission on practices that limit consumer exposure to RF emissions, notes that the Commission does not encourage such practices, and provides links to a few groups

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171 *See GAO Report* at 26 (noting that such information is voluntarily provided, "as there are no federal requirements that manufacturers provide any specific information to consumers about the health effects of mobile phone use.").

172 Verizon Wireless, *RF Emissions FAQs*, http://aboutus.verizonwireless.com/commitment/safety_security/RF_Emissions_FAQs.html (last viewed July 21, 2013).

who state the opposing viewpoint that cell phones pose a health risk.[173] Sprint directs consumers to the Commission's website on RF Safety.[174] T-Mobile also quotes from Commission and FDA resources and includes information on how consumers may limit exposure to RF emissions.[175]

Manufacturers' offerings are varied and evolving, reaching consumers through websites, instruction manuals and even device software. For example, Motorola's website notes that "expert panels and government organizations around the world . . . have consistently concluded that RF products that meet internationally recognized safety standards for exposure to radio waves pose no established health risk."[176] The iPhone's software contains RF information that consumers may access on the device.[177] And the instruction manual accompanying Samsung's Galaxy S4 discusses recent studies on RF energy, including the 2010 Interphone study, and states that "[t]he scientific community at large therefore believes that the weight of scientific evidence does not show an association between exposure to Radio Frequency (RF) from cell phones and

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[173] AT&T, *Information on Wireless Telephones and Health*, http://www.att.com/shop/wireless/telephonehealth.html#fbid=FwplyrXMFeG (last viewed July 21, 2013).

[174] Sprint, *RF Emissions from Wireless Telecommunications Facilities*, http://www.sprint.com/responsibility/ourcustomers/health_concerns/rf-emissions-from-wireless-telecommunications-facilities.html (last viewed July 21, 2013).

[175] T-Mobile, *Radio Frequency Safety*, http://www.t-mobile.com/Company/CompanyInfo.aspx?tp=Abt_Tab_CompanySafety&tsp=Abt_Sub_Radio_Frequency_Safety (last viewed July 21, 2013).

[176] Motorola, *Wireless Communications and Health*, http://responsibility.motorola.com/index.php/consumers/wirelesscommhealth/ (last viewed July 21, 2013).

[177] Apple, *iPhone User Guide*, at 147, http://manuals.info.apple.com/en_US/iphone_user_guide.pdf (last viewed July, 21, 2013) (directing consumers seeking information about radio signals and steps they may take to reduce exposure to access information through their iPhone).

adverse health outcomes."[178] Furthermore, the Mobile Manufacturers Forum has voluntarily set up "SAR Tick," a website providing additional information and necessary context on SAR and a voluntary uniform disclosure on SAR compliance.[179] This voluntary industry effort explains what SAR does and does not mean, links to RF reviews conducted by other governments and international organizations, and provides information from the Commission, FDA and the WHO on ways to limit exposure to RF emissions.[180]

Though the *Notice of Inquiry* characterizes these offerings as "inconsisten[t],"[181] the underlying message to consumers is in fact both consistent and accurate: that federal authorities tasked with responsibility for RF issues believe that the scientific evidence does not demonstrate that wireless phone use causes cancer or other health problems.[182] While carriers and manufacturers may present information in different ways or in different terms, their fundamental message is correct. Given the general message that federal authorities believe RF standards are sufficiently protective—which is true—there is no need for a government-mandated disclosure or warning.

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178 Samsung, *Galaxy S4 User Manual*, at 362, *available at* http://support.t-mobile.com/docs/DOC-5889 (last viewed July 21, 2013).

179 *SAR Tick*, http://www.sartick.com/sar-tick.cfm.

180 *See id*.

181 *NOI*, ¶ 234 ("We agree that there is inconsistency in the supplemental information voluntarily provided in the manuals provided with portable and mobile devices.").

182 *See GAO Report* at 25 (noting federal agency information offerings on RF differ because of their differing missions, but the overall message is "broadly consistent"); *id*. at 27 (noting manufacturer instruction manuals "are consistent with how the devices were tested and certified by the FCC").

The conservative nature of the Commission's RF regime also obviates the need for consumer advisories.[183] The Commission's bifurcated approach to RF standards sets a higher standard for "occupational exposure," and a more restrictive standard for "general population exposure," which is the relevant standard that applies to consumers.[184] The present standards incorporate a safety factor "50 times below the level at which adverse biological effects have been observed in laboratory animals as a result of tissue heating from RF exposure."[185] The Commission's testing protocol is also designed to be conservative.[186] And, as it stands, the Commission's RF emission standards are more conservative than those currently recommended

[183] If the Commission were to harmonize exposure limits with the latest recommendations of ICNIRP and the IEEE, CTIA's position on consumer advisories would not change. ICNIRP's recommended general population standard of 2.0 Watts/kg over 10 grams of tissue is also designed to be conservative and also incorporates a fifty-fold safety factor. *See* WHO, *What Are Electromagnetic Fields?*, http://www.who.int/peh-emf/about/WhatisEMF/en/index4.html ("ICNIRP applies a safety factor of 10 to derive occupational exposure limits, and a factor of 50 to obtain the guideline value for the general public.").

[184] *RF Order II*, ¶ 111 (noting guidelines adopt "the most conservative aspects of the ANSI/IEEE and NCRP recommended [standards]").

[185] *NOI*, ¶ 236; *see also* FCC OET, *Questions and Answers About Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields*, OET Bulletin 65, 4th ed. at 13 n.10 (Aug. 1999), *available at* http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf (noting the SAR limits incorporate "appropriate safety factors"); Declaration of Ronald C. Petersen, Exhibit 1 at 9, *CTIA-The Wireless Association v. The City and County of San Francisco*, 827 F. Supp. 2d 1054 (N.D. Cal. 2011) (3:10-cv-03224) (noting the emission standards incorporate a safety factor of 50); IEEE Standards Coordinating Committee 28 on Non-Ionizing Radiation Hazards, *IEEE Standard for Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 400 GHz*, at 28 (Sept. 26, 1991) (recommending the RF emission standard includes an additional safety factor above the then-current ten-fold safety factor).

[186] *NOI*, ¶ 245 ("The SAM does not model children, tissue layers, or a hand holding the device but SAM was designed to be conservative relative to these factors.").

by international standard-setting bodies.[187] Taken together, these features ensure that the current limits are sufficiently protective of the public and render a mandatory warning unnecessary.[188]

Besides the fact that a warning would be unnecessary, a mandatory RF disclosure would be unwise as a matter of law and policy. Federal agencies must remain sensitive to the adverse consequences that unnecessary warnings can create, as "warnings about dangers with less basis in science or fewer hazards could take attention away from those that present confirmed, higher risks."[189] The FDA has also recognized the dangers of "over-warning."[190] Consumer advisories and warnings thus should be reserved for known dangers and situations where concrete steps can be taken to avert a known threat. Otherwise, mandatory disclosures or advisories could confuse

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187 *GAO Report* at 17-18.

188 CTIA's position on mandatory consumer disclosure extends to the Commission's proposal to give consumers an "informed choice to behave in such a manner that may result in somewhat exceeding the exposure limits," *NOI*, ¶ 223, as well as the proposal to "better enable consumers to correlate the make and model number of their device to an FCC ID," *id.* ¶ 235. There is no need for consumers to evaluate and weigh such information as the current limits adequately protect the public.

189 *Brooks v. Howmedica, Inc.*, 273 F.3d 785, 796 (8th Cir. 2001) (finding plaintiff's failure to warn claim against pharmaceutical manufacturer preempted by the Medical Device Amendments to the Food, Drug and Cosmetics Act); *see also Doe v. Miles Laboratories, Inc., Cutter Laboratories Div.*, 927 F.2d 187, 194 (4th Cir. 1991) ("If pharmaceutical companies were required to warn of every suspected risk that could possibly attend the use of a drug, the consuming public would be so barraged with warnings that it would undermine the effectiveness of these warnings.").

190 *See* Supplemental Applications Proposing Labeling Changes for Approved Drugs, Biologics, and Medical Devices, 73 Fed. Reg. 49603, 49605-06 (Aug. 22, 2008) (noting overwarning "may deter appropriate use of . . . products, or overshadow more important warnings"); FDA, *Write it Right: Recommendations for Developing User Instruction Manuals for Medical Devices Used in Home Health Care*, at 7, *available at* http://www.fda.gov/downloads/MedicalDevices/.../ucm070771.pdf ("Note: Overwarning has the effect of not warning at all. The reader stops paying attention to excess warnings."); FDA, Draft Guidance, *Brief Summary: Disclosing Risk Information in Consumer Directed Print Advertisements*, at 4 (Jan. 2004), *available at* http://www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/ucm069984.pdf ("[O]mitting less serious, infrequent risks from patient labeling may actually increase the usefulness of this labeling for its audience by making the more important risks stand out more clearly.")

or alarm consumers about risks that do not exist, or worse yet numb them to warnings about risks that do exist.[191]

Introducing a mandatory RF disclosure would bring these problems into stark relief. Given federal authorities' repeated pronouncements that the Commission's current emission standards adequately protect the public, a mandatory RF advisory would, at the very least, confuse consumers because the very existence of such an advisory would be perceived as a warning, and would contradict the federal government's message that wireless phones are safe. Even if worded carefully to avoid specifying any health risks associated with cell phone use, a mandatory disclosure would needlessly undermine consumer confidence in cell phones.[192] As studies have found, consumers are likely to latch on to worst-case scenarios when presented with a diverse amount of information on the perceived risk.[193] Thus, providing "more" information to consumers through the form of a mandatory RF advisory may cause them to mistakenly view cell phone RF emissions as a health risk, despite the wide availability of information to the contrary.

Accordingly, even an attempt to promote "information" like the WHO's classification of RF as in group 2B would be perilous. The public is particularly sensitive to warnings about

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191 *See* Lars Noah, *The Imperative to Warn: Disentangling the "Right to Know" From the "Need to Know" about Consumer Product Hazards*, 11 Yale J. on Reg. 293, 296 (1994) (noting substantial costs are associated with "the overuse of warnings, particularly the twin dangers of diluting the impact of more serious warnings and prompting counterproductive consumer behavior in response to overly alarming warnings about relatively insignificant risks.").

192 *See* Noah, *supra* note 191 at 365 (noting that "references to completely unspecified health risks" in certain federally-mandated warnings are ambiguous and "will undermine consumer confidence").

193 *See, e.g.*, Viscusi, K., *Alarmist Decisions with Divergent Risk Information*, 107 *Economic Journal* 1657 (1997).

cancer,[194] and is likely to misunderstand IARC's 2B classification of RF energy without the proper context.[195] As San Francisco discovered when defending its Cell Phone "Right-to-Know" ordinance, using the words "radiation" or "cancer" or quoting the IARC's "possibly carcinogenic" classification without further clarification or context can be misleading and alarmist.[196] Even "a truthful warning of an uncertain or remote danger may mislead the consumer into misjudging the dangers."[197] Given the Commission's conservative safety standards and the scientific consensus concerning the sufficiency of these standards, any consumer concern induced by a mandatory RF warning would be unjustified. As a result, the value of such a warning is dubious at best.[198]

Moreover, creating an appropriate, useful, non-misleading, uniform RF disclosure or advisory would be difficult, if not impossible. Any SAR-based disclosure requirement would be

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194 *See* Noah, *supra* note 191 at 385 (1994). This may be because consumers are particularly susceptible to believe worst case scenarios with respect to risk and more apt to weigh negative information more heavily. *See, e.g.*, Ito, et al., *Negative Information Weighs More Heavily on the Brain: The Negativity Bias in Evaluative Categorizations*, 75 Journal of Personality and Social Psychology 887 (1998)*;* Viscusi, *supra* note 193.

195 *See* Noah, *supra* note 191 (noting overreaction "is especially likely in the case of warnings about statistically remote risks of dreaded diseases such as cancer"); Liz Szabo & Mary Brophy, *WHO: Cellphone Possibly Carcinogenic*, USA Today (June 1, 2011), *available at* http://usatoday30.usatoday.com/news/world/2011-05-31-Cellphones-cancer_n.htm ("When we as consumers hear 'possibly carcinogenic,' we freak," says Otis Brawley, chief medical officer at the American Cancer Society. "But the data is not at all certain and needs further study.").

196 *See CTIA*, 827 F. Supp. 2d at 1063 ("A second misleading omission is the failure to explain the limited significance of the WHO 'possible carcinogen' classification. The uninitiated will tend to misunderstand this as more dangerous than it really is because they will go uninformed that RF energy falls short of the 'carcinogenic to humans' category and even short of the 'probably carcinogenic to humans' category.").

197 *Dowhal v. SmithKline Beecham Consumer Healthcare*, 88 P.3d 1, 14 (Cal. 2004).

198 *See* Noah, *supra* note 191 at n.440 ("[W]e must question the value of labels warning about substances whose toxicity is far from certain (e.g., saccharin). If not ignored, such labels are likely to confuse people or raise their anxiety level, without providing much information relevant to decision making.") (citations omitted).

problematic. The Commission itself has recognized this, noting that SAR is not a useful consumer education metric[199] and is highly misleading when used out of context.[200] Given SAR's limitations, a disclosure premised on SAR can only mislead the public and incite alarm – a fact that San Francisco effectively conceded when it amended its original cell phone "right to know" ordinance to remove references to maximum SAR.[201] Likewise, any efforts to enable consumers to correlate their devices to an FCC ID for the sole purpose of accessing SAR information would also be likely to mislead or confuse consumers.[202] The benefits of such an exercise would be illusory because the minor differences in SAR among variations of handsets are not meaningful in terms of possible harm. Indeed, the *Notice of Inquiry* itself recognizes the potential for consumer confusion by pointing consumers to only the SAR information on the Commission's website.[203]

Finally, government-mandated advisories or warnings connected with approved phones confront a First Amendment minefield. Courts have repeatedly found that governments may not

199 *NOI*, ¶ 234 ("[T]he maximum SAR value that is normally supplied is not necessarily a reliable indicator of typical exposure and may not be useful for comparing different devices.").

200 SAR measurements are properly used to demonstrate compliance; overemphasizing them encourages their misuse as a comparative safety measure, which renders them highly misleading. *See* FCC SAR Factsheet ("Many people mistakenly assume that using a cell phone with a lower reported SAR value necessarily decreases a user's exposure to RF emissions …. While SAR values are an important tool . . . , 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 Wireless Devices and Health Concerns ("Some parties recommend that you consider the reported SAR value of wireless devices. However, comparing the SAR of different devices may be misleading.").

201 *See* Second Amended Complaint of CTIA–The Wireless Association ¶¶ 5-6, *CTIA*, 827 F. Supp. 2d at 1054.

202 *NOI*, ¶ 235.

203 *Id*. (" We recognize that it is not always easy for some to access the SAR information, because the FCC ID is not tied to the model number or marketing name of the device, and there may be multiple records for each FCC ID, *potentially creating confusion*) (emphasis added).

compel warnings—or "advisories" that will be perceived as warnings—in the absence of evidence establishing an actual harm.[204] Thus, in order to mandate specific statements and cautions on RF safety by wireless service providers and cell phone retailers, the Commission would have to "demonstrate that the harms it recites are real and that its restriction will in fact alleviate them to a material degree."[205] But given the existing scientific evidence, such a demonstration simply cannot be made. The agency's existing RF rules were intended to protect public health and were intentionally set at a level that obviated the need for consumer information about exposure. As discussed above, the overwhelming scientific consensus is that they are effective in meeting those goals, which means any alleged "harms" that parties may urge the Commission to address through warnings are simply illusory.[206] Thus, were the Commission to craft mandatory advisory in spite of the scientific consensus on RF emissions, its advisory would run the risk of being an empty piece of useless information,[207] or opinion, rather than

[204] *See, e.g., CTIA-The Wireless Ass'n*, 494 F. App'x 752 (9th Cir. 2012) (enjoining fact sheet on health effects of cell phones where city conceded "there is no evidence of cancer caused by cell phones); *Video Software Dealers Ass'n*, 556 F.3d at 964 (finding restriction on speech was not justified where research submitted by the State did not establish or suggest a causal link between minors playing violent video games and actual psychological or neurological harm); *Int'l Dairy Foods Ass'n v. Amestoy*, 92 F.3d 67, 73 (2d Cir. 1996) (noting that in the absence of "real harms," Vermont could not justify "requiring a product's manufacturer to publish the functional equivalent of a warning" simply to satisfy perceived curiosity);

[205] *Edenfield v. Fane*, 507 U.S. 761, 770-71 (1993); *see also Ibanez v. Fla. Dept. of Bus. and Prof'l Regulation*, 512 U.S. 136, 146 (1994) (requiring Board to "demonstrate that the harms it recites are real" to justify the restriction on speech) (citing *Edenfield*, 507 U.S. at 771).

[206] *CTIA-The Wireless Ass'n*, 494 F. App'x 752.

[207] *See Int'l Dairy Foods Ass'n v. Amestoy*, 92 F.3d 67, 73 (2d Cir. 1996) ("We are aware of no case in which consumer interest alone was sufficient to justify requiring a product's manufacturers to publish the functional equivalent of a warning about a production method that has no discernible impact on a final product.").

fact.[208] Without a foundation of scientific validity justifying its adoption, any mandatory RF disclosure or advisory would be hard to justify and easy to attack.

2. There Is No Basis For Encouraging Consumers To Reduce Their Exposure To RF Emissions When Using Approved Devices.

CTIA believes that the Commission's current position on exposure reduction is appropriate given the current state of the science and the conservative nature of its standards.[209] As the Commission notes, consumers already have access to an abundance of information about proven exposure reduction methods—time and distance—that address thermal effects from RF exposure.[210] While the Commission provides this information, it "does not endorse the need for nor set a target value for exposure reduction[.]"[211] This approach is consistent with that of federal health and safety agencies as well as the WHO.[212] Furthermore, it is consistent with the overarching goal of the Commission's RF regulations, which is to set the emission standards at

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208 *CTIA*, 827 F. Supp. 2d at 1060 ("Whether or not cell phones cause cancer is a debatable question and, at this point in history, is a matter of opinion, not fact. San Francisco has its opinion. The industry has the opposite opinion."); *Video Software Dealers Ass'n*, 556 F.3d at 953 (finding video game labeling requirement unconstitutionally compelled speech "because it does not require the disclosure of purely factual information; but compels the carrying of the State's controversial opinion.").

209 *NOI*, ¶ 242 (seeking comment on the Commission's current position regarding exposure reduction measures).

210 *Id.* ¶ 233.

211 *Id.* ¶ 242.

212 *Id.* ("We significantly note that extra precautionary efforts by national authorities to reduce exposure below recognized scientifically-based limits is considered by the WHO to be unnecessary"); *see also* FDA, *Radiation Emitting Products: Reducing Exposure: Hands-free Kits and Other Accessories*, http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116293.htm (last viewed Jul. 23, 2013) ("If there is a risk from being exposed to radiofrequency energy (RF) from cell phones--and at this point we do not know that there is--it is probably very small. But if you are concerned about avoiding even potential risks, you can take a few simple steps to minimize your RF exposure.").

levels that are so conservative that precautionary measures by consumers are unnecessary.[213] Having incorporated a fifty-fold safety factor to prevent thermal effects—the only scientifically-established mechanism of harm from RF emissions—the Commission has met that goal.[214]

Encouraging consumers to take precautionary measures against unproven harms would be unwarranted and unwise.[215] As the Commission acknowledges, no scientific evidence supports exposure reduction based on non-thermal effects,[216] extremely low frequency fields ("ELF fields"), or modulation effects.[217] Even if such precautionary measures were shown to have "little or no impact on performance,"[218] there would be no grounds for taking them because they are not backed by scientific evidence. The Commission has rejected calls to regulate based on non-thermal effects, modulation effects and ELF fields,[219] and the science has not changed.[220]

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213 *NOI*, ¶ 236 ("The present Commission exposure limit is a 'bright-line rule.' That is, so long as exposure levels are below a specified limit value, there is no requirement to further reduce exposure.").

214 *Id.*

215 *Id.* ¶¶ 240-41.

216 *Id.* ¶ 237.

217 *Id.* ¶ 241 (seeking comment on precautionary measures based on modulation effects).

218 *Id.*

219 *RF Order I*, ¶ 32; *RF Order II*, ¶ 33. *See also EMR Network v. FCC*, 391 F.3d 269, 271 (D.C. Cir. 2004) (noting Commission declined to regulate on the basis of non-thermal effects due to "scientific uncertainty about such effects"); *Cellular Phone Taskforce v. FCC*, 205 F.3d 82, 90-92 (2d Cir. 2000) (upholding the Commission's decision not to regulate on the basis of non-thermal effects and ELF due to a lack of scientific evidence supporting the idea that non-thermal exposure poses an adverse risk human health).

220 *See IARC Monograph* at 97 (noting a number of studies have "concluded that it is theoretically implausible" to observe physiological effects from RF without tissue heating ; International Agency for Research on Cancer, *Monograph, Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields*, Vol. 80 at 328 (2002) (finding insufficient evidence supporting an association between ELF and any other type of cancer); *see also* WHO, *What Are Electromagnetic Fields?*, http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html ("There is little scientific evidence to support the idea of electromagnetic hypersensitivity.")

Indeed, without scientific evidence establishing a health risk from non-thermal effects, modulation effects or ELF fields, how would one even formulate such a regulation?[221]

Without a scientific basis to endorse further exposure reduction measures, any such endorsement would necessarily be premised on the "precautionary principle," a policy choice that prioritizes the avoidance of potential harm, even in the absence of evidence of harm.[222] Under the precautionary principle, "the fact that authorities do not have full scientific certainty shall not be used as a reason for not taking prompt cost-effective measures to prevent" the threatened harm.[223] Indeed, because the precautionary principle concedes the absence of evidence of harm, its very nature is political rather than scientific.[224] While some governments have relied on this principle to justify regulation, the fundamental nature of the "precautionary principle" means that those decisions are untethered from the existing body of scientific research. Imposing prophylactic measures until such time as a product can be "proven" safe means that

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221 *NOI*, ¶ 241; *see also id.* ¶ 238 (acknowledging the absence of a "specific quantitative goal for improvement" with respect to RF emission reduction).

222 *See* Brief of the U.S. Chamber of Commerce et al. as Amici Curiae In Support of Plaintiff-Appellant at 6-7, CTIA-The Wireless Association v. City and County of San Francisco, 494 F. App'x 752 (9th Cir. 2012) (No. 11-17707); Jonathan Adler, *The Problems With Precaution: A Principle Without Principle*, The American (May 25, 2011), *available at* http://www.american.com/archive/2011/may/the-problems-with-precaution-a-principle-without-principle.

223 Laurent A. Ruessmann, *Putting the Precautionary Principle in Its Place: Parameters for the Proper Application of A Precautionary Approach and the Implications for Developing Countries in Light of the Doha WTO Ministerial*, 17 Am. U. Int'l L. Rev. 905, 909 (2002) (citing United Nations Conference on Environment and Development: Rio Declaration on Environment and Development, U.N. Doc. A/Conf.151/5/Rev.1 (June 13, 1992)).

224 Professor Adler notes that the precautionary principle is often invoked to justify "essentially political decisions," making it "difficult to maintain that the precautionary principle provides the foundation for safety or health-enhancing policies." Adler, *supra* note 222. Professor Bratspies notes that critics of the precautionary principle maintain that it allows "political concerns rather than science to drive regulatory decisions." *See* Rebecca M. Bratspies, *Rethinking Decisionmaking in International Environmental Law: A Process-Oriented Inquiry into Sustainable Development*, 32 Yale J. Int'l L. 363, 383 (2007).

new products and innovations must be frozen in amber pending the impossible proof of a negative. The nature of scientific inquiry means that there can never be absolute proof of the negative, i.e., proof of safety; the most science can do is just to accumulate more and more data showing a lack of harm. This is a policy choice wholly inconsistent with the Commission's mandate to balance public safety and efficient deployment of wireless communications,[225] and would represent a radical departure from the Commission's emphasis on a science-based RF regime.[226]

Thus, not only would further precautionary measures be unnecessary and inappropriate, they would be arbitrary and capricious.[227] Because the Commission lacks a scientific basis to justify additional precautionary measures, CTIA does not believe it should pursue such efforts.

The Commission notes that other countries have taken measures in the name of "prudent avoidance,"[228] but these policies do not sway the calculus in favor of additional hortatory efforts. First, the exposure reduction measures cited in the *Notice of Inquiry* relate to fixed transmitters,

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225 *See* H.R. Rep. No. 104-204-(I) at 94 (1995).

226 A number of academics have articulated more nuanced formulations of the "precautionary principle," which attempt to more closely align the idea of precautionary regulation with science-based inquiry. *See, e.g.*, Cass R. Sunstein, *Beyond the Precautionary Principle*, 151 U. Pa. L. Rev. 1003, 1004 (2003) (identifying four different types of the precautionary principle) (citing Richard B. Stewart, Environmental Regulatory Decision Making Under Uncertainty, in 20 Research in Law and Economics 71, 76 (Timothy Swanson ed., 2002)). One such formulation is the "margin of safety," which limits activities to below the level at which adverse activities have been found or predicted. *Id*. In this sense, the FCC's fifty-fold safety factor is already sufficiently "precautionary," as it sets the limit for general population exposure fifty times below the threshold at which thermal effects are observed. *See NOI*, ¶ 236.

227 *See Indus. Union Dep't., AFL-CIO v. Am. Petroleum Inst.*, 448 U.S. 607, 609 (1980) (rejecting standard based on precautionary principle and holding that agency should first find that long-term exposure to benzene presented a "significant risk of material health impairment"); *see generally* Sunstein, *supra* note 226 at 1004 (challenging the precautionary principle "not because it leads in bad directions, but because, read for all that it is worth, it leads in no direction at all.").

228 *NOI*, ¶ 237.

not portable devices.[229] Second, the Commission itself acknowledges the activities of other countries or agencies are instructive only if the Commission has "*confidence in the research, analysis and principles upon which they are based, as well as the tangible benefits they would provide*."[230] As the WHO, IARC and the IEEE have found, there is a lack of credible scientific evidence establishing health risks caused by non-thermal effects, ELF fields or modulation effects,[231] and thus the Commission is without a basis for confidence in such a conclusion.

The current regime adequately protects the public, and promoting precautionary measures would impose undue burdens on industry and be inconsistent with the Commission's mandate.[232] For example, were the Commission to advocate that consumers turn their wireless phones off, as San Francisco tried to do, its advice would contradict its goal of promoting an advanced and efficient wireless network[233] and be at cross-purposes with its own public safety initiatives.[234]

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229 *Id*. Indeed, the *NOI* itself notes that these exposure reduction policies in other countries do not apply to portable devices.

230 *Id*. ¶ 238 (emphasis added).

231 *See IARC Monograph* at 97; WHO, What Are Electromagnetic Fields?", http://www.who.int/peh-emf/about/WhatisEMF/en/index1.html; IEEE Std C95.1-2005 at 35 ("Further examination of the RF literature reveals no reproducible low level (non-thermal) effect that would occur even under extreme environmental exposures. The scientific consensus is that there are no accepted theoretical mechanisms that would suggest the existence of such effects.").

232 *NOI*, ¶ 209 (noting Commission's mandate "to adequately protect the public without imposing an undue burden on industry").

233 Network optimization relies on the transmission of information from devices that are "on" but not "in use." *See* Plaintiffs' Motion for Preliminary Injunction at 20-21, *CTIA-The Wireless Association v. The City and County of San Francisco,* 827 F. Supp. 2d 1054 (N.D. Cal. 2011) (3:10-cv-03224).

234 For example, the Commission and the Federal Emergency Management Agency (FEMA) have worked to deploy Wireless Emergency Alerts (WEA, formerly known as the Commercial Mobile Alert System). *See* FCC, *Wireless Emergency Alerts,* http://www.fcc.gov/guides/wireless-emergency-alerts-wea (last viewed Jul. 26, 2013). This public safety system allows customers who own certain wireless devices to receive geographically-targeted text messages alerting them to "imminent threats to safety in their area."

CTIA also agrees that encouraging further precautionary measures could also result in increased infrastructure costs.[235] Moreover, any measures that would further restrict network operations, design or deployment would be burdensome if applied in anything other than a prospective manner.[236] These undue burdens would not be justified, given the adequate protection that the current RF regime already affords.

As with general mandatory disclosures or warnings, advocating precautionary measures or endorsing exposure reduction measures would needlessly cause concern and confusion.[237] Consumer confusion and alarm would also open the door to fraudulent and unnecessary devices, services or applications that purport to control, limit or shield RF. Such devices are already being marketed even though the FTC, Commission and FDA all agree they are ineffective and may actually be counterproductive.[238] The FTC has already pursued actions against companies

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Id. If consumers were to turn their phones off when not "in use," they would not receive alerts about tornado warnings, flash floods, or missing children (Amber Alerts).

235 *NOI*, ¶ 237.

236 *Id.* ¶ 240 (seeking comment as to whether any precautionary measures adopted should be applied prospectively or also to existing situations).

237 *Id.* ¶ 242 ("We seek information on . . . the utility and propriety of such messaging as part of this Commission's regulatory regime.").

238 FTC, *Cell Phone Radiation Scams*, http://www.consumer.ftc.gov/articles/0109-cell-phone-radiation-scams (last viewed Jul. 25, 2013) ("[A]ccording to the FTC, there is no scientific proof that so-called shields significantly reduce exposure from these electromagnetic emissions."); OET RF Safety ("Studies have shown that these devices generally do not work as advertised. In fact, they may actually increase RF absorption in the head due to their potential to interfere with proper operation of the phone, thus forcing it to increase power to compensate."); FDA, *Radiation-Emitting Products: Reducing Exposure: Hands-free Kits and Other Accessories*, http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116293.htm ("Studies have shown that [RF shields] generally do not work as advertised.").

promoting RF shields, noting that such devices may also interfere with a phone's signal.[239] Were the Commission to urge precautionary measures based on unproven theories of harm, the market for such dubious devices would blossom.

Thus, the Commission should not encourage exposure reduction beyond scientifically-established limits. Such efforts would offer no known benefit and would carry significant costs.

D. The Commission Should Remain Open To Alternative Means Of Compliance Evaluation While Continuing Its Longstanding Endorsement Of SAM And The KDB Structure.

The Commission has encouraged investment, innovation and improvement by employing testing methodologies that are both sensible and flexible. Its longstanding approach has been to provide timely guidance on acceptable methodologies for evaluation based on sound scientific principles and engineering practices in connection with the equipment authorization process. This approach has the benefit of providing the necessary flexibility to address rapidly evolving technology as well as assuring reliability by incorporating evolving best practices. Accordingly, while CTIA encourages the Commission to remain open to alternative means of compliance and device evaluation, it should continue to endorse the SAM method and KDB structure.

1. The Commission Should Continue to Embrace SAM as an Approved Safe Harbor and Await Conclusions of the Scientific Community as to the Efficacy and Accuracy of Other Evaluation Methods.

In response to the Commission's request for comment on "the pros and cons of measurement versus computation, as well as standardization of human models,"[240] CTIA states that it supports continued use of the SAM, and at the same time encourages research into reliable and verifiable computational evaluation methods. CTIA agrees that SAR evaluation has been a

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239 CBS News, *FTC: Cell Phone Shields Don't Work*, (Feb. 11, 2009) http://www.cbsnews.com/stories/2002/02/20/tech/main330039.shtml.

240 *NOI*, ¶ 245.

significant undertaking and that standards development in this area will be a continuous process. For that reason, the Commission should continue to embrace SAM while supporting efforts to identify other science-based evaluation methods.

As the Commission notes, most compliance evaluations submitted to the Commission are based on measurements using SAM. For years, SAM has been *the* preferred method and the industry standard for compliance.[241] Indeed, it is the only specifically approved method for demonstrating compliance with RF standards.[242] It is the only scientifically defensible and time-tested evaluation method, and it is prevalently—if not exclusively—used by those CTIA members whose devices undergo compliance evaluations.

Through its KDBs and other pronouncements, the Commission has established SAM as a safe harbor for compliance. Simply put, if a device satisfies the Commission's existing emission standards via use of the SAM model, it is compliant. This has been so for more than a decade. Indeed, the Commission has taken the position that the SAM model cannot be attacked, either through state or local regulation or in litigation,[243] and the industry has relied on Commission pronouncements that SAM is an approved evaluation method. Accordingly, the Commission should continue to embrace SAM as a safe harbor for compliance.

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[241] *See Office of Engineering and Technology Announces a Transition Period for the Phantom Requirements of Supplement C to OET Bulletin 65*, Public Notice, DA-02-1438 (June 19, 2002) (stating that the Commission will "require that the new standard IEEE SC 34 head phantom (the 'SAM' phantom) be used for all SAR testing in any FCC certification application submitted on or after September 15, 2002."); *Office of Engineering and Technology Announces Release of Revised Supplement C to OET Bulletin 65*, Public Notice, DA 01-1557 (June 29, 2001) (stating that "[a]fter the transition period, the new standard head phantom should be used for all SAR testing").

[242] *See, e.g.*, FCC KDB 447498.

[243] *See Dahlgren Letter* at 2-3 ("[I]t is the FCC's position that any claims that depend on a judicial finding that the Commission's compliance procedures fail to ensure that wireless phones are safe are . . . preempted.").

At the same time, CTIA shares the Commission's interest in identifying other reliable evaluation methods. SAR measurement and modeling methods continue to evolve to achieve greater accuracy, and not all proposed techniques prove to be precise.[244] Certain computational modeling techniques are prone to error or have other shortcomings, and computational modeling lacks standards and uniformity.[245] Moreover, there is a lack of consensus among international standard-setting bodies about how computational modeling could be successfully performed. The Commission should not stifle innovation by requiring the use of one reliable methodology to the exclusion of others. On the contrary, it should continue to encourage innovation and exploration by remaining open to any methodology that is shown to be reliable and consistent with good engineering practices. If the science coalesces in support of computational modeling or some other testing methodology, CTIA would support the Commission's establishment, after review and comment, of appropriate standards and approval processes for it, just as it has done with SAM.

2. The Commission Should Continue to Encourage Innovation And Improvement By Issuing Compliance Directives in KDB Publications.

CTIA supports and encourages continuation of the Commission's current approach to device evaluation in the equipment authorization process. Under the current regulatory structure, devices achieve evaluation compliance by satisfying the directives found primarily in OET

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[244] *NOI*, ¶ 245.

[245] *See, e.g.*, OET Bulletin 65, Supplement C at 15 (June 2001), *available at* http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65c.pdf ("[C]omputational uncertainties are usually the results of errors due to numerical algorithm implementation, benchmark validation, methods used to compute SAR from the field components and procedures used to determine the one-gram averaged SAR."); FCC KDB 447498 (With respect to computational modeling, "there could be difficulties in applying numerical simulation to complex devices and exposure configurations. It may be necessary to discuss with the FCC to determine the appropriate parameters and modeling approaches required to simulate specific devices and anatomical models.")

Bulletin 65 Supplement C and KDB publications. By requiring compliance evaluation based on sound scientific principles and engineering practices as confirmed by OET first in Supplement C and later in KDB publications, the Commission ensures compliance without stifling innovation in testing methodologies or device design. This approach is consistent with Congress's directive to protect public health while also promoting innovation and growth in addressing growing marketplace demands for improved communications services and technologies.[246]

The Commission has correctly concluded that it should not stifle the development of alternative testing and compliance protocols. Evaluation is a "rapidly evolving area, keeping pace with technological changes, that is most effectively guided by good engineering practice rather than specific regulations."[247] The plasticity of the KDB publications accomplishes that. KDB publications have successfully served as living documents that can be (and have been) easily modified to reflect changes in technology or scientific consensus.[248] By requiring adherence to OET-approved evaluation methodologies as part of the equipment authorization process, and by constantly updating OET guidance based on state of the art information, the Commission best serves Congress's direction to protect the public while ensuring that regulatory burdens do not stifle innovation and growth.

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[246] *See* FCC Murray Br. at *15-16.

[247] *NOI*, ¶ 244.

[248] As the Commission notes, the evaluation techniques referenced and reflected in KDB publications were developed through international standard setting bodies such as IEEE and IEC and sometimes require modification and "self-correct[ion] as information and analysis becomes more readily available." *NOI,* ¶ 244. *See also* LS Research Wireless RF Design Blog, *FCC Certification: OET KDB Updates*, Dec. 7, 2012, http://info.lsr.com/LSR-Wireless-RF-Design-blog/bid/256853/FCC-Certification-OET-KDB-Updates (summarizing recent updates to various KDB publications).

E. Current Body-Worn Emission Standards Adequately Protect Public Health, Account For Variations Of Usage, And More Accurately Mimic Real-World Conditions Than A Zero-Spacing Protocol.

Given that the current RF regime, including body-worn exposure standards, is adequately protective of the public health, CTIA submits that adopting a "zero-spacing" testing protocol is not appropriate at this time.[249] CTIA agrees that no scientific evidence suggests that failing to maintain a specified separation poses a health risk.[250] Nor does any evidence suggest that SAR values that exceed Commission limits necessarily imply unsafe operation, or that lower SAR values imply "safer" operation.[251] In this context, CTIA agrees that exceeding the SAR limit "should not be viewed with significantly greater concern than compliant use," in part due to the fifty-fold safety factor incorporated into the existing RF emission standards.[252] CTIA considers Supplement C's body-worn device separation requirement an issue of proper use and operation, as opposed to one of health and safety.[253]

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249 *NOI*, ¶ 252 (seeking comment on "what steps, if any, the Commission should take relative to [its] policies for testing of devices on the basis of an expectation of some separation from the body, including whether it is appropriate to consider 'zero' spacing, or actual contact with the body when testing.").

250 *See id.* ¶ 251.

251 *Id.*

252 *Id.* As a result of this "large safety factor," the Commission and experts in the scientific community have concluded that "exposure well above the specified SAR limit should not create an unsafe condition." *Id*.

253 *See* Mobile Antenna Systems Handbook at 340 (Kyohei Fujimoto ed., 3rd Ed. 2008) ("During committee deliberations that led to IEEE C95.1-2005, the focus was on conservatism; during deliberations on the compliance standards, the focus was on precision. Worst-case assumptions were always considered. While it is always a good practice to make precise and accurate measurements, there is a trade-off when assessing compliance of a device with limits having large built-in safety margins. That is, whether or not a product meets a specified limit is a compliance issue—not a safety issue. An unrealistic focus on precision causes one to lose sight of the objective."); *IARC Monograph* at 35 ("The whole-body SAR provides little information about spatial or organ-specific energy deposition, as it strongly depends on field polarization and animal posture.").

The existing emission standards are premised on the assumption that consumers have neither knowledge of, nor the ability to control, RF emissions.[254] As the Commission notes, the SAR data for body-worn configurations does not apply when consumers disregard manufacturer disclosures about maintaining a body-worn separation distance.[255] Likewise, because such disclosures are discretionary, some consumers may not receive the information in the first place. Consistent with the fifty-fold safety factor and the Commission's assumption about the general population's lack of knowledge and control, emission standards and evaluation criteria for the general public have and should continue to be viewed as accounting for all reasonable scenarios.

There is no shortage of usage scenarios or variables that affect body-worn SAR values,[256] and thus there is no proximity restriction that will accurately measure the amount of RF energy absorbed by a single person, let alone an entire population. As between a zero-spacing restriction and the existing proximity restriction, however, the latter more accurately mimics real-world SAR levels and usage. For one, SAR measurements are performed while a device is operating at maximum power, "[but] given typical operating conditions, the SAR of the device

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[254] OET Bulletin 65, Supplement C (June 2001), at 10, *available at* http://transition.fcc.gov/-Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65c.pdf.

[255] *NOI*, ¶ 248.

[256] No testing regime can account for all consumer use or misuse, or knowledge or lack thereof. The Commission surely had this in mind when it established the fifty-fold safety factor. As the Commission explains, "[t]his 'safety' factor can well accommodate a variety of variables such as different physical characteristics and individual sensitivities – and even the potential for exposures to occur in excess of our limits without posing a health hazard to humans." FCC, "Reassessment of Exposure to Radiofrequency Electromagnetic Field Limits and Policies, Proposed Rule" (June 4, 2013), *available at* https://www.federalregister.gov/articles/2013/06/04/2013-12713/reassessment-of-exposure-to-radiofrequency-electromagnetic-fields-limits-and-policies.

during normal [body-worn] use would be less than tested."[257] A device's given power levels depend in part on whether it is in use and the strength of the signal it is accessing. Because consumers typically leave their phones on but are not always "using" them, the device is often not operating at maximum power—and therefore emitting RF at a level below the tested SAR. In fact, "to minimize interference in the networks, the power is dynamically reduced to the minimum necessary to carry out calls," and 3G phones, even when in use, "only operate[] at a few percent of the maximum power."[258] Moreover, most modern devices possess power-saving functionalities that reduce RF emissions when a phone is on but not in use, meaning "transmissions . . . are brief and infrequent, and exposure is expected to be very small when averaged over time."[259] Clothing, holsters and other accessories—which can serve as barriers between the device and the body—likewise reduce the amount of RF energy absorbed by the body. Finally, absorption also varies from person to person based on the inevitable inhomogeneity of human anatomy and tissues.[260] Each of these factors significantly *reduces* a device's *actual* (as opposed to tested) SAR level, yet the existing compliance procedures and proximity restrictions do not take them into account.

The above examples illustrate that emission-reduction mechanisms and varying usage practices play a significant role that can *more than* counteract the fact that a device is sometimes kept closer than 2.5 cm from the body. Although imperfect (as any separation standard will be), the existing separation standard acknowledges the dual realities that devices are oftentimes held

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257 *NOI*, ¶ 251; *see also IARC Monograph* at 54 ("Values in normal usage positions should be lower than the values declared by manufacturers because the positions used in the testing standards are designed to mimic near worst-case conditions.").

258 *IARC Monograph* at 54.

259 *Id.* at 55.

260 *Id.* at 73.

near the body, and in such instances, the amount of RF energy absorbed is generally less than the SAR value would suggest. Ultimately, CTIA supports the existing proximity restriction and does not believe a zero-spacing measurement requirement would either mimic actual usage or increase safety.

In response to the Commission's request for comment on whether to advise consumers about body-worn separation distance, CTIA submits that no such disclosures are necessary.[261] As already discussed above, the conservative nature of the current emission standards and their incorporation of a fifty-fold safety factor already provides appropriate protection to the public. Despite variability of device usage and associated RF emission levels, the current emission standards "accommodate a variety of variables."[262] Under the "bright-line rule" of the current RF emission standards,[263] body-worn separation does not pose a serious safety issue. CTIA observes that, while the body-worn separation distance disclosures once recommended by the Commission were well-intended, they have been taken out of context to suggest that devices are dangerous within 2.5 cm distance.[264] Thus, body-worn disclosures may simply create unnecessary confusion on the part of the consumer and raise unwarranted doubts about the sufficiency of the RF standard.[265]

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261 *NOI*, ¶¶ 248, 252.

262 *NOI*, ¶ 236.

263 *Id.* (noting that under the bright-line rule of the present Commission exposure limit, "there is no further requirement to further reduce exposure."). .

264 *See* Mobile Manufacturers Association, *How Head and Body SAR are Measured*, *available at* http://mmfai.info/public/docs/eng/111027_MMF_vp_SARReporting_final.pdf (last viewed Aug. 6, 2013) (explaining that one "issue that routinely causes confusion is when a user manual refers to a 'separation distance' between the phone and the body.").

265 *See* Section III.C.1, *supra*.

Further confusion for both the consumer and manufacturer results from the discretionary nature of body-worn disclosures. As the Commission explains, "[m]anufacturers have been *encouraged* since 2001 to include information in device manuals to make consumers aware of the need to maintain the body-worn distance."[266] This disclosure, however, is not mandatory.[267] And, given the Commission's limited guidance on the content of disclosures, the messaging and level of detail in device manuals varies from manufacturer to manufacturer.[268] What is more, with the forthcoming discontinuation of OET Bulletin 65 Supplement C, this recommendation may become even more nebulous. CTIA suggests that the Commission revisit the advisability of consumer disclosures concerning separation distances and normal usage. The Commission's general population emission standards more than account for all expected exposures, including exposures associated with abnormal usage.

Finally, CTIA submits that any guidelines relating to body-warn SAR should be issued through the OET's KDB publications. The Commission's policies in this area have evolved as devices have evolved,[269] and it has timely issued KDBs to reflect changes in body-worn SAR evaluation procedures as a result of novel technologies, among other reasons.[270] As devices and

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[266] *NOI*, ¶ 248 (emphasis added).

[267] The disclosure recommendation is found in OET Bulletin 65, Supplement C at 41. The Commission has noted, however, that "OET Bulletin 65 (including its Supplements) is not mandatory." *See also* FCC KDB 212821, *available at* https://apps.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=20559&switch=P ("[I]t is recommended that some information about SAR may be useful in the manual for users to understand the device characteristics.").

[268] Supplement C merely provides that "[i]n order for user to be aware of the body-worn operating requirements for meeting RF exposure compliance, operating instructions and caution statements should be included in the manual." OET Bulletin 65, Supp. C at 41 (June 2001).

[269] *NOI*, ¶ 250.

[270] *See, e.g.*, FCC KDB 941225 D01 "SAR Measurement Procedures for 3G Devices;" FCC KDB 941225 D02 "SAR Guidance for HSPA, HSPA+, DC-HSDPA and 1x-Advanced;" FCC KDB 941225 D03 "Recommended SAR Test Reduction Procedures for GSM/GPRS/EDGE;"

technologies will undoubtedly continue to evolve, so too should the Commission's guidelines. Continued use of the KDB publications is the best way to accomplish that.

IV. CONCLUSION

Given the scientific evidence backing the current RF emission standards, the Commission is correct to have confidence in its current regime. Nevertheless, CTIA applauds the Commission's inquiry into its RF standards and its efforts to ensure that the standards reflect the latest scientific developments.

Respectfully submitted,

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FCC; Reply Comments of the CTIA - The Wireless Association,
ET Docket No. 13-84 (Nov. 18, 2013)

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 ET Docket No. 03-137
	)	
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	)))	

REPLY COMMENTS OF CTIA – THE WIRELESS ASSOCIATION®

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November 18, 2013

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REPLY COMMENTS OF CTIA – THE WIRELESS ASSOCIATION®

I. INTRODUCTION AND SUMMARY

CTIA – The Wireless Association® ("CTIA") respectfully submits these reply comments in response to the Commission's *Further Notice of Proposed Rulemaking and Notice of Inquiry* in the above-captioned proceedings.[1] The record indicates that the Commission's current radiofrequency ("RF") standards are more than adequate to protect public safety. Moreover, the Commission should continue its science-based approach to RF emission standards and testing methodologies because the FCC's regime is grounded in the scientific consensus.[2] The Commission also should refrain from either requiring RF safety disclosures or encouraging methods to limit exposure to RF emissions from mobile devices, and it should continue to rely on approved testing mechanisms and existing proximity restrictions for mobile device usage.[3]

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1 *Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies*, First Report and Order, Further Notice of Proposed Rulemaking and Notice of Inquiry, ET Docket Nos. 13-84, 03-137 (rel. Mar. 29, 2013) ("*NOI*" or "*FNPRM*").

2 Comments of CTIA – The Wireless Association®, ET Docket Nos. 13-84, 03-137, at 2 (Sept. 3, 2013) ("CTIA Comments").

3 *See id.* at 2-3.

The record supports CTIA's recommendations and demonstrates that confidence in the RF exposure regime is well-founded.[4] First, the scientific consensus supports the Commission's current RF exposure standards as more than adequate to protect the public, based on years of research and the fifty-fold safety margin incorporated into the general population exposure standard. If anything, the record shows that the Commission's standard may be more conservative than necessary. The latest recommendations by the International Committee on Non-Ionizing Protection (ICNIRP) and the Institute for Electrical and Electronics Engineers (IEEE), which reflect the current scientific consensus, are that the safety standard for mobile devices should be set at 2.0 W/kg, averaged over 10 grams of tissue. The GAO recently suggested that harmonization of the FCC's standard with either one of those internationally-adopted standards would be sensible policy and could benefit the public. In contrast, calls in the record to adopt more restrictive exposure standards flatly contradict the scientific consensus and would have the Commission radically depart from the science-based inquiry that has previously guided it.

Second, the record does not support stringent, mandatory consumer disclosures, and the conservative nature of the FCC's existing standard means there is no basis for encouraging additional exposure reduction. A wide variety of information about mobile phone use and RF exposure is available to consumers, and any attempt to adopt a mandatory RF "safety" disclosure would raise significant policy and legal issues. Calls for the Commission to endorse formally the precautionary principle in the name of exposure reduction are similarly inconsistent with the Commission's regulatory mandate.

[4] *See NOI*, ¶ 216.

Third, because there is no reliable evidence proving that current testing protocols fail to ensure compliance with RF standards, the record does not support a change in existing testing guidelines. The conservative nature of the FCC's RF standards and testing protocols is more than adequate to account for variation in consumer usage. Moreover, a zero-measuring requirement would not accurately mimic real usage or increase safety. Were the Commission to attempt to accurately model "typical" consumer usage, as some commenters urge it to do, the task would be exponentially more complicated than the simple recommendation to adopt a "zero-spacing" testing distance. For example, current testing protocols also test the device at its maximum power level output (*i.e.* all applications and functions running simultaneously), but "typical" consumer usage involves nothing of the sort; actual power levels during consumer use of the device are typically far lower. Any move to revise the testing guidelines must be carefully weighed against the Commission's mandate to balance safety with an efficient deployment of wireless service. Revising testing protocols in an attempt to replicate potential real world conditions will require more complex and onerous testing, without any clear improvement in the results. Because the record does not show that a revision is necessary to assure consumer safety, further changes to the testing protocols would simply impose additional complexity and costs without any corresponding benefit, and are thus not warranted.

Finally, in response to proposals advanced in the *Further Notice*, CTIA comments on the Commission's proposal to revise the criteria that exempt certain transmitter sites from routine environmental evaluation. The Commission should ensure that its proposed exemption criteria do not have the unintended effect of eliminating categorical exemptions for transmitters that pose little risk to public safety. The Commission's proposed exemption criteria for single transmitters may jeopardize the categorical exemption that currently applies to small cell sites. As the record does not reflect a public safety need for routine environmental evaluation of small cell sites, the Commission should ensure that any revisions of the exemption criteria do not unwittingly subject small cell sites to unwarranted, new roadblocks.

II. THE RECORD DOES NOT SUPPORT A MORE RESTRICTIVE EXPOSURE STANDARD.

The *Notice of Inquiry* sought to "open a discussion" about the FCC's current RF exposure limits and policies in order to "establish whether the present limits are insufficiently protective, appropriately protective, or overly restrictive."[5] The record demonstrates that the consensus among international standards-setting organizations, international scientific groups, and federal health and safety agencies is that the current FCC standards are more than "appropriately protective" of consumers. Indeed, to the extent the record suggests any change in exposure standards, it demonstrates that the less restrictive international standard of 2.0 W/kg averaged over 10 g of tissue reflects the best available science. Calls in the record for a more restrictive standard contradict the scientific consensus and therefore cannot provide the basis for agency action in a science-driven proceeding like this one.[6]

A. The Commission's RF Exposure Standards Are More Than Adequate To Protect The Public.

The Commission's inquiry into its RF exposure standards[7] has yielded a record showing broad agreement that the current exposure standards are more than adequately protective of

5 *Id.*, ¶¶ 216, 218.

6 *Id.*, ¶ 210 ("The purpose of this *Inquiry* is to open a science-based examination of the efficacy, currency, and adequacy of the Commission's exposure limits for RF electromagnetic fields."); *see also* CTIA Comments at 18 (encouraging the Commission to continue its science-based approach to regulation concerning RF exposure standards).

7 *See supra*, note 6.

human health.[8] The Commission adopted exposure standards backed by federal health and safety agencies and international standards-setting bodies,[9] whose position is that the standards were safe when established and remain safe today. As shown by CTIA and others, the Commission, federal health and safety agencies, and international standards-setting bodies agree that cell phone use is not associated with adverse health effects:

- **Federal Communications Commission (FCC):** "There is no scientific evidence that proves that wireless phone usage can lead to cancer." [10]

- **Federal Drug Administration (FDA): "**The scientific evidence does not show a danger to any users of cell phones from RF exposure."[11]

- **U.S. Government Accountability Office (GAO):** "In 2001, we reported that FDA and others had concluded that research had not shown RF energy emissions from mobile phones to have adverse health effects, but that insufficient information was available to conclude mobile phones posed no risk. Following another decade of scientific research and hundreds of studies . . . , FDA maintains this conclusion."[12]

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8 *See, e.g.*, CTIA Comments at 18; Comments of GSMA, ET Docket Nos. 13-84, 03-137, at 1 (Aug. 30, 2013) ("GSMA Comments") (noting the Commission's expressed confidence in the current exposure limits "is consistent with the conclusions of many other expert reviews").

9 *See* CTIA Comments at 18-20; *see also* Comments of Telecommunications Industry Association, ET Docket Nos. 13-84, 03-137, at 3 (Sept. 3, 2013) ("TIA Comments"); Comments of Nokia, ET Docket Nos. 13-84, 03-137, at 8 (Sept. 3, 2013) ("Nokia Comments").

10 FCC, *FAQs: Wireless Phones*, *available at* http://www.fcc.gov/encyclopedia/faqs-wireless-phones#evidence (last visited Aug. 6, 2013)); *see also* CTIA Comments at 20 n.94 (citing amicus briefs in *Murray v. Motorola* and *Farina v. Nokia* stating that wireless phones in compliance with the FCC's RF standards are safe for use by the public).

11 FDA, *Radiation-Emitting Products, Children and Cell Phones* (Mar. 10, 2009), *available at* http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116331.htm (last visited Aug. 3, 2013); *see also* CTIA Comments at 19 (citing FDA).

12 United States Government Accountability Office, Report to Congressional Requesters, *TELECOMMUNICATIONS: Exposure and Testing for Mobile Phones Should be Reassessed*, GAO-12-771, at 6 (July 2012) ("GAO Report"); *see also* CTIA Comments at 20 (citing GAO).

- **National Cancer Institute (NCI):** "A new analysis by NCI researchers has turned up no evidence to support a link between cell phone use and brain cancer in the United States."[13]

- **National Council on Radiation Protection and Measurements (NCRP)**: "[A]vailable evidence indicates that exposure to RF fields at levels in compliance with FCC guidelines does not lead to additional risk for cancer or adverse effects on potentially sensitive tissues . . . ."[14]

- **World Health Organization (WHO): "**A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use."[15]

- **International Commission for Non-Ionizing Radiation Protection (ICNIRP):** "[E]xtensive research has not established any biological mechanism by which radiofrequency fields . . . could cause cancer."[16]

- **IEEE:** "A lack of credible scientific and medical reports showing adverse health effects for RF exposures at or below similar exposure limits in past standards supports the protective nature of the exposure limits."[17]

Foreign regulators assessing the scientific literature have come to the same conclusion. The Mobile Manufacturers Forum ("MMF") compiled statements by Sweden's Radiation Safety

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[13] National Cancer Institute, *Cancer Research Highlights* (July 2010), *available at* http://www.cancer.gov/ncicancerbulletin/072710/page3#d); *see also* CTIA Comments at 22 (citing National Cancer Institute).

[14] National Council on Radiation Protection and Measurements (NCRP), *Letter Report on Wireless Telecommunications Radiofrequency Safety Issues for Building Owners and Managers*, Scientific Committee 89-6 (Dec. 20, 2002); *see also* CTIA Comments at 17 n.83 (citing NCRP).

[15] WHO, *Electromagnetic fields and public health: Mobile Phones*, (June 2011), *available at* http://www.who.int/mediacentre/factsheets/fs193/en/index.html ("WHO EMF Fact Sheet"); *see also* CTIA Comments at 17 n.83 (citing WHO EMF Fact Sheet); TIA Comments at 4 (citing same).

[16] International Commission for Non-Ionizing Radiation Protection (ICNIRP), Standing Committee on Epidemiology, *Mobile Phones, Brain Tumours and the Interphone Study: Where Are We Now?* (2011), *available at* http://www.icnirp.de/documents/SCIreview2011.pdf; *see also* Comments of Mobile Manufacturers Forum, ET Docket Nos. 13-84, 03-137 Annex A, at 79 (Sept. 3, 2013) ("MMF Comments") (citing ICNIRP).

[17] Institute of Electrical and Electronics Engineers, Inc. (IEEE), *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*, IEEE Std. C95.1-2005, at 2 (2006) ("IEEE Std C95.1-2005").

Authority, the Health Council of the Netherlands, the European Union's Health Risk Assessment Network on Electromagnetic Fields Exposure, the United Kingdom's Health Protection Agency, Norway's Institute for Public Health, Germany's Radiation Protection Commission, Spain's Scientific Advisory Committee on Radio Frequencies and Health, and South Africa's Department of Health, all concluding that RF exposure from mobile phone use was not causally linked to brain tumors or other adverse health effects.[18] The Telecommunications Industry Association ("TIA") also provided support from the Latin American Experts Committee on High Frequency Electromagnetic Fields and Human Health, the European Commission's Scientific Committee on Emerging and Newly Identified Health Risks, and the Swedish Counsel for Working Life and Social Research.[19]

Furthermore, studies conducted by researchers in the United States have found no association between mobile phone use and brain cancer.[20] In fact, the National Cancer Institute (NCI) has stated that "there is no evidence from studies of cells, animals, or humans that radiofrequency can cause cancer."[21] As the NCI explains, "[i]t is generally accepted that damage to DNA is necessary for cancer to develop. However, radiofrequency energy . . . does not cause DNA damage in cells," nor has it been found to cause cancer in animals or enhance the effects of known chemical carcinogens.[22] The NCI's Surveillance, Epidemiology and End Results (SEER)

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18 *See* MMF Comments, Annex A at 75-80.

19 *See* TIA Comments at 4-6.

20 *See* P.D. Inskip, et al., *Cellular-Telephone Use and Brain Tumors*, 344 New Eng. J. Med. Vol. 79 (2001) (finding no increased risk of brain cancer associated with mobile phone use); J.E. Muscat, et al., *Handheld Cellular Telephone Use and Risk of Brain Cancer*, 284 J. Am. Med. Ass'n 3001 (2000) (same).

21 National Cancer Institute, Fact Sheet, *Cell Phones & Cancer Risk* (Jun. 2013), *available at* http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones.

22 *Id.*

Program, which tracks cancer incidence in the United States, found "no increase in the incidence of brain or other central nervous systems cancers between 1987 and 2007, despite the dramatic increase in cell phone use in this country during that time."[23] A study published by the National Institute of Health (NIH) also found no increase in the incidence of brain or other central nervous system cancers between 1996 and 2006, during which time the use of mobile phones skyrocketed.[24] As illustrated in the chart below, brain tumor rates have remained flat or even fallen slightly here in the United States, contrary to the predictions of outlier scientists who previously forecast ruinous incidence rates.[25]

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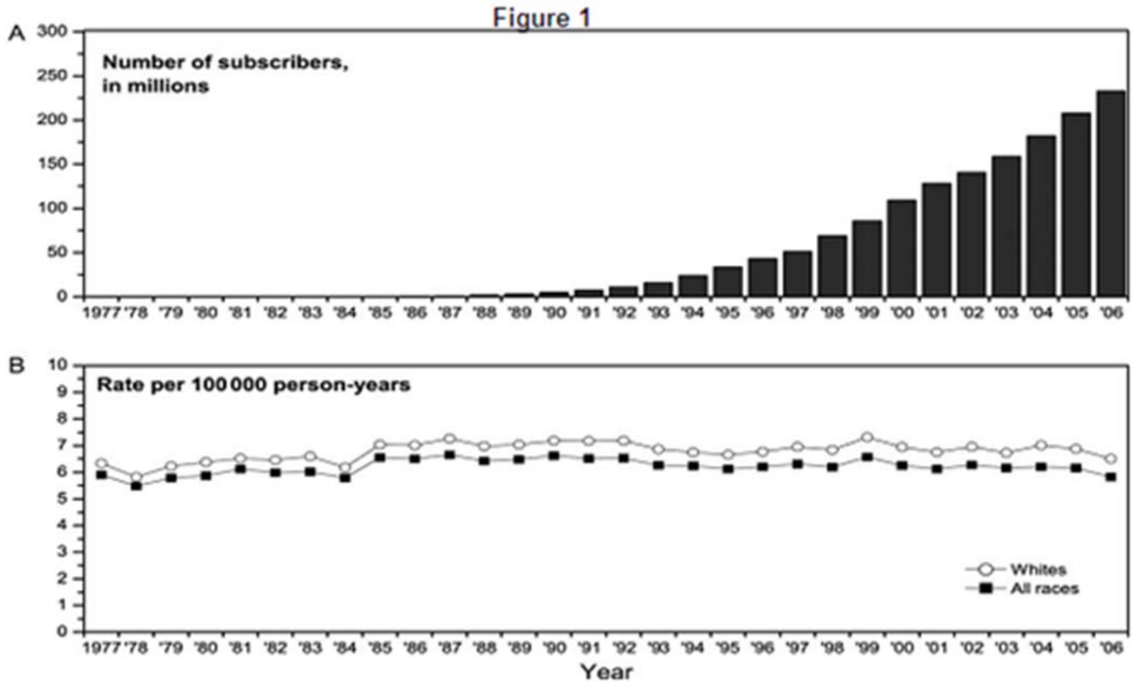
[23] *Id.* (emphasis added) (citing Little MP, Rajaraman P, Curtis RE, et al., *Mobile phone use and glioma risk: comparison of epidemiological study results with incidence trends in the United States*, British Med. J. 2012; 344:e1147). Studies in Denmark, Finland, Norway and Sweden from 1974 through 2008 also reveal no increase in age-adjusted incidence of brain tumors. *Id.* (citing Deltour I, Auvinen A, Feychting M, et al., *Mobile phone use and incidence of glioma in the Nordic countries 1979–2008: consistency check*, Epidemiology 2012; 23(2):301–307).

[24] *See* CTIA Comments at 21-22 (citing P.D. Inskip, Hoover RN, Devesa SS. *Brain cancer incidence trends in relation to cellular telephone use in the United States*, Neuro-Oncology (2010); 12(11):1147–1151).

[25] *See* CTIA Comments at 22 (citing Little).



Indeed, a study comparing actual incidence with rates predicted by those who believe RF emissions can cause brain cancer concluded that actual incidence rates are at least 40 percent lower than such predictions.[26]

If anything, the record indicates that the current standards are conservative. As the *Notice of Inquiry* recognizes, the general population exposure standard includes a fifty-fold safety factor, just as IEEE Standard C95.1-1991 does.[27] As MMF also pointed out, the current standard of 1.6 W/kg averaged over 1 g of tissue is set "well below the threshold for adverse health effects."[28]

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[26] Little MP, Rajaraman P, Curtis RE, et al., *Mobile phone use and glioma risk: comparison of epidemiological study results with incidence trends in the United States*, British Med. J. 2012; 344:e1147.

[27] *See NOI*, ¶ 236; *see also* Comments of International Committee on Electromagnetic Safety to the Institute of Electrical and Electronic Engineering, Inc., ET Docket Nos. 13-84, 03-137, at 4 (Aug. 30, 2013) ("ICES Comments") (explaining the total safety factor of 50 in IEEE C95.1-1991).

[28] MMF Comments at 17.

Consequently, the record reflects a broad and wide-ranging consensus among federal regulatory bodies, their international counterparts, and independent standards-setting organizations.[29] Commenters echoed the Commission's confidence in the current standards.[30] The GSM Association noted that the FCC's confidence in the current exposure limits is "consistent with the conclusions of many other expert reviews."[31] Motorola Solutions stated that the "regime in place since 1996 has facilitated the rapid expansion and development of wireless technology in a manner that experience has demonstrated is *fundamentally safe*."[32] The Commission's confidence in its current exposure standards is thus supported by the record.[33]

B. Although The Record Fully Supports The Current Standard, It Also Suggests That The IEEE and ICNIRP 2.0 W/Kg Standard Reflects The Latest Science

To the extent the record contains support for any change in the exposure standards, it suggests that the international standard of 2.0 W/kg averaged over 10 g of tissue reflects the best available scientific evidence.[34] As the record shows, both ICNIRP and IEEE recommend a

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[29] ANSES, France's regulatory agency for food, environmental and occupational health and safety, recently reviewed studies published since 2009 and was "unable to establish any causal link" between mobile phone use and adverse health effects. *See* ANSES, *ANSES issues recommendations for limiting exposure to radiofrequencies* (Oct. 15, 2013), *available at* http://www.anses.fr/en/content/anses-issues-recommendations-limiting-exposure-radiofrequencies.

[30] *See* Comments of Dr. Mark Douglas, ET Docket Nos. 13-84, 03-137, at 3 (Sept. 3, 2013) ("IT'IS Comments"); Comments on Behalf of Cohen, Dippell & Everist P.C., ET Docket Nos. 13-84, 03-137, at 3 (Sept. 3, 2013) ("Cohen, Dippell & Everist Comments").

[31] GSMA Comments at 1 (citing to GSMA index of reports and statements on the science concerning RF exposure).

[32] Comments of Motorola Solutions, ET Docket Nos. 13-84, 03-137, at 10 (Sept. 3, 2013) ("Motorola Solutions Comments") (emphasis added).

[33] *See* CTIA Comments at 18.

[34] IEEE Standard C95.1-2005 and the 1998 ICNIRP standard (reaffirmed in 2009) both recommend a general population exposure standard of 2.0 W/kg averaged over 10 g of tissue.

general population exposure standard of 2.0 W/kg averaged over 10 g of tissue.[35] International trends show adoption of this standard: more than 115 countries and territories have implemented a general population exposure standard based on it.[36]

The record shows that the international 2.0 standard reflects more recent research than the FCC's current standard of 1.6 W/kg over 1 g of tissue. The FCC adopted its current general population exposure standard in 1996, basing it on 1986 guidelines from the National Council on Radiation Protection and Measurements ("NCRP") and the 1992 ANSI/IEEE C95.1 standard.[37] ICNIRP issued its recommendation on 2.0 in 1998 and the IEEE followed suit in 2005.[38] Consistent with the GAO's conclusion that the FCC's current RF emission standard "may not reflect the latest evidence on the thermal effects of RF energy exposure,"[39] the latest IEEE and

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See ICES Comments at 3 (explaining that the 2005 IEEE standard is consistent with ICNIRP's 1998 recommendation).

35 *See id.* at 3 (explaining that the 2005 IEEE standard is consistent with ICNIRP's 1998 recommendation); CTIA Comments at 30 (stating IEEE's adoption of 2.0 W/kg in 2005 brought it into harmony with ICNIRP's 1998 recommendation of 2.0). The Commission recognizes that the IEEE and ICNIRP standards are not identical in that they differ in how they model the 10 grams of tissue. *See NOI*, ¶ 220. For ease of reference in these Reply Comments, CTIA will refer to both standards as the "international standard."

36 *See* MMF Comments at 16; CTIA Comments at 30; ICES Comments at 7; *see also* TIA Comments at 4. As MMF notes, only nine countries, including the United States, follow the 1.6 W/kg standard for mobile devices. MMF Comments at 5. Thus, while other countries may look to the United States as a leader in telecommunications and technology, it is behind the international trend on this specific issue.

37 CTIA Comments at 5.

38 *Id.* at 30.

39 GAO Report at 27. Several commenters, including the City of San Francisco, have pointed to this GAO statement to argue for the adoption of stricter exposure limits. *See* Reply Comments of the City of San Francisco, ET Docket Nos. 13-84, 03-137, at 3-4 (Nov. 1, 2013) ("San Fransisco Reply Comments"); *see also* Comments of National Association of Telecommunications Officers and Advisors, ET Docket Nos. 13-84, 03-137, at 2 (Sept. 3, 2013) ("NATOA Comments"). This misstates the findings of the GAO Report. The Report does not advocate making the current federal standards stricter. Rather, the GAO Report concludes that

ICNIRP standards are based on improved and updated research.[40] ICES explained that the IEEE adopted the 2.0 standard following an "extensive review of the latest scientific literature"[41] by a broad-ranging committee of experts that included representatives of the federal RF Interagency Working Group.[42] MMF further noted the 2.0 standard is based on a "significantly improved understanding of RF and thermal dosimetry."[43] Thus, while the scientific consensus continues to support the FCC's current exposure standards as adequately protective of consumers, the prevalent international standard incorporates more recent available scientific evidence.[44]

The 2.0 standard incorporates its own fifty-fold safety factor, as does the current Commission standard, resulting in a conservative framework that appropriately protects the general public. Industry stakeholders also asserted that harmonization with the international standard might benefit the public.[45] MMF gave several reasons why. First, harmonization is consistent with federal policy, as both Congress and the Office of Management and Budget have

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"significantly improved RF research" led to the adoption of the *less restrictive* international 2.0 standard, and may support harmonization of U.S. regulations with that standard. *See* GAO Report at 19; *see also id.* at 17-18 (discussing the IEEE's updated 2.0 recommendation).

40 *See* GAO Report at 27.

41 ICES Comments at 3.

42 *Id.* at 2 n.8; *see also* Motorola Solutions Comments at 10-11 (stating that IEEE C95.1-2005 "was developed in a multi-stakeholder approach, with the active participation of" the FCC, the FDA, OSHA, and NIOSH); Comments of Joe A. Elder, ET Docket Nos. 13-84, 03-137, at 2 (Aug. 31, 2013) ("Elder Comments") (noting participation of federal officials in the development of the 2005 IEEE RF standard).

43 MMF Comments at 27.

44 *See* CTIA Comments at 29; Motorola Solutions Comments at 12 ("IEEE C95.1-2005 contains the most current, research-based findings").

45 *See, e.g.,* Comments of CEA Association, ET Docket No. 13-84, 03-137 , at 6 (Sept. 3, 2013) ("CEA Comments") (supporting harmonization); Comments of Wi-Fi Alliance, ET Docket Nos. 13-84, 03-137, at 4 (Sept. 3, 2013) ("Wi-Fi Alliance Comments") (supporting harmonization).

directed federal agencies to use standards developed by voluntary consensus organizations.[46] Second, harmonization with the international standard would improve coverage and quality of service for customers in rural areas and regions with limited coverage.[47] Third, improved coverage and greater network capacity resulting from harmonization will translate to a better wireless experience for consumers.[48] Harmonization with the international standard could lead to streamlined device manufacturing, promoting market efficiencies.

The record thus confirms the current standards as adequately protective of consumers and suggests that harmonization to the international standard is also consistent with the latest scientific evidence and the public interest.

C. The Scientific Consensus Does Not Support A More Restrictive Exposure Standard.

Notwithstanding the global scientific consensus, some commenters urge the Commission to adopt a more restrictive standard for general population exposure.[49] As shown by the record supporting the current FCC standard and the international 2.0 standard, such arguments contradict the prevailing scientific wisdom. Adopting a more restrictive standard would be bad policy. Calls for a more restrictive exposure standard are largely based on the so-called "precautionary principle"[50] and outlier studies criticized by government agencies and other

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46 MMF Comments at 35.

47 *Id.* at 38.

48 *Id.* at 41.

49 *See, e.g.*, Comments of Cindy Sage and David Carpenter, ET Docket Nos. 13-84, 03-137 (Aug. 27, 2013) ("Sage and Carpenter Comments"); Comments of Blake Levitt and Henry Lai, ET Docket No. 13-84, 03-137 (Aug. 26, 2013) ("Lai and Levitt Comments"); Comments of Environmental Working Group, Docket Nos. 13-84, 03-137, at 2-7 (Sept. 3, 2013) ("EWG Comments").

50 *See, e.g.*, Sage and Carpenter Comments at 6 (calling on FCC to regulate based on the precautionary principle); Comments of Paul Dart, ET Docket No. 13-84, 03-137, at 1 (Sept. 1,

reputable entities.[51] These proposals rely on theories that the Commission has previously considered and rightly rejected, and on which the scientific consensus has not changed since the Commission first adopted its exposure standards. Supporters of a more restrictive standard thus have failed to present new or credible theories that could justify a reversal of the Commission's past approach to RF exposure regulation.

Proposals for Commission adoption of a more restrictive standard rely on theories of harm that the FCC and federal health and safety agencies have long deemed not credible. For example, some commenters called on the FCC to adopt a more restrictive standard due to alleged "non-thermal" effects of RF emissions.[52] However, the organizations that promulgated the two standards upon which the current FCC standard is based, the ANSI/IEEE and the NCRP, both considered "non-thermal effects" before releasing their original recommendations and found no reliable, scientific evidence of such effects.[53] When crafting the current exposure standards, the Commission independently examined this issue and determined that the scientific literature did

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2013) ("Dart Comments") (same). *See* Section III, *infra*, for further discussion of the precautionary principle.

51 *See* CTIA Comments at 23.

52 *See, e.g.*, Sage and Carpenter Comments at 3; Comments of Ellen K. Marks, ET Docket Nos. 13-84, 03-137 at 2-3 (Sept. 2, 2013) ("Marks Comments"); Kelley Comments at 3, 5; Comments of EMRadiation Policy Institute, ET Docket Nos. 13-84, 03-137, at 18-22 (Aug. 30, 2013) ("EMPRI Comments"). Proponents of "non-thermal" effects generally believe that RF emissions cause adverse health effects below the threshold at which tissue heating from RF exposure is observed. *See* EMPRI Comments, ¶¶ 66-69.

53 *See* CTIA Comments at 13-14 (citing *Cellular Phone Taskforce v. FCC*, 205 F.3d 82, 91 (2d Cir. 2000)).

not support the existence of "non-thermal" effects.[54] Two federal Courts of Appeals upheld the Commission's judgment on this issue.[55]

Nor has the scientific consensus on "non-thermal" effects changed in the intervening years. Though proponents of the BioInitiative Report call on the FCC to reject the "thermal" model upon which the 1.6 W/kg and 2.0 W/kg standards are based,[56] Motorola Solutions pointed out that the thermal model adequately protects against thermal effects, which are the only known potential adverse health effects of RF emissions.[57] Leading reviews of the recent scientific literature agree, despite some commenters' assertions otherwise.[58] In its 2012 review of available scientific research, the GAO noted scientists' failure to replicate studies that purportedly establish DNA breakage from RF energy exposure below the threshold for tissue-heating.[59] Furthermore, as Ellen Marks notes in her comments, GAO specifically considered the theory of "non-thermal" effects and still concluded that scientific research to date does not demonstrate adverse health effects from mobile phone emissions.[60] The recently published IARC Monograph also reviewed the entire body of scientific literature on health effects of RF

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54 *See* CTIA Comments at 12 (citing In re Procedures for Reviewing Requests for Relief from State and Local Regulations, 12 FCC Rcd. 13494, ¶¶ 26-28, 31 (1997) ("*RF Order II*")).

55 *See EMR Network v. FCC*, 391 F.3d 269 (D.C. Cir. 2004) (upholding Commission's dismissal of petition for review of RF guidelines based on purported need to address non-thermal effects from mobile phone emissions); *Cellular Phone Taskforce*, 205 F.3d at 82 (upholding Commission's decision against tightening its RF exposure limits to account for non-thermal effects).

56 *See, e.g.*, Sage and Carpenter Comments at 5-6.

57 *See* Motorola Solutions Comments at 11.

58 *See* Sage and Carpenter Comments at 3 (asserting that "[t]he scientific evidence for health harm in 2012 is stronger and more consistent than in 2007[.]").

59 GAO Report at 10-11.

60 *See* Marks Comments at 3 (noting Marks met with the GAO to discuss non-thermal effects); GAO Report at 8.

emissions and concluded that tissue-heating remains the "best established mechanism for RF radiation-induced effects in biological systems."[61] Nor did IARC's classification of RF as a 2B agent change the scientific consensus with respect to non-thermal effects or the overall assessment of RF emissions.[62] After IARC released its classification, the FDA reiterated its conclusion that "the weight of scientific evidence does not show an association between exposure to radiofrequency from cell phones and adverse health outcomes."[63]

Another discredited theory put forth by proponents of a more restrictive standard is the notion that the current standard is not adequate to protect children or "hypersensitive" individuals.[64] As CTIA previously noted, the Commission previously considered and rejected

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[61] *See* International Agency for Research on Cancer, Monograph, Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields, Vol. 102 at 104 (2013) ("IARC Monograph") (acknowledging that the 2B classification was based on weak mechanistic evidence); *see also id.* at 360 (finding studies reporting alterations in gene/protein expression under non-thermal exposure conditions were "typically in single, usually unreplicated experiments, or under experimental conditions with methodological shortcomings"); *id.* at 369 (noting the Working Group concluded that "despite consistent results from one laboratory, the experimental evidence did not support the notion that non-thermal RF radiation affects the permeability of the blood–brain barrier").

[62] CTIA Comments at 25 (noting IARC classification did not represent a sea change). Contrary to Dr. Sage and Dr. Carpenter's assertion, the FCC has not "ignored" the IARC's classification of RF emissions as a 2B agent. *See* Sage and Carpenter Comments at 6. The FCC is aware of the IARC classification, *see NOI*, ¶ 219, and makes information available about it on its website, *see* FCC, *Radio Frequency Safety*, *available at* http://transition.fcc.gov/oet/rfsafety/highlights.html.

[63] FDA, Current Research Results, *available at* http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116335.htm.

[64] *See, e.g.*, Comments of American Academy of Pediatrics, ET Docket Nos. 13-84, 03-137 (Aug. 29, 2013) ("AAP Comments"); Comments of American Association for Justice, ET Docket Nos. 13-84, 03-137, at 4 (Sept. 3, 2013) ("AAJ Comments"); EWG Comments at 2-7; Comments of Pong Research Corp., ET Docket Nos. 13-84, 03-137, at 6, 8-10 (Sept. 1, 2013) ("Pong Comments"); Dart Comments at 1; San Francisco Reply Comments at 5.

claims that its RF emission standards do not adequately protect such individuals.[65] And as MMF, CTIA and TIA pointed out in their comments, the scientific consensus on this issue, particularly with respect to children, has not changed.[66] GAO's review found that studies by the UK Health Protection Agency and CEFALO, which both included children, did not find a relationship between mobile phone use and brain tumor risk.[67] The IEEE states that its exposure standards are "intended to apply to all people,"[68] including children and sensitive members of the public. And the FCC, the FDA and the WHO all continue to maintain that the scientific evidence does not demonstrate a causal link between wireless device use and cancer.[69]

In contrast to supporters of a separate exposure standard for children and hypersensitive individuals, who cited few studies, MMF identified several studies specific to children's RF exposure that conclude that children are not at heightened risk.[70] The IARC Monograph also reviewed studies finding that SAR values assessed with SAM provide a "conservative measure of exposure of both adults and children," providing assurance that phones in compliance with

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65 CTIA Comments at 27 (citing *RF Order II*, ¶ 26).

66 *See* MMF Comments at 20 (citing FDA); TIA at 8 (citing FDA); CTIA Comments at 26-28.

67 *See* GAO Report at 7, 9. The Environmental Working Group ("EWG") suggested that the CEFALO study suggests "that increases in brain cancer risk may correspond to duration of cell phone use," EWG Comments at 7, but this "assessment" is at odds with the study's overall conclusion, which found "no relationship between mobile phone use and risk for brain tumors." *See* GAO Report at 9 (citing Aydin 2011).

68 TIA Comments at 8 (citing IEEE 2005 Standard at 20).

69 *See* CTIA Comments at 28 (citing FCC Wireless Devices and Health Concerns factsheet; FDA Children and Cell Phones factsheet); TIA Comments at 8 (citing to the FDA and WHO).

70 *Compare* MMF Comments at 20-26 (citing numerous studies and reviews by international regulatory agencies) *with* American Academy of Pediatrics Comments (no studies cited) and American Association for Justice Comments at 4 (citing just two studies).

existing exposure standards adequately protect children.[71] While noting that "hypersensitive" individuals are concerned about their health, the WHO has termed hypersensitivity to RF a "perceived" phenomenon, noting that "a number of well-conducted laboratory studies show no relation between the health symptoms experienced by some individuals and RF EMF exposure."[72]

Proponents of a more restrictive standard not only flout the scientific consensus and the conclusions of federal health and safety agencies,[73] but also ignore the conservative nature of the current FCC exposure standards.[74] The record shows that the current general population exposure standard's fifty-fold safety factor "accommodates a variety of variables such as different physical characteristics," thus accounting for both adults and children.[75] Moreover, the

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71 IARC Monograph at 74 (citing Christ & Kuster; Martens; Wiart).

72 WHO, Research Agenda on Radiofrequency Fields at 25.

73 *See, e.g.*, CTIA Comments at 10-13.

74 CTIA also notes that any move to a more restrictive exposure standard would adversely impact the emerging market for medical devices by stunting innovation. The current regulatory environment has led to innovative developments in medical technology, and any change in the exposure standards would negatively impact the public health benefits in bringing such devices to market. *See* Comments of Medtronic, Inc., ET Docket Nos. 13-84, 03-137, at 7-8 (Sept. 3, 2013) ("Medtronic Comments"); *see also* CTIA, *mHealth Solutions*, *available at* http://www.ctia.org/advocacy/policy_topics/topic.cfm/TID/59 (explaining that mobile health technologies and applications have "vast potential to improve the delivery of healthcare in America and around the world by strengthening personalized care for patients, lowering costs and reducing errors and removing geographic and economic disparities.").

75 *See* CTIA Comments at 28 (citing *NOI*, ¶ 236); *see also* TIA Comments at 7 (noting fifty-fold safety factor protects all users, including children). The City of San Francisco ignores the conservative nature of the Commission's RF regime, claiming without either support or citation that current exposure standards "leave[] very little safety margin to account for the extra sensitivity of children." San Francisco Reply Comments at 5. This is a proposition that the Commission itself has rejected in the past. Similarly, EWG quarrels with the Commission's failure to include an additional safety factor in the exposure standards for children, *see* EWG Comments at 5, but such a measure is unjustified given the current safety margin's applicability to children.

record shows that both the FCC and FDA view the specific anthropomorphic model (SAM) for mobile phone testing as conservative for both children and adults.[76] As TIA explains, these built-in precautions to the exposure standard and testing protocols obviate the need to adopt additional precautionary measures.[77] Any further revision of the standard to accommodate theories of harm based on "non-thermal effects" or the supposedly unique vulnerability of children or hypersensitive individuals simply would not be supported by the scientific consensus.[78]

Indeed, though proponents of a more restrictive RF exposure standard have offered studies they claim support their theories of harm, they cherry-pick studies and ignore the hundreds of other available studies.[79] For example, some commenters rely on the BioInitiative Report, which has been widely criticized for its misplaced reliance on only a select group of

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[76] *See NOI*, ¶ 219; CTIA Comments at 29 (citing Beard et al., *Comparison of Computed Mobile Phone Induced SAR in the SAM Phantom to that in Anatomically Correct Models of the Head*, 48 IEEE Trans. Electromagn. Compat. 397 (May 2006)).

[77] *See* TIA Comments at 9 (arguing against invocation of the precautionary principle).

[78] For these same reasons, separate smart meter exposure restrictions are not supported by the scientific consensus and are unnecessary. *See* Joint Testimony of William H. Bailey, Ph.D. & Yakov Shkolnikov, Ph.D., Docket No. 2011-00262, at 51 (Maine PUC Sept. 19, 2012) (reviewing the scientific literature regarding smart meters and concluding that the exposure limits in the FCC standard "are protective of public health."). Indeed, the President, Congress, and the FCC have identified smart grids and smart meters as a promising way to advance energy independence and efficiency. *See* CTIA, *Wireless Industry Sustainability*, at 1, *available a*t http://www.ctia.org/advocacy/position_papers/index.cfm/AID/12063. Imposing separate smart meter restrictions would only hinder these important advancements.

[79] The BioInitiative Report has been firmly discredited by the scientific community as "an egregiously slanted review." Kenneth R. Foster & Lorne Trottier, *Picking Cherries in Science: The BioInitiative Report* (Feb. 15, 2013), *available at* http://www.sciencebasedmedicine.org/picking-cherries-in-science-the-bio-initiative-report/ ; *see also* Committee on Man and Radiation, *Expert Reviews on Potential Effects of Radiofrequency Electromagnetic Fields and Comments on the BioInitiative Report*, 97 Health Physics 348-356 (Oct. 2009); Indian Council of Medical Research, Study on Radiation from Mobile Towers and Cell Phones, *available at* http://inbministry.blogspot.com.au/2013/02/study-on-radiation-from-mobile-towers.html.

studies that indicated adverse health effects.[80] In contrast, the leading international standards-setting organizations and federal health and safety organizations have assessed the entire body of scientific research and are in general agreement that there is no link between cell phones and adverse health effects.[81] Several commenters also cited studies that have not been independently replicated or whose methods have been criticized.[82] The record also shows that proponents of a more restrictive RF exposure standard repeatedly cite to one another, precisely because their views are not generally accepted in the scientific community, and—as long-standing outliers, their theories have not shifted the scientific consensus.[83]

III. THE RECORD OFFERS NO SUPPORT FOR STRINGENT, MANDATORY CONSUMER DISCLOSURES OR EXPOSURE REDUCTION POLICIES, AND SHOWS THAT THESE WOULD LIKELY BE COUNTER-PRODUCTIVE.

Because the scientific consensus establishes that RF emissions from mobile phone use do not cause adverse health effects and because the current regulations incorporate a fifty-fold safety factor, there is no basis for the Commission to mandate a consumer warning on RF safety or adopt measures aimed at encouraging consumers to limit their exposure to RF emissions. Among other responsibilities in this field of RF safety regulation, the Commission performs "an

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80 *See* Bailey and Shkolnikov Testimony, *supra* note 78, at 40.

81 *See generally id*.

82 *See* CTIA Comments at 22-23 (explaining criticism of the Hardell studies); EWG Comments at 6 (citing Hardell); Dart Comments (citing Hardell). Drs. Levitt and Lai also cite to Dr. Panagopolous, whose methods were criticized by the IARC Working Group. *See* IARC Monograph at 291 (noting "several shortcomings related to the methods" used by Dr. Panagopolous).

83 For example, Drs. Sage and Carpenter submitted comments urging the Commission to adopt a more restrictive exposure standard, basing their comments on the BioInitiative Report. *See* Sage and Carpenter Comments. Drs. Sage and Carpenters are the editors of the 2012 BioInitiative Report and also participated in the 2007 Report. They worked with Dr. Lai, who also submitted comments in the opening round. *See* Levitt and Lai Comments. The comments by Drs. Levitt and Lai cite to other members of the BioInitiative Report working group: Drs. Belyaev, Liboff and Panagopolous.

education role," ensuring that the general public can access information about RF safety.[84] By making information available to consumers, the Commission promotes consumer awareness without provoking consumer alarm. Indeed, the record developed in response to the *Notice of Inquiry*'s call for comment on these issues demonstrates that the Commission's current efforts with respect to consumer disclosures and exposure reduction are not only consistent with the science, but prudent with respect to public policy and the state of the law.

A. <u>The Record Demonstrates That Stringent, Mandatory Consumer Disclosures In This Context Are Unnecessary and Impractical.</u>

The *Notice of Inquiry*'s request for comment on additional consumer information about RF exposure and the potential required disclosure of SAR information[85] has resulted in a record that shows why imposing stringent, mandatory disclosures is both unnecessary and impractical. First, the record shows that because federal authorities believe that FCC-compliant devices do not pose a health risk, any adoption of a mandatory RF "warning" is unnecessary. Second, the record shows that a mandatory RF disclosure would raise practical problems and legal concerns. Proposals supporting such a disclosure are either vague or inconsistent with each other, showing the difficulty of crafting a warning that would satisfy those who disagree with the scientific consensus. Furthermore, against this backdrop, mandatory warnings, whether promulgated by the Commission or state and local entities, would implicate important First Amendment issues.

The record shows that a wide variety of information on the issue of mobile phone use and RF emissions is available to consumers.[86] The FCC, the FDA and other federal authorities

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84 CEA Comments at 6.

85 *NOI*, ¶¶ 231, 234.

86 *See* CEA Comments at 6-7 (noting the FCC provides a wide variety of information and acts in an educational role); IT'IS Comments at 4 (stating FCC provides "balanced and scientifically sound information"); Nokia Comments at 14-15 (explaining SAR Tick); MMF

provide information via their websites. Industry stakeholders voluntarily provide information from the FCC, FDA and other RF resources in their own voices, through device manuals, websites and even device software. Despite the diversity of information available, the underlying message is the same: federal authorities believe the scientific evidence does not demonstrate that wireless phone use causes cancer or other health problems.[87]

In light of the reigning scientific consensus, several commenters agreed with CTIA that mandatory disclosures are not necessary.[88] And as the record shows, the Commission's voluntary approach to consumer disclosures avoids inciting unnecessary and unjustified consumer alarm.[89] Indeed, given the public's sensitivity to warnings about cancer, a departure from the status quo would likely cause consumer alarm disproportionate to any "risk" that RF emissions pose to consumers.[90]

Comments at 48 (noting information available from the FCC, the FDA, manufacturer websites, user manuals, and trade associations like MMF, GSMA and CTIA).

87 *See also* MMF Comments at 43-45 (discussing SAR Tick); Nokia Comments at 14-15.

88 *See also* CEA Comments at 7-8 (stating that mandatory SAR disclosure would likely cause consumer confusion); Motorola Solutions Comments at 15 ("[t]he Commission should not adopt new disclosure requirements that would provide no new useful information to consumers"); TIA Comments at 13 (stating there is no scientific justification for mandating consumer information on RF exposure).

89 *See* TIA Comments at 19 (noting "precautionary information is uncalled for and runs counter to the confidence" consumers should have in FCC-approved technology); Motorola Solutions Comments at 14 (noting new precautionary measures could confuse consumers and raise unwarranted concern); CTIA Comments at 41-43 (recognizing the dangers of over-warnings and that, in light of the public's sensitivity to cancer warnings, such warnings must be reserved for known dangers).

90 *See* TIA Comments at 16 (noting an FCC recommendation on reducing RF exposure runs the risk of consumers developing the unfounded belief that they should be concerned about RF emissions and that they need to reduce their exposure to be safe); Testimony of the Maine Center for Disease Control & Prevention, Maine Dep't of Health & Human Servs. in Opposition to LD 1706, *An Act to Create the Children's Wireless Protection Act* (Mar. 2, 2010) (explaining that it is inappropriate to warn consumers about an ill-defined risk when there is no consensus on what to do with the warning).

The record shows not only that there is there no need for mandatory disclosures, but also that adopting such a disclosure would raise significant practical and legal issues for the Commission. First, many proposals supporting the FCC's adoption of a mandatory RF disclosure are vague and do not explain how they would better serve consumers than the Commission's current information offerings. For example, Drs. Sage and Carpenter called on the Commission to adopt specific language endorsing the precautionary principle,[91] but as CTIA explained in its opening comments and as further discussed below, the precautionary principle itself is vague and amorphous, and thus unlikely to help consumers.[92] It is not clear what these commenters would have the Commission adopt. The American Academy of Pediatricians called on the Commission to develop "standards that provide consumers with the information they need to make informed choices,"[93] but did not explain how the information already available to consumers on RF emissions hinders consumers from doing so. Similarly, Dr. Paul Dart urged the Commission to adopt "appropriate precautionary warning language" by a hypothetical EPA Working Group,[94] neglecting to explain how the Commission's current information offerings, which are consistent with the scientific consensus, are not appropriate for consumers.[95]

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91 Sage and Carpenter Comments at 6.

92 *See* Section III.B, *infra*.

93 AAP Comments at 2.

94 Dart Comments at 1.

95 Pong Research called on the FCC to actively inform consumers that the science is "inconclusive," Pong Research Comments at 35, a conclusion that implies greater uncertainty in the scientific literature than currently exists. While the FCC notes that "studies are ongoing," it can and has confidently concluded that "there is no scientific evidence to date that proves that wireless phone usage can lead to cancer[.]" *See* OET, *RF Safety FAQs, available at* http://transition.fcc.gov/oet/rfsafety/rf-faqs.html. In a similar vein to Pong Research, the Environmental Working Group calls on the FCC to acknowledge adverse health effects associated with mobile phone use, which would directly contradict the scientific consensus. *See*

Second, many of the proposals offered are inconsistent with one another, demonstrating the near impossibility of creating a single, uniform RF "safety" disclosure that would satisfy those who disagree with the scientific consensus. While a number of commenters agreed with the Commission's assessment of SAR as a metric of limited utility,[96] other commenters called on the Commission to promulgate SAR-based disclosures.[97] Some even called on the Commission to discard SAR values and formulate new metrics.[98] Others expressed support for a labeling requirement with more general information about separation distance and usage.[99] The cacophony in the record shows the absence of an immediate, identified concern.

Third, as CTIA explained in its opening comments, government-mandated advisories or warnings on RF emissions would implicate important First Amendment issues.[100] Given the

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EWG Comments at 15. The FCC should reject suggestions that it promote alarmist or confusing characterizations of the state of the science.

96 *See, e.g.*, EWG Comments at 11-12; San Francisco Reply Comments at 9; CEA Comments at 7-8; CTIA Comments at 43-44; MMF Comments at 49 (noting SAR cannot be viewed as a relative safety indicator). Consumers for Safe Cell Phones went so far as to say that "SAR is a meaningless value for consumers to be made aware of the potential risks of exposure to microwave radiating devices." CSCP Comments, ¶ 234.

97 *See, e.g.*, EMF Comments at 9 (advocating for SAR values to be posted on the FCC website and at the point of sale); EMRPI Comments at 37 (recommending that SAR be posted on an FDA website and on labels for devices); City of Portland Comments at 6 (calling for a standardized SAR-based disclosure to be widely disseminated and publicized through manuals, point-of-sale and website postings); Comments of Grassroots Environmental Education o/b/o Dr. Gandhi, ET Docket No. 13-84, 03-137, at ¶ 2 (Sept. 3, 2013) ("Grassroots Comments") (calling for SAR disclosure at point of sale or on the cell phone itself); Comments of Devra Lee Davis, ET Docket Nos. 13-84, 03-137, at ¶ 8 (Sept. 3, 2013) ("Davis Comments").

98 EWG Comments at 14; Pong Research Comments at 33-34; San Francisco Reply Comments at 9.

99 *See, e.g.*, CSCP Comments, ¶ 233; Comments of Green Swan, ET Docket No. 13-84, 03-137, at 2 (Sept. 3, 2013) ("Green Swan Comments").

100 The City of San Francisco's discussion of First Amendment issues that it litigated and lost before the Ninth Circuit confirms the complexity of the issues that the Commission would face in developing a meaningful consumer disclosure, particularly where, as here, there is simply

scientific consensus and the fifty-fold safety factor, the Commission cannot demonstrate that the "harms" of mobile phone use are real and that an RF warning would "alleviate them to a material degree."[101] Here, the alleged harms that supporters urge the Commission to address through a warning are illusory,[102] and based on opinion instead of fact.[103] TIA agreed that a mandatory warning would be difficult to reconcile with the First Amendment, stating that in the absence of scientific harm to consumers, the Commission has no basis for compelling companies to provide precautionary information.[104]

Thus, the record confirms the prudence of the Commission's current approach toward consumer disclosures. The Commission's accurate portrayal of the scientific consensus, coupled with voluntary disclosures by industry stakeholders, advances consumer awareness without inciting unnecessary alarm. This approach also avoids the practical and constitutional concerns that a mandatory warning would surely raise.

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no evidence of harm that would be remedied by a mandatory warning. *See* San Francisco Reply Comments at 10-12. San Francisco implicitly acknowledges that any disclosure requirement would have to be backed by scientific evidence. *See id.* at 11, 12. However, its reply comments rely solely on EWG for its claims about "the current scientific research," and do not attempt to address the scientific evidence submitted in this proceeding by CTIA, MMF, the IEEE and other parties.

[101] *See Edenfield v. Fane*, 507 U.S. 761, 770-71 (1993). To do so, as even proponents of a disclosure admit, the Commission would first have to identify some actual alleged "harms" that a warning would address. *See* San Francisco Reply Comments at 10-12. To do so would constitute a direct reversal of the Commission's expressed confidence in its current RF regime, and such a reversal is clearly not supported by the evidence in this record.

[102] *See* CTIA Comments at 45; *see also* Lars Noah, *The Imperative to Warn: Disentangling the "Right to Know" From the "Need to Know" about Consumer Product Hazards*, 11 Yale J. on Reg. 293, 296 (1994) (explaining that the overuse of warnings can cause consumers to ignore them altogether).

[103] *See CTIA – The Wireless Ass'n v. The City and Cnty. Of San Fransisco*, 827 F. Supp. 2d 1054, 1060 (N.D. Cal. 2011), *aff'd* 494 F. App'x 752, 753 (9th Cir. 2012).

[104] *See* TIA Comments at 20; *see also CTIA*, 494 F. App'x at 753 (9th Cir. 2012) (affirming preliminary injunction against City ordinance and factsheet mandating warnings about RF).

B. The Record Shows That Formal Adoption or Endorsement of Exposure Reduction Policies Would Be Inconsistent With the Commission's Regulatory Mandate.

In addition to counseling against adoption of mandatory RF disclosures, the record also counsels against the Commission's formal adoption or endorsement of exposure reduction policies. The record shows that it would be improper for the Commission to pursue such measures, "hortatory" or otherwise,[105] to limit risks that are at best unknown or only possible.[106]

The *Notice of Inquiry* itself expressed uncertainty about whether adoption or endorsement of further exposure reduction policies was necessary,[107] and the record confirms the Commission's instinct. As the *Notice of Inquiry* makes plain (and as commenters also noted), consumers already have access to information about exposure reduction measures—time and distance—that address thermal effects from RF emissions.[108] Furthermore, the fifty-fold safety factor provides a "substantial margin between the exposure limits and the level where any health effects have been observed."[109] And as the record shows, the evolution of wireless devices has resulted in a natural downward progression of RF emissions.[110] Thus, the Commission's current position and policies with respect to exposure reduction continue to be appropriate.[111]

Nevertheless, the *Notice of Inquiry* sought comment on the possibility that other "precautionary measures" unrelated to reducing SAR "could possibly reduce potential risk,

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105 *NOI*, ¶ 242.

106 *Id.*, ¶ 237 (noting that "risks have not been established by scientific research"); ¶ 240 (noting that "extra precautions" may be "fundamentally qualitative" in the absence of "any known, underlying mechanism for harm").

107 *Id.*, ¶ 243 (indicating that the Commission might not pursue "further action" in this area).

108 *Id.*, ¶ 233; *see also* CTIA Comments at 46; TIA Comments at 16.

109 TIA Comments at 9; *see also NOI*, ¶ 236.

110 TIA Comments at 20-22; *see also* IARC Monograph at 406.

111 *NOI*, ¶ 242.

without necessarily assuming that such risks are known."[112] Federal agencies do not regulate in response to assumed or unknown risks.[113] The inherent difficulty in crafting exposure reduction measures to address unknown risks is readily apparent. The wide-ranging proposals in the record confirm the flaws in this approach. Proposals run the gamut: proposals to adopt "precautionary measures,"[114] recommendations for children and pregnant women to avoid exposure to wireless devices entirely,[115] and the proposed removal of wireless devices and equipment from all public buildings,[116] to name a few. These vague proposals do not provide a basis for the Commission to take regulatory action.[117]

Moreover, such proposals are predicated on fundamental dissatisfaction with the existing RF standards and the scientific consensus.[118] Thus, through exposure reduction policies, proponents seek a "back-door" revision of the Commission's exposure standards. Accordingly, there is no limiting principle on the potential precautionary measures that proponents would have the Commission adopt. But the Commission's regulatory mandate in this arena imposes its own

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112 *Id.*, ¶ 241 (emphasis added).

113 Indeed, the Commission's statutory mandate compels striking a balance between the "need to protect the public and workers" and "the requirement that industry be allowed to provide telecommunications services to the public in the most efficient and practical manner possible." *Cellular Phone Task Force v. FCC*, 205 F.3d 82, 90-92 (2d Cir. 2000).

114 For example, Drs. Sage and Carpenter argue that "new precautionary measures" are needed, but do not specify what form such measures would take. *See* Sage and Carpenter Comments at 4, 6. Weaver calls on the FCC to "'endorse' common sense precautionary measures." Comments of Kit Weaver, ET Docket Nos. 13-84, 03-137, at 20 (Sept. 3, 2013) ("Weaver Comments").

115 Comments of Dianne Wilkins, ET Docket Nos. 13-84, 03-137, at 15 (Sept. 3, 2013) ("Wilkins Comments").

116 *Id.* at 15.

117 *See NOI*, ¶¶ 240-41.

118 *See, e.g.*, Sage and Carpenter Comments at 4, 6 (suggesting "new precautionary measures are needed in the interim while new safety standards are developed").

limit: the Commission must balance public safety with the goal of fostering wireless deployment.[119] Or, in other words, it must adequately protect the public without unduly limiting the public's ability to use and enjoy mobile devices.[120] As CTIA noted, the Commission's adoption of precautionary measures addressing unknown risks would imperil this balance and constitute the height of arbitrary and capricious agency action.[121]

Some commenters argue that the Commission should adopt exposure reduction policies on the basis of the "precautionary principle."[122] Yet such calls ignore the precautionary principle's infirmities.[123] Commenters have not offered a coherent vision of how the precautionary principle would be implemented, an ambiguity that is likely traceable to the fact that there is no one definition of the concept.[124] Furthermore, there is increasing recognition of the precautionary principle's political nature and, consequently, its arbitrary application.[125]

[119] *RF Order II*, ¶ 29.

[120] *NOI*, ¶ 209.

[121] CTIA Comments at 49-50.

[122] *See* Sage and Carpenter Comments at 6.

[123] *See, e.g.*, Cass R. Sunstein, *Safe and Sorry*, Forbes (Jul. 5, 2004), *available at* http://www.forbes.com/forbes/2004/0705/048.html ("The Precautionary Principle has a lot of intuitive appeal . . . But the problem is that while promising safety, it can be both dangerous and incoherent. Risks are on all sides of social situations, and regulation itself creates risks. Because risks are everywhere, the Precautionary Principle forbids action, inaction and everything in between. It is therefore paralyzing; it bans the very steps that it mandates.").

[124] *See* CTIA Comments at 49 n.226 (citing Cass R. Sunstein, Beyond the Precautionary Principle, 151 U. Pa. L. Rev. 1003, 1004 (2003) (identifying four primary types of the precautionary principle)).

[125] *See* CTIA Comments at 48; CAST, *Impact of the Precautionary Principle on Feeding Current and Future Generations*, Vol. 52, at 6 (Jun. 2013" ("CAST Issue Paper").

Governments abroad are actually distancing themselves from the concept due to its arbitrary nature and uneven implementation.[126]

Furthermore, policymakers are increasingly aware of the precautionary principle's adverse impacts. Because the precautionary principle boils down to the concept of "better safe than sorry" even where there is no reliable science supporting a need for precautionary measures, it suppresses innovation,[127] an integral characteristic of the wireless industry's meteoric growth and success.[128] Here, introducing the precautionary principle to justify further exposure reduction measures would wreak the same havoc and then some. Innovation in the wireless industry has actually reduced RF emissions;[129] thus, the Commission's endorsement of exposure reduction in the name of the precautionary principle could paradoxically stunt this natural evolution. Should the Commission adopt some of the more extreme proposals advanced in the record, it would actively discourage use of wireless phones for large sectors of the population, thereby threatening its own public safety initiatives.[130]

IV. THE RECORD DOES NOT SUPPORT A CHANGE IN CURRENT TESTING PROTOCOLS.

The record compiled in response to the *Notice of Inquiry*'s request for comment on compliance evaluation, proximity restrictions and disclosure requirements regarding mobile

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126 *See id.* at 4 (noting the EU has moderated its application of the precautionary principle); *id*. at 5 (noting France and Italy's attempt to regulate genetically-modified food products on the basis of the precautionary principle were rejected by the European Court of Justice in 2012).

127 *See* CAST Issue Paper at 7-8; (noting the precautionary principle may suppress innovation and "do more harm than good by placing an impossible or highly burdensome impediment in the pathway of the development of new technologies").

128 *See* CTIA Comments at 7-8.

129 TIA Comments at 20-22; IARC Monograph at 406.

130 *See* CTIA Comments at 50.

device testing shows that no change in existing testing protocols is warranted.[131] A number of commenters agreed that the Commission's current testing guidelines are sufficient to assure consumer safety, pointing to the safety margin built in to the existing exposure standards and the conservative nature of the specific anthropomorphic model ("SAM").[132] Nokia noted that the Commission's compliance framework is very conservative, due to the conservative nature of SAM and the fact that devices are tested at maximum power, a reality that is rarely experienced by consumers due to adaptive power control.[133] TIA pointed out that the safety margin renders the testing guidelines into a "compliance threshold and not a safety level beyond that which a consumer is at risk."[134] Indeed, SAM is the only scientifically defensible and time-tested evaluation method. Treating SAM as a safe harbor for compliance has provided predictability to industry, and the scientific consensus establishing FCC-compliant devices as adequately protective of consumers demonstrates that the industry's reliance on SAM has not threatened consumer safety in any way. Accordingly, the Commission should continue to treat SAM as a safe harbor.[135]

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131 *See NOI*, ¶¶ 245, 248-52. Some commenters take issue with the Commission's treatment of the pinna as an extremity, but such calls are misplaced. *See* Sage and Carpenter Comments at 5-6; Grassroots/Gandhi at 2; Davis Comments at 4-5; Levitt and Lai Comments at 12-13. The FCC determined in its Order that the pinna would be subject to the same RF exposure standard applicable to hands, wrists, feet and ankles. *RF Order II*, ¶ 44. Challenges to that determination are properly raised in petitions for reconsideration, but the period to file such petitions ended in July 2013.

132 CEA Comments at 12; TIA Comments at 25; Nokia Comments at 11-13; MMF Comments at 7.

133 Nokia Comments at 11-13.

134 TIA Comments at 25.

135 CTIA Comments at 53.

Some commenters argue for a "zero-spacing" testing protocol,[136] which the Commission cannot adopt in isolation. CEA highlighted the Commission's own observation that "there is no evidence that body-worn devices without enforced separation from the body 'pose[] any significant health risk.'"[137] Given the lack of evidence, CTIA agrees with CEA that "there is no apparent need for testing to be conducted at reduced separation distances."[138] Furthermore, as noted above, the conservative nature of the exposure standards and the testing protocols makes a "zero-spacing" testing protocol unnecessary, as there are sufficient precautions already built in to applicable regulations.[139]

More to the point, however, is the fact that proponents of revising the testing protocol in the name of "typical" consumer usage[140] advance a simplistic view of what "typical" use entails. These commenters ignore the fact that while some aspects of the current testing model seemingly bear little resemblance to "real world" use, such features are designed to compensate for the vagaries of individual use. As the record shows, phones are consistently tested at maximum power but are not consistently operated at maximum power.[141] Furthermore, the Commission

136 *See, e.g.*, Sage and Carpenter Comments at 6; Levitt and Lai Comments at 12; CSCP Comments at 5; Pong Research Comments at 15-16.

137 CEA Comments at 11 (citing *NOI*, ¶ 251).

138 *Id.*

139 Some commenters suggest that zero-spacing protocols are necessary because industry's disclosures on separation distance are inadequate and confusing. But they fundamentally misunderstand the purpose of such disclosures, which are not a safety instruction to consumers, but a testing compliance standard followed by manufacturers. As noted above, there is no evidence that use within the minimum separation distance poses a safety risk to consumers. Elevating separation distance disclosures thus risks unnecessary consumer confusion and alarm.

140 *See, e.g.*, Marks Comments at 2 ("Currently your standards do not protect consumers from normal use"); San Francisco Reply Comments at 6-7 (calling on the FCC to update standards and testing guidelines to reflect "actual use patterns").

141 *See* MMF Comments at 7, Nokia Comments at 17; EWG Comments at 14.

currently tests mobile phones with all wireless radios operating at full capacity even though often only 1-2 radios operate at a given time during "normal" use. Finally, as several commenters recognized, today's consumers often use their mobile devices with accessories and cases sold by third parties, not manufacturers.[142] To test devices with such third-party accessories would be impractical and inefficient. As MMF noted, current testing protocols in the U.S. already lead to market delays.[143] To burden manufacturers with the responsibility of testing devices with third-party accessories would only exacerbate the problem.

As CEA recognized, no testing regime can account for every facet of "typical" usage.[144] It is seemingly impossible for the FCC to design a testing protocol that polices the whole universe of "typical" consumer usage. Any revision of the testing protocols must therefore be carefully weighed against the FCC's mandate to balance safety with an efficient deployment of wireless service. But given the absence of scientific evidence calling for a change in the testing protocols and the conservative nature of the existing regime, the record shows that any modification of the testing protocols may hinder efficiency and competition without any corresponding benefit to consumer safety.

Any attempt to replicate consumer usage more accurately would require an extensive, fact-intensive record that could prove administratively burdensome—if not impossible—to develop. The blunt instrument of a Commission rulemaking would be ill-suited to the nuance that such an endeavor would require. At minimum, the myriad issues raised by the current

142 Motorola Solutions Comments at 16; EWG Comments at 9.

143 MMF Comments at 68.

144 CEA Comments at 12.

record on testing demonstrates that OET is best equipped to implement any adjustment of RF testing protocols, as its capacity for flexibility is better suited to such a task.

V. THE FURTHER NOTICE'S PROPOSED EXEMPTION CRITERIA COULD UNNECESSARILY ELIMINATE THE CATEGORICAL EXEMPTION FOR MANY SMALL CELL SITES.

CTIA wishes to comment on one aspect of the *Further Notice*, in which the FCC proposes to streamline "the determination of whether preparation of a routine RF evaluation is necessary,"[145] and to do so in a way that "appropriately protect[s] the public without imposing an undue burden on industry."[146] These proposals reflect the Commission's long-standing goal in this proceeding of balancing public safety with an efficient deployment of wireless service.[147] Any changes the Commission makes to its rules and guidance for site evaluation at transmitter sites thus should be practical to implement and designed to actually result in a more safe and effective environment.

Here, however, the *Further Notice* proposes to revise the exemption criteria for single transmitters in a way that could eliminate categorical exclusions for an important type of network infrastructure: small cell sites.[148] CTIA agrees with observations in the record that the Commission's proposed formula for exempting single transmitters is too strict and will subject a number of small cell and distributed antenna system (DAS) transmitters to routine environmental evaluation.[149] As CTIA wrote in its opening comments, demand for wireless services has

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145 *FNPRM*, ¶ 108.

146 *Id.*, ¶ 109.

147 *See, e.g.*, *RF Order II*, ¶ 2.

148 *See FNPRM*, ¶¶ 128-38; Appendix C to FNPRM.

149 *See* Comments of Verizon and Verizon Wireless, ET Docket Nos. 13-84, 03-137, at 3-5 (Sept. 3, 2013) ("Verizon Comments"); *see also* Comments of PCIA, ET Docket Nos. 13-84, 03-

increased exponentially and will only continue to grow.[150] To meet consumer demand for increased network and throughput, small cells will become increasingly critical to service providers' wireless network infrastructure, especially in densely populated areas. Under the *Further Notice*'s proposed exemption criteria, however, many more small cell sites could be required to undergo burdensome environmental assessments.[151]

Such an effect is incongruous both with the record and the Commission's broader policy goal of reducing the regulatory burden that environmental assessments pose. Commenters did not raise any public safety issues with respect to small cell sites, thus demonstrating that continued exemption for small cell sites would not be averse to public safety. As Motorola Solutions astutely recognized, it is sensible to adopt evaluation exemptions for "cases that obviously present little to no risk" as such exemptions are "an effective way to conserve time and other resources for both the Commission and industry."[152] Small cell sites clearly qualify as a case that presents little to no risk. Furthermore, the Commission's *Notice of Proposed Rulemaking* on wireless siting evinces a policy goal of moving away from broad, time-consuming environmental assessments for many transmitter sites, particularly small cell sites.[153] Yet by eliminating the categorical exclusion for many small cell sites, the *Further Notice*'s

137 at 4 (Sept. 3, 2013) ("PCIA Comments") ("the proposed exemption criteria are needlessly restrictive and will require routine evaluations for more sites").

150 *See* CTIA Comments at 7-8.

151 *See* Verizon Comments at 3.

152 Motorola Solutions Comments at 4.

153 *In the Matter of Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies*, Notice of Proposed Rulemaking, WT Docket No. 13-238, ¶¶ 7, 31-67 (Sept. 26, 2013).

proposed single transmitter exemption criteria would contradict the Commission's broader policy goal of reducing these types of assessments.

Changes to FCC transmitter site rules should not unnecessarily burden the deployment of small cells where no public safety benefit is gained.[154] The Commission should amend its proposal for single transmitter MPE-based exemption thresholds to ensure that small cell sites continue to be exempt under the rules.[155]

VI. CONCLUSION

The record shows that the scientific consensus supports the Commission's current exposure standards and testing policies. Furthermore, the Commission's current stance toward consumer disclosures and exposure reduction is justified. Accordingly, the record confirms the Commission's confidence in its existing RF exposure regime.

To ensure that future efforts do not imperil the Commission's balancing of public safety and undue burdens on industry, the Commission should revise its proposed exemption criteria to ensure that small cell sites are not categorically subjected to routine environmental evaluation.

Respectfully submitted,

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154 *See FNPRM*, ¶ 108 (noting rules should "appropriately protect the public without imposing an undue burden on industry.").

155 *See* Verizon Comments at 3.

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November 18, 2013

FCC; Mobile Manufacturers Forum Comments,
ET Docket No. 13-84 (Sept. 3, 2013)

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

Federal Communications Commission FCC 13-39

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 BY MOBILE MANUFACTURERS FORUM

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I - INTRODUCTION AND SUMMARY

The Mobile Manufacturers Forum (MMF) submits these comments in response to the Federal Communications Commission's ("FCC") Further Notice of Proposed Rulemaking ("FNPRM") and Notice of Inquiry ("NOI") seeking comment on the FCC's regulations, rules, limits and related measures pertaining to the health and safety of radiofrequency ("RF") emissions from radio transmitters.[1] The MMF is an international association of telecommunications equipment manufacturers with an interest in mobile or wireless communications, including the manufacturers of mobile handsets and devices as well as the manufacturers of the network infrastructure. Established to support research into the health and safety of radio frequency electromagnetic fields, the MMF has worked with national and international health agencies to support identified research. Further information on the MMF can be found on our website at www.mmfai.org.

The MMF has indicated in this submission our support in-principle for the discontinuation of Supplement C and with the proposed replacement of that reference with a greater reliance on the Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB). The MMF has some concerns though and has indicated a number of principles that should govern KDB development and use. Most importantly, we urge the Commission to use the KDB process to embrace harmonization, consistent with the Commission's own

[1] See Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies; Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields, First Report and Order, Further Notice of Proposed Rulemaking and Notice of Inquiry (rel. March 29, 2013) ("NPRM").

stated objectives as well as those that are required of it via the Office of Management and Budget (OMB) Circular A-119.

The MMF also supports the use of the proposed maximum time-averaged power or ERP evaluations for various transmitters. This approach has a number of practical benefits while still ensuring inherent product compliance. The MMF encourages the FCC to adopt IEC 62479-2010 as part of this process.

With regards to the FCC's exposure standards, the MMF submits that the scientific basis of these is now more than 20 years old and the rationale for continuing to maintain two separate standards in a world that has in the main adopted the guidelines set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) is increasingly difficult to justify. On the contrary, there is very strong policy, practical and scientific grounds to justify an alignment with these international guidelines. The current FCC standards were based on early dosimetry considerations alone, whereas the ICNIRP 1998 or IEEE C95.1- 2005[2] standards 2.0 W/kg averaged over 10 g of tissue for general public exposure and 10 W/kg averaged over 10 g for occupational exposure are based on a significantly improved understanding of the RF and thermal dosimetry, and biological and health effects.

Both ICNIRP guidelines and IEEE C95.1- 2005 standard provide a very conservative framework for the protection of persons exposed to RF fields. From

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[2] The American National Standard Institute (ANSI) adopted IEEE C95.1-2005 standard in 2006 as ANSI/IEEE C95.1-2006.

the substantial safety margin inherent in the standards themselves, through to the specificity of SAR measurement protocols and how the devices are tested compared to how they typically operate, the result is a very conservative framework suitable for widespread adoption. In fact, the World Health Organization (WHO) recommends that national governments should adopt the exposure guidelines developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998) or the Institute of Electrical and Electronics Engineers (IEEE C95.1- 2005), which are for the present purposes, essentially the same and collectively referred to as IEEE/ICNIRP or the "international standards".[3]

Currently, at least 115 countries, territories and regions use the ICNIRP guidelines as the basis of national safety standards for mobile devices and 105 for mobile phone networks. This is in contrast to only nine that follow the FCC for mobile networks and thirteen for mobile devices.

More importantly, the adoption of consistent science based standards increases consumer confidence and reduces community concerns: and as we show in the submission when countries have adopted arbitrary values in an attempt to pacify community concerns this has generally increased concern – the very opposite of what was desired. The MMF strongly urges the FCC to avoid such consequences by following science-based recommendations. The science-based approach not only will result in adoption of internationally harmonised exposure standards

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[3] Both adopt a SAR compliance level of 2.0 W/kg averaged over 10 grams of tissue for general public exposure and 10 W/kg averaged over 10 grams of tissue for occupational exposure.

but, as will be shown below, will be consistent with a precautionary approach due to the ample safety margin in the current IEEE/ICNIRP standards.

Moreover, any arbitrary reduction in standards can have significant unintended consequences, which would make the operation of telecommunication networks difficult and in some cases impossible as we see in in some parts of Europe today. Thus, the MMF submits that the adoption of arbitrary values below those established by IEEE/ICNIRP and recommended by the WHO, represents a poor policy choice that actually threatens the proven safety, security and economic benefits that mobile communications provides to the community at large.

Members of the MMF remain sensitive to the concerns and questions raised with regards to RF emissions. We provide a range of consumer information including on company and industry websites and publications as well as in user manuals. If some members of the community remain concerned, the best way for them to reduce their exposure from cell phones is to follow the FCC's own advice that is consistent with the WHO's advice to use "hands-free" devices which keep cell phones away from the head and body during calls and to limit the number and length of calls.

Furthermore, the MMF supports the Commission's existing requirements to include information in device manuals to make consumers aware of the need to maintain the body-worn separation distance. While testing data for body-worn configurations would not be applicable to situations in which a consumer disregards this information on separation distance and maintains a device closer to the body than the distance at which it is tested, we agree with the Commission's statements that this should not be viewed with any great concern for the reasons stated. As we discuss in detail in the course of this submission, both the international exposure standards and the compliance assessment framework are very conservative.

It should also be remembered that the telecommunications network is inherently precautionary. Studies of cell phones in everyday use show that when talking on a mobile phone while walking around a major city or inside city buildings, smartphones operate at less than one per cent of the phones maximum power output. This and other technical features such as discontinuous transmission, the existence of exposure standards, continuous research and on-going review as well as the availability of consumer information make the existing environment inherently precautionary.

Most importantly, international and national health authorities and expert bodies continue to maintain the consensus view that there are no established health effects below the levels recommended by ICNIRP and IEEE C95.1-2005.

These international standards are also recognised as providing ample protection for children and any other vulnerable groups in the community. The standards have taken concern such as lifetime exposure, increased absorption, and stages of childhood development into account and include significant added safety margins when setting safe exposure levels. The measurement standards have been developed using worst-case scenarios to ensure children are adequately protected.

The MMF also submits that there is also strong congressional and executive support for the harmonisation of standards. The continued retention of the current FCC's standards, especially in the absence of scientific support from relevant standards committees, has resulted in a "government unique standard" ('GUS'), a position directly at odds with existing government policy and one which should be rectified by the adoption of IEEE C95.1-2005.

In addition, the adoption of harmonized international standards in the US would improve coverage with fewer dropped calls and better access to data services particularly in regional communities where services can sometimes be limited or patchy. Better coverage also results in better access to emergency services via the cellular network, which is a well-recognized public health benefit.

Likewise consumer expectations for mobile coverage are rapidly changing in the US like the rest of the world as more users adopt smartphones and tablets and are demanding reliable, fast and efficient mobile broadband connections. Adoption of the international standards would allow additional transmission power to be utilised in areas where the device is currently being required to operate at maximum power to connect to the network thereby effectively expanding coverage and resulting in a better mobile broadband experience.

With the extensive deployment of LTE, the United States currently enjoys a position of considerable technology leadership, but this technological lead can quickly be lost in this rapidly changing environment. Already manufacturers are finding the compliance framework established by the FCC for LTE devices exceptionally complicated and time consuming. The harmonization of standards would make the production of new devices much more efficient with only one global standard to design and comply with.

In relation to the evaluation of devices, the MMF submits that the FCC's current LTE testing requirements are unduly onerous, involving in some cases in excess of 100 SAR tests for head and body exposure in only two LTE frequency bands, equating to 4 – 6 weeks of testing for SAR type approval. Alternative approaches based on initial screening of conducted power are being used internationally and have been shown to be as effective as the current FCC specified approach. These alternative processes involve considerably less testing time – an important factor for products that often have a market life cycle of 12 months or so.

Finally, the MMF would also like to see a presumption of adoption operating where the FCC is actively involved in standards committees, rather than have all parties invest considerable time and resources into standards development only to see the FCC fail to adopt them or to mandate contradictory requirements. The MMF believes that this could be achieved through the KDB process and is consistent with the principles and requirements of OMB Circular A-119.

II - FURTHER NOTICE OF PROPOSED RULEMAKING

A - TECHNICAL EVALUATION REFERENCES IN RULES

The MMF notes the FCC's decision to "discontinue use of Supplement C as an informative reference for evaluation of mobile and portable devices" and, instead, to utilize "the Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB) to provide current guidance and policies on acceptable procedures for evaluating wireless devices."[4] KDBs, therefore, will constitute the sole repository of documented requirements for grant authorization testing. As such, KDB requirements will reflect, on a day-to-day basis, the extent of the FCC's commitment to harmonization with international standards and requirements.

In order for the KDB process to effectively supplant the more authoritative – but, concededly less flexible – guidance issued through an OET Bulletin and supplements, the MMF believes that KDBs must have the following qualities:

a. KDBs should be released in draft in order with an adequate notice period during which stakeholders can provide input;

[4] Id. at Paragraph 28.

b. KDBs issued in final should provide adequate time for an orderly transition of practices;[5]

c. KDBs must provide testing guidance that is consistent, as much as possible, both with current standards and international practices. (Where departure from international standards and practices are called for by a KDB, a rationale for such departure should be provided.)

d. KDBs should provide adequate flexibility to allow for innovation in both testing and technology.

In accordance with the above principles, the MMF urges the FCC to use this opportunity to embrace harmonized requirements through the KDB process. Such an approach will be in line with the FCC's statement that "we fully intend to continue to use the KDB to provide guidance on techniques and methodologies recommended by internationally and domestically accepted expert standards bodies, such as the Institute of Electrical and Electronics Engineers ("IEEE") and the International Electrotechnical Commission ("IEC"), to the extent that their standard procedures ensure compliance with our exposure limits."[6] As items covered by Supplement C are recast through the KDB process, the FCC should avoid developing unique U.S. requirements and work to keep the testing process aligned with international standard processes.

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[5] The MMF members note that the FCC currently engages in such a practice, and MMF urges that this practice be continued.

[6] Id. at Paragraph 38.

By way of example, the MMF would note the ongoing issue of testing fluids for use with the SAM phantom. In 2001, the FCC initiated its ongoing requirement that simulants for head and body measurements each be unique such that two simulants are required for a complete suite of tests rather than the one simulant formula adopted in other countries, as provided for in IEC standard 62209-2 (2010). As a consequence, testing requirements are effectively doubled for products shipped to both the US and internationally since the approach outlined in the KDB must be followed for US product while product destined for the rest of the world will be tested according to IEC 62209-2 (2010).

The MMF notes that the above proposed KDB principles and our proposal for internationally recognized testing procedures are not only consistent with, but called for by the Office of Management and Budget ('OMB') Circular A-119, which directs Government agencies "to use voluntary consensus standards in lieu of government-unique standards except where inconsistent with law or otherwise impractical."[7]

[7] http://www.whitehouse.gov/omb/circulars_a119

B - EXEMPTION OF FIXED, PORTABLE, AND MOBILE DEVICES

The MMF supports the inclusion of both MPE- and SAR-based exemptions for the various transmitters based on using the variable sliding scale as proposed in the discussion as referenced in R&O 03-137. The use of a sliding scale in regards to Maximum Permissible Exposure ("MPE") or SAR exclusion provides the industry with a more accurate tool to determine and test for compliance. Using the referenced formulas and table for SAR-based exemption, it will be possible for manufacturers of devices such as laptops with antennas built into back of the display, cordless phones, and tablets to demonstrate that maximum time-averaged power or ERP evaluations are adequate under some circumstances, thus reducing the costs of performing SAR engineering and compliance tests. Furthermore, the MMF supports the retention of the option for manufacturers to continue to do SAR testing should they wish to do so for a particular product or situation.

In reviewing Table 2 as proposed by the FCC for use with single transmitters, the MMF notes that the table does not specify the units of measurement for the power in the title to the table. The MMF therefore recommends that the actual units of measure are included as part of the table to avoid any uncertainty. The FCC should also include an explanation of which devices that the table applies to. The MMF queries whether this table will be part of the actual rulemaking or included in a KDB, since it is not clear what the FCC's intent is. For the sake of clarity, we recommend it be placed into a KDB.

For transmitters operating above 1GHz, the table has the same exclusion thresholds for 20cm as well as 40cm. While one would normally expect that the larger distance would be accompanied by an allowance for an increase in power output at higher frequencies and still be exempt, the FCC's explanation why this is not the case is an important element that should remain alongside the table in whatever form it is finally published in (i.e., KDB or Rulemaking).

Furthermore, we recommend that the FCC adopt IEC62479-2010[8] in order to provide a simple conformity assessment method for low-power equipment. IEC 62479 includes SAR-based test exemption criteria that would greatly reduce unnecessary testing for low-power devices.

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[8] IEC 62479, Edition 1.0 (2010-06-16), Assessment of the compliance of low-power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz), International Electrotechnical Commission, Geneva, Switzerland.

III - NOTICE OF INQUIRY

A - EXPOSURE STANDARDS

The MMF notes that the FCC's existing RF exposure standards, adopted in 1996, are based on the standards extant at that time: the ANSI/IEEE C95.1-1992 Standard[9], and the NCRP's 1986 report on Biological Effects of RF Fields.[10] The scientific basis of the FCC's standard is therefore more than 20 years old and, as explained further below, has now been rejected by the majority of the world's scientists and regulatory bodies in favor of the current ICNIRP/IEEE standards. As expressly stated in the IEEE C95.1-2005 Standard:

> *Since publication of ANSI C95.1-1982 significant advances have been made in our knowledge of the biological effects of exposure to RF energy[11].*

As a result of reviews of the RF literature and the state of the science, the World Health Organization (WHO) provides the following advice to national governments with regards to RF exposure standards:

> ***Protection standards***
>
> *International exposure guidelines have been developed to provide protection against established effects from RF fields by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998) and the Institute of Electrical and Electronics Engineers (IEEE, 2005).*

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[9] The IEEE C95.1-1991 standard was adopted by ANSI in 1992 to become ANSI/IEEE C95.1-1992.
[10] 47 CFR 2.1093 (d), "The limits to be used for evaluation are based generally on criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate ("SAR") in Section 4.2 of "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE C95.1-1992, Copyright 1992 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86, Section 17.4.5. Copyright NCRP, 1986, Bethesda, Maryland 20814."
[11] IEEE C95.1-2005, page 35.

> *National authorities should adopt international standards to protect their citizens against adverse levels of RF fields. They should restrict access to areas where exposure limits may be exceeded.*[12]

The WHO advice has been widely followed. A recent paper[13] presented at the Joint Meeting of the Bioelectromagnetics Society and the European BioElectromagnetics Association in June 2013 found there are currently 115 countries, territories, dependencies and sub-national regions using the ICNIRP guidelines as the basis of national exposure standards for mobile devices and 105 for mobile phone networks. This is in contrast to only nine countries that follow the FCC standard for mobile networks and thirteen for mobile devices.

It is interesting to note that China adopted the ICNIRP guidelines in 2007 for devices[14] and several countries, including Australia[15] and Taiwan[16] that previously followed the FCC have now adopted national standards based on ICNIRP guidelines. The change in the international landscape towards greater harmonization of RF exposure standards based on IEEE C95.1-2005/ICNIRP was recognized in the recent Government Accounting Office (GAO) report:[17]

> *These international organizations have updated their exposure limit recommendation in recent years, based on new research, and this new limit has been widely adopted by other countries, including countries in the European Union.*

For the foregoing reasons, it is evident that the overwhelming view of the

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[12] http://www.who.int/mediacentre/factsheets/fs304/en/index.html accessed on 04 March 2013

[13] Rowley J., Joyner K., Zollman P. & Larsson LE. Radiofrequency Exposure Policies Relevant to Mobile Communication Devices and Antenna Sites. BioEM 2013, 10-14 June Thessaloniki Greece

[14] GB 21288-2007: *Limits for Human Local Exposure to Electromagnetic Fields Emitted by Mobile Phones*

[15] *Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz* available at http://www.arpansa.gov.au/pubs/rps/rps3.pdf

[16] CNS 14959 (2005): Limits for exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)

[17] http://www.gao.gov/products/GAO-12-771

scientific community, national experts and the international health agency actively overseeing this field, is that the current science supports the harmonized 2W/kg with 10g averaging for general public exposure and 10W/kg with 10g averaging for occupational exposure standard rather than the scientifically outdated standards still followed by the FCC.

In developing these more recent standards, the experts and scientists followed the example of the earlier standards body and built in substantial safety margins.[18] Consequently, there is no basis for continued use of the outdated standard that is no longer supported by the IEEE: it cannot be said to be either safer or more useful than the later standard. More specifically, given that both the 1.6W/kg averaged over 1 g tissue and the 2.W/kg averaged over 10 g of tissue – as well as the MPE values - are well below the threshold for adverse health effects with large safety margins[19], both values must be regarded as being equally safe for consumers.

In a world that is harmonizing around the science based international standards, any rationale for continuing to maintain a separate national standard would need to be based on strong public policy considerations. The contrary holds true, however: as detailed below there are very strong policy, as well as practical and scientific grounds to justify an alignment with international standards.

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[18] See IEEE C95.1-2005, Annex C.6 Safety factors and uncertainty factors

[19] See ICNIRP's 2009 Statement On The "Guidelines For Limiting Exposure To Time-Varying Electric, Magnetic, And Electromagnetic Fields (Up To 300 GHz) at http://www.icnirp.de/documents/StatementEMF.pdf

B- RATIONALE FOR HARMONIZATION OF FCC'S STANDARDS

In addition to the fact that the scientific basis of the FCC's standards has become outdated with the original IEEE C95.1-1991 standard having been superseded twice in the intervening years (firstly by C95.1-1999 then by C95.1-2005), and that the WHO recommends adoption of either the IEEE C95.1-2005 standard or ICNIRP guidelines, there are significant policy grounds to justify the update and harmonization of the FCC's standards.

1 – CLEAR SCIENTIFIC SUPPORT FOR HARMONIZED STANDARDS

While the FCC has made the perfectly correct point that the "[c]ontinued use of present exposure limits is currently supported by statements from significant qualified expert organizations and governmental entities", it is important that the statement be understood as recognition that there is no public health risk from continued use of the standard and not as an endorsement of the thresholds of the standard. Therefore, such a statement should not be construed as support for continuing to use the outdated present standard rather than the updated one. In fact, there is strong support from international health and government expert agencies for the 2W/kg ICNIRP/IEEE standard. Key statements of such support include those made by:

The United Kingdom's Advisory Group on Non-Ionising Radiation:

> *In summary, although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes health effects in adults or children.*[20]

The Swedish Council of Working Life and Social Research:

> *Extensive research for more than a decade has not detected anything new regarding interaction mechanisms between radiofrequency fields and the human body and has found no evidence for health risks below current exposure guidelines. While absolute certainty can never be achieved, nothing has appeared to suggest that the since long established interaction mechanism of heating would not suffice as basis for health protection.*[21]

The German Radiation Protection Commission:

> *(Unofficial Translation): … In line with other international bodies (ICNIRP 2009, WHO 2011) it can be determined that the underlying concepts of the existing protection limits are not in question.*[22]

The Norwegian Institute of Public Health:

> *The current regulations are based on the ICNIRP reference values for maximum exposure. The Expert Committee does not recommend special measures to reduce exposure, e.g., by changing the threshold limit values.*[23]

These representative and recent statements, demonstrate that health agencies and expert bodies do not consider that there are any established health effects below the levels recommended by ICNIRP and IEEE C95.1-2005[24]. Taken in conjunction with the recommendation of the World Health Organization, the FCC

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[20] *Health Effects from Radiofrequency Electromagnetic Fields* – RCE 20, Advisory Group on Non-ionising Radiation (AGNIR), Health Protection Agency, April 2012. http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1317133826368

[21] *Radiofrequency electromagnetic fields and risk of disease and ill health: Research during the last ten years*, Swedish Council of Working Life and Social Research (FAS), 2012. http://www.fas.se/

[22] http://www.ssk.de/de/werke/2011/kurzinfo/ssk1109.htm

[23] "Svake høyfrekvente elektromagnetiske felt – en vurdering av helserisiko og forvaltningspraksis. FHI-rapport 2012:3" *(In English: Low-level radiofrequency electromagnetic fields – an assessment of health risks and evaluation of regulatory practice. NIPH report 2012:3).* http://www.fhi.no/dokumenter/6563fe9a33.pdf, *page 43.*

[24] Additional statements by expert bodies and health agencies are provided in Annex A.

therefore has strong scientific support for harmonizing its own standard.

2 – INTERNATIONALLY HARMOIZED STANDARDS PROVIDE A HIGH LEVEL OF PROTECTION FOR ALL, INCLUDING CHILDREN

The FCC has asked whether its current standards are appropriate as they relate to the use of devices by children.[25] MMF notes that the U.S. Food and Drug Administration (FDA) currently states on its website that "scientific evidence does not show a danger to users of wireless phones, including children and teenagers."[26] This position of the FDA is consistent with that of the WHO, as outlined in Fact Sheet 193: "Present scientific evidence does not indicate the need for any special precautions for the use of mobile phones. If individuals are concerned, they might choose to limit their own or their children's RF exposure by limiting the length of calls, or by using "hands-free" devices to keep mobile phones away from the head and body."[27]

Scientific reviews have specifically addressed the area of children's RF exposure. For example, in a 2009 survey of relevant research conducted by seven internationally recognised experts, the researchers determined:

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[25] Id. at Paragraph 6
[26] http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116331.htm (accessed on 21 May 2013)
[27] http://www.who.int/mediacentre/factsheets/fs193/en/index.html

> *Overall, the review of the existing scientific literature does not support the assumption that children's health is affected by RF EMF exposure from mobile phones or base stations.*[28]

Similarly a 2007 review by the Irish Government Expert Group[29], which conducted an in-depth scientific review of all the science on mobile phones and children, found:

> *There is no data available to suggest that the use of mobile phones by children is a health hazard.*

Likewise a 2011 review by the Health Council of the Netherlands[30] concluded:

> *There is no scientific evidence for a negative influence of exposure to electromagnetic field of mobile telephones, base station antennas or Wi-Fi equipment on the development and functioning of the brain and on health in children. This is the main conclusion of an advisory report the Health Council presented today to the State Secretary of Infrastructure and the Environment.*

Also, a comprehensive review of all the scientific evidence by the UK Health Protection Agency's independent Advisory Group on Non-ionising Radiation (AGNIR)[31] in April 2012 concluded:

> *Although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes effects in adults or children.*

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[28] "Children's health and RF EMF exposure" was issued by the Mensch Umwelt Technik (MUT) of the Julich Research Institute, Germany.
[29] http://www.dcenr.gov.ie/NR/rdonlyres/9857119F-CE1A-443F-9F17-44BB299D6FE6/0/ReportoftheExpertGroupontheHealthEffectsofElectromagneticFields2006.pdf
[30] Health Council of the Netherlands, 2011, *Influence of radiofrequency telecommunication signals on children's brains*. The Hague: Health Council of the Netherlands, 2011; publication no. 2011/20E. ISBN 978-90-5549-859-8
[31] http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1317133826368

Thereafter a review[32] by the Norwegian Institute of Public Health in September 2012 also found there was no scientific evidence for an association between mobile phone use and fast or slow growing brain tumours for people who had used mobile phones for up to 20 years. The research Committee considered the implications of long-term phone use for young people and the likelihood of health hazards occurring in the future and found they were unlikely:

> *There is always an element of uncertainty in all risk assessments. In this case, the Committee considers the uncertainty to be small... It is unlikely that long-term use of mobile phones will cause health risks that are unknown today.*

An Austrian study[33], published in January 2008 investigated previous health risk assessments and established physiological knowledge regarding mobile phone use, particularly with reference to children's health. The report stated:

> *Based on the assessments of the international committee and established knowledge on children's development it can be concluded that existing exposure limits do in fact provide reasonable safety.*

Furthermore, the report concluded:

> *There are no sufficient grounds to generally condemn mobile phone use by children, in particular, nor is there an established basis for pinpointing a specific age limit (above 3 years) as has been done by some overreacting committees.*

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[32] Low-level radiofrequency electromagnetic fields – an assessment of health risks and evaluation of regulatory practice. NIPH report 2012:3, 978-82-8082-510-0 English Summary, viewed 24 July 2013 http://www.fhi.no/dokumenter/c5ab86c32b.pdf

[33]Norbert Leitgeb, 2008, *Mobile phones: are children at higher risk?* Institute of Clinical Engineering, Graz University of Technology, Infeldgasse 18, Graz, Austria. Wiener Medizinische Wochenschrift 02/2008; 158(1-2):36-41. DOI:10.1007/s10354-007-0447-1

A study[34] conducted at the German Academy of Pediatrics and Adolescent Medicine published in October 2007, said there is no indication that children are particularly vulnerable to electromagnetic fields:

> *There are presently no scientific data supporting the concept of a special vulnerability of children and adolescents to high-frequency EMF, even if the usual caveats (developing organisms and structures may be more vulnerable, decades of life to come) are considered.*

International safety standards have taken these concerns and potential risks into account when setting their recommendations. The guidelines have been developed using worst-case scenarios and include added safety margins to ensure children are protected. For example, then Chairman of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), Dr. P. Vecchia stated[35]:

> *The protection system using basic restrictions and reference levels makes the ICNIRP guidelines flexible and applicable to virtually any exposure condition, and any group of population. Therefore, there is no need, or justification, for a special approach to the protection of children.*

Research has also been undertaken to assess whether there are differences between the absorption of RF in adults or children. Papers by Schönborn et al.[36], Kuster and Balzano[37], Hornbach et al.[38] and Meir et al.[39] have found that there

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[34]Otto M, von Mühlendahl, KE, 2007, *Electromagnetic fields (EMF): do they play a role in children's environmental health (CEH)?* Int J Hyg Environ Health. 2007 Oct;210(5):635-44. Epub 2007 Aug 31.

[35] Dr P. Vecchia, Chair ICNIRP, WHO meeting, Electromagnetic Fields and Children, Istanbul, 9-10 June 2004.

[36] Schonborn F., Burkhardt M., Kuster N. Differences In Energy Absorption Between Heads Of Adults And Children in the Near Field Of Sources. Health Physics, Vol. 74, Pg. 160 - 168, 1998

[37] Kuster N And Balzano Q. , Energy Absorption Mechanism by Biological Bodies in The Near Field Of Dipole Antennas Above 300 MHz. IEEE Transactions On Vehicular Technology, Vol. 41, No. 1, February 1992

[38] Hombach V., Meier K., Burkhardt M., Kuhn E., And Kuster N., The Dependence of EM Energy Absorption upon Human Head Modeling at 900 MHz. IEEE Transactions On Microwave Theory

are no significant differences between the absorption of RF in adults or children. Gandhi and Kang[40] and Bit-Babik et al.[41] have reported similar SAR patterns in adult and children head, in contrast to the results shown in Gandhi et al.[42] which were due to improper scaling of the size and color.

The results of these studies into children's absorption of RF have been considered by several expert and health agency reviews. In 2004, the Health Council of the Netherlands considered the available research on mobile phones and children and concluded:

> *There is no scientific data to assume a difference in the absorption levels of electromagnetic energy in heads of children and adults, nor is it likely that the electromagnetic sensitivity of children's heads changes significantly after the second year of life. Because of this, the Health Council of the Netherlands sees no reason for recommending limiting the use of mobile phones by children.*

The Health Council of the Netherlands[43] also specifically addressed the question of whether or not there needed to be different exposure limits for children or other vulnerable groups in the community and concluded:

> *The answer to this question is: no, because the potential additional*

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and Techniques, Vol. 44, No. I0, October 1996

[39] Meier K., Hombach V., K¨Astle R.Tay R., Kuster N., The Dependence Of Electromagnetic Energy Absorption Upon Human-Head Modeling At 1800 MHz. IEEE Transactions on Microwave Theory and Techniques, Vol. 45, No. 11, November 1997

[40] Gandhi O And Kang G. 2002. Some Present Problems And A Proposed Experimental Phantom For SAR Compliance Testing For Cellular Telephones At 835 And 1900 MHz *Phys. Med. Biol.* 47: 1501–18.

[41] Bit-Babik G, Guy A W, Chou C K, Faraone A, Kanda M, Gessner A, Wang J And Fujiwara O. 2005. Simulation of Exposure and SAR Estimation for Adult and Child Heads Exposed to Radiofrequency Energy from Portable Communication Devices *Radiat. Res.* 163: 580–90.

[42] Gandhi O P, Lazzi G, and Furse C. 1996. Electromagnetic Absorption in the Human Head and Neck for Mobile Telephones at 835 And 1900 MHz *IEEE Trans. Microw. Theory Tech.* 44: 1884–97.

[43] Health Council of the Netherlands, 2011, *Influence of radiofrequency telecommunication signals on children's brains*. The Hague: Health Council of the Netherlands, 2011; publication no. 2011/20E. ISBN 978-90-5549-859-8

> *sensitivity of children and other vulnerable groups was explicitly accounted for in setting the exposure limits.*
>
> *It is one of the reasons why the exposure limits for the general population include an ample uncertainty margin of a factor of 50. Based on the data presented in this report, the Committee sees no reason to recommend different exposure limits for children than for adults.*

Furthermore the Health Council of the Netherlands also undertook a further report in 2011[44] on the issue and reached the following conclusion:

> *In summary, the Committee concludes that there is no cause for concern based on the knowledge about short-term effects outlined in this advisory report. Available data do not indicate that exposure to radiofrequency electromagnetic fields affect brain development or health in children.*

It is also instructive to note that when the Australian Radiation and Protection and Nuclear Safety Agency moved away from the FCC's standard to adopt the ICNIRP guidelines in their new standard, it stated on the issue of children and mobile phones[45]:

> *In respect to the ongoing debate about possible health effects arising from use of mobile phone handsets, it has been suggested that children may be more vulnerable than adults because of their developing nervous system and greater absorption of energy in the tissues of the head (IEGMP 2000). However, there is insufficient evidence to substantiate this hypothesis. For mobile phone handsets, the basic restriction is spatial peak SAR applicable to all individuals of different sizes including children. Schönborn, Burkhardt and Kuster (1998) have shown that, at mobile phone frequencies, there is no substantive difference in the absorption of RF energy between an adult head and the heads of children aged 3 and 7 years. Notwithstanding this, the basic restrictions given in this Standard account for different sizes and tissue properties of all individuals including children.*

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[44] Influence of radiofrequency telecommunication signals on children's brains. The Hague: Health Council of the Netherlands, 2011; publication no. 2011/20E: http://www.gezondheidsraad.nl/sites/default/files/201120E.pdf

[45] Radiation protection Standard for Maximum Exposure to Radiofrequency Fields - 3kHz to 300GHz (2002) published by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), 2002

While the policy and scientific discussions continue, it is clear that parents are deciding for themselves whether their children should use a mobile phone or not. By and large, parents appear to be allowing their use because of the perceived benefits in terms of safety and security that mobile phones provide for both children and parents alike.

Therefore the weight of scientific evidence, as reviewed by the experts in several independent fora, supports the position that the international standards provide ample protection for children and continue to be sufficient without additional measures being needed.

3 – INTERNATIONAL STANDARDS PROVIDE A BIOLOGICAL BASIS BETTER SUITED TO A HEALTH PROTECTION STANDARD

On the issue of the differences between the averaging of exposures,[46] the MMF notes that the FCC's peak spatial-average SAR for localized exposure of the general public (1.6 W/kg averaged over 1 g of tissue) and workers (8 W/kg averaged over 1 g of tissue) are based on the C95.1-1991 standard (and NCRP Report 86) which differ from the 2 W/kg and 10 W/kg averaged over 10 g of tissue SAR recommendation found in the ICNIRP guidelines and the IEEE C95.1-2005 standard.

In the revised IEEE C95.1-2005 standard, the recommended peak spatial-

[46] Id. at Paragraph 220

average SAR values for the controlled environment and the general public (if no RF safety program is implemented) have been changed and are now harmonized with the ICNIRP SAR guidelines, i.e., 10 and 2.0 W/kg averaged over 10 g of tissue, respectively. The rationale for the change is explained in Appendix C, Section C.2.2.2.1 of C95.1-2005. Whereas the 1991 SAR values were based on early dosimetry considerations alone, those in the 2005 standard are based on a significantly improved understanding of RF and thermal dosimetry and biological/health effects considerations as explained in the standard itself:

> The peak spatial-average SAR limits in IEEE Std C95.1, 1991 were based on dosimetry considerations. The 8 W/kg and 1.6 W/kg limits were determined from the 20:1 ratio between the peak spatial-average SAR and whole body average (WBA) SAR in experimental data available in the late 1970's. The 1 g averaging mass was consistent with data limited by the resolution of thermographic measurements at the time. Recent advances in numerical calculations have shown that the ratio of peak spatial-average SAR to WBA SAR for a 1 g averaging mass can be much higher, with reported values of more than 100:1.
>
> The committee, however, considered it inappropriate to relax the peak spatial-average SAR limits to 40 W/kg and 8 W/kg for the revision and instead discussed alternatives, one of which was to examine the basis of the ICNIRP peak spatial-average SAR limit. In an ICNIRP statement, a 10 gram averaging mass was recommended, "because of the very inhomogeneous spatial distribution of energy absorbed inside the head, together with concerns about possible localized heating of the eye and other parts of the head with equivalent mass." The committee agrees that the biologically based ICNIRP rationale is more appropriate than the purely dosimetry based rationale in IEEE Std C95.1-1991.
>
> Furthermore, the limit of 10 W/kg averaged over 10 g is supported by results from animal experiments showing that this limit is 10 times below the SAR threshold for cataracts in humans, which is estimated to be 100 W/kg deposited in the eyeball, a mass of about 10 g.[47]

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[47] Paraphrased, Appendix C, Section C.2.2.2.1 IEEE C95.1-2005

The scientific judgment of IEEE, as expressed above, is very much in line with the views of other independent expert groups around the world. For example, McIntosh and Anderson indicated in their paper[48]:

> *Similarly for SAR, the averaging mass of 10 g appears superior (when compared to 1, 3, 5, and 7 g). This superiority disappears at 6 GHz where none of the averaging volumes/masses perform well. That is, the analyses suggest that as the frequency of exposure increases to 6 GHz, the ability of SAR and VAR appears to diminish as a reliable correlate to DT, in line with previous findings by Hirata and Fujiwara [2009] and McIntosh and Anderson [2010a], and the incident power flux density should be considered as a more suitable exposure metric for RF safety limits.*
>
> *Both the cube and the sphere appear to be equally suitable averaging shapes with minimal differences found between the two in the analyses performed in this article. Therefore, for safety standards and guidelines, it is recommended to specify the averaging shape that is easier to assess.*

The above comments indicate that there is a strong justification for the IEEE C95.1-2005 recommendation for SAR values to be averaged over a 10 g cube and applicable up to 6 GHz.

Likewise in relation to the comments and questions with regards to possibility of a 30-minute source-based averaging time[49], the MMF notes that this is also derived from the IEEE C95.1-2005 Standard. This averaging time can be source-related, e.g., the source repetition method, or use-related, i.e., designed to ensure that devices that have a particular functionality or usage condition will comply with the limit when measured over the time period in question[50]. If consumer demand is for devices with particular features (for example a device that has a

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[48] McIntosh RL., and Anderson V. SAR Versus VAR, and the Size and Shape That Provide the Most Appropriate RF Exposure Metric in the Range of 0.5-6 GHz, *Bioelectromagnetics* 32(4): 312-321, 2011

[49] Id. at Paragraph 222

[50] Further comment on time averaging is provided in Annex B.

"super burst" mode that could be activated in emergencies to boost TX power when a signal may not be available or reception is very poor) and it is tested according to the standard, then that should be permitted. In such a case, the phone would be designed to still be compliant with the standard using the permitted time-averaging period. Ensuring compliance with the standard over a time period that reflects the technology or reflects the intended use, still ensures that the overall objective is achieved.

Therefore considering the intent of the standard (and the FCC's objective) is to provide adequate protection for human exposure to RF energy, then it makes sense for the FCC to adopt a standard that is both biologically based and one that also takes into account the variety of ways that products can use RF energy.

4 – INTERNATIONAL STANDARDS ARE CONSERVATIVE

The MMF notes that both ICNIRP and IEEE C95.1-2005 provide a very conservative framework for the protection of persons exposed to RF fields. From the substantial safety margin inherent in the standards themselves, through to the specificity of SAR measurement protocols and how the devices are tested compared to how they typically operate, the result is a very conservative framework suitable for widespread adoption.

The following provides details on how conservativeness is built in to various components of the standards:

a) The safety margin built into the standards

As the IEEE C95.1-2005 standard details:

The safety factor for whole-body exposure durations greater than the averaging time has been estimated to be in the range of 10 to 50 in power (10 to 17 dB) for the upper tier BRs or MPEs. The corresponding BRs and MPEs of the lower tier incorporate an additional safety factor of 5 relative to the upper tier, i.e., an additional 7dB. The safety factors for special exposure measures, such as peak (short pulse) limits and contact and induced currents in the limbs, are often related to the safety factors incorporated in the BRs or MPEs for fields. This factor is generally of the order of at least 10dB.

b) SAM phantom

The combination of higher tissue conductivities, a large head size, a thin ear and the exclusion of a hand holding the handset were all chosen to provide a conservative estimate of the peak spatial-average SAR associated for the operating configurations expected by typical wireless handset users.

The collective impact of the above parameters is to produce a margin such that the SAR values assessed using the test procedures of this standard are expected to be higher than during actual use conditions of a handset.

i. **Head size:** A head geometry that results in overall smaller distances between the handset and the tissue boundary will provide more conservative results because the separation between the equivalent current densities on the device under test and the tissue equivalent liquid will be less. Thus, a larger anthropomorphic head model, with larger local radii of curvature, will satisfy the criterion for minimal distances.

ii. **Phantom shape:** The dimensions and shape of Specific Anthropomorphic Mannequin (SAM), except for the ear protrusions discussed later, were derived from a subset of the 90th percentile dimensions from the survey of the US Army males.

iii. **Head tissue-equivalent liquid:** To fulfil the conservative criteria in SAR assessment, the homogenous liquid parameters must be carefully selected taking into account the energy coupling enhancement due to standing waves that occurs in tissue layers of the human head. The tissue-equivalent liquids are based on a study of the anatomical variations in the head region behind and above the ear for a cross section of a representative user population. At each frequency, the possible ranges of layered-structure thickness and conductivity of the tissue-equivalent liquid that resulted in the highest peak spatial-average SAR values (1 g and 10 g average) were evaluated. Dielectric properties for homogeneous head tissue-equivalent liquids were determined to produce the same (or slightly higher) peak spatial-average SAR values compared to the highest values occurring in the heterogeneous cases.

iv. **Pinna shape, orientation, and thickness:** In the selection of any phantom for handset SAR testing, a properly designed and positioned pinna (external ear) is necessary in order to achieve correct and repeatable geometrical relationships between the handset and the tissue boundary. For SAM, the pinna orientation and shape were selected to maximize the inductive coupling from a handset. The relevant IEEE standards committee decided to simulate the pinna using a stable, simplified loss-less spacer with a thickness of 6 mm (inclusive of the 2 mm phantom shell thickness). This spacer thickness is considerably less than the typical 19–28 mm spacing between the rear edge of the pinna (when not compressed) and the head shown in the anthropometric data, thereby contributing to the conservative conditions of SAM for SAR assessments.

The conservativeness of SAM has been repeatedly shown in numerous computational studies using anatomical correct models from MRI scans. The spatial peak SARs in the SAM head model used for compliance evaluation have been shown to be conservative for both adults and children (by the teams of Beard et al[51]., Chris et al.[52] and Hadjem et al.[53]). Their conclusions are summarized in the following statements taken from the abstracts of their papers:

The results show that when the pinna SAR is calculated separately from the head SAR, SAM produced a higher SAR in the head than the anatomically correct head models. Also the larger (adult) head produced a statistically significant higher peak SAR for both the 1- and 10-g averages than did the smaller (child) head for all conditions of frequency and position. [Beard et al.]

The peak spatial specific absorption rate (SAR) assessed with the standardized specific anthropometric mannequin head phantom has been

[51] Beard BB, Kainz W, Onishi T, Iyama T, Watanabe S, Fujiwara O, et al., "Comparisons of computed mobile phone induced SAR in the SAM phantom to that in anatomically correct models of the human head," *IEEE Trans. Electromagn. Compat.*, vol. 48, no. 2, pp. 397–407, May 2006.
[52] Christ A, Gosselin MC, Christopoulou M, Kuhn S, Kuster N, "Age-dependent tissue-specific exposure of cell phone users," *Phys. Med. Biol.*, vol. 55, pp. 1767–1783, Mar. 2010.
[53] Hadjem A, Conil E, Gati A, Wong MF and Wiart J, "Analysis of power absorbed by children's head as a result of new usages of mobile phones," *IEEE Trans. Electromagn. Compat.*, vol. 52, no. 4, pp. 812–819, Nov. 2010.

shown to yield a conservative exposure estimate for both adults and children using mobile phones. [Chris et al.]

The specific anthropomorphic mannequin (SAM) homogeneous head model has been also used to compare all the results and to confirm that the SAM model always overestimates adult and child head exposure... It was also pointed out that the value of the maximum local peak SAR in the SAM was always higher than in the adult and children models. [Hadjem et al.]

The MMF notes that IEEE 1528-2003 provides additional information about the SAM phantom in Section 5 of the standard.

c) Testing at Maximum Power

During SAR testing, the devices are tested using maximum power. In reality this is rarely experienced by users due to the existence of adaptive power control in the network. Power control is undertaken at the cell site level and serves to adjust the output power only to that level needed to make and maintain a quality connection. Discontinuous transmission is another network efficiency feature by which transmissions are minimised when the user is not talking, but rather listening[54].

Studies that have been undertaken on devices in real network conditions have shown that devices operate at average power levels of between 1% to 35% of their maximum as a result of power control and discontinuous transmission[55]. A more detailed discussion and their impact can be found in section D2 of this document, however the result is that by testing the devices at maximum power and without taking into account the impact of

[54] Further information about power control and discontinuous transmission is contained in Annex C
[55] Study details are provided in Annex C

power control and discontinuous transmission results in a very conservative SAR result.

The combination of all of these factors undoubtedly results in a very conservative compliance framework, such that even if one or more elements is shown at a later date to require modification, or the users fails to use the device as intended, the end result in terms of fundamental safety is not in question. As the FCC itself points out in relation to the issue of body-worn usage where a consumer disregards the information contained in product documentation about the correct distance to use the device, "a use that possibly results in non-compliance with the SAR limit should not be viewed with significantly greater concern than compliant use" as there is "no evidence that this poses any significant health risk"[56]. Therefore, in relation to the issue of separation distance, the MMF submits that there is no need to change existing requirements.

What can be established though from the above discussion is that both ICNIRP and IEEE C95.1-2005 provide a conservative exposure standard, and along with the relevant testing requirements, provide for a conservative compliance assessment framework.

5 – CONGRESSIONAL AND EXECUTIVE SUPPORT FOR HARMONIZATION

With the passage of section 12(d)(1) of the National Technology Transfer and

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[56] Id. at Paragraph 251

Advancement Act (NTTAA)[57], Congress gave a clear direction to all federal agencies to use standards developed by voluntary consensus organizations as a means to carry out policy objectives or activities. The only exceptions to this mandate were if the use of these standards were inconsistent with applicable law or otherwise impractical (12(d)(3)).

This was further elaborated upon by the Office of Management and Budget ('OMB') Circular A-119[58], whereby Government agencies are "*direct(ed) to use voluntary consensus standards in lieu of government-unique standards except where inconsistent with law or otherwise impractical.*"

The FCC has previously acknowledged[59] that ANSI/IEEE C95.1-1992, was a voluntary consensus standard for the purposes of the Act. At that time, the FCC drew upon two lines of reasoning to suggest that adoption of the standard 'in its entirety' was "impractical". The first was that that ANSI/IEEE C95.1-1992 was not an internationally accepted consensus standard since it differed in key aspects from the recently released ICNIRP recommendations and secondly, that comments were filed by Federal health and safety agencies in that proceeding indicating that they were concerned about the safety ramifications of adopting certain aspects of the ANSI/IEEE C95.1-1992 standard. Therefore, based on these comments, the FCC concluded that adoption of ANSI/IEEE C95.1-1992 in its entirety would be problematic, and, therefore, would constitute an "impractical" action under the above-noted provision of the NTTAA, since it

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[57] 15 U.S.C. §3701 et seq. (1996)
[58] http://www.whitehouse.gov/omb/circulars_a119
[59] Second Memorandum Opinion and Order and Notice of Proposed Rulemaking, 12 FCC Rcd 13494 (1997) at Paragraph 36

would not satisfy public safety concerns raised by these expert federal safety and health agencies.

In relation to the first argument, the passage of time has now resulted in a harmonized "internationally accepted consensus standard", since both ICNIRP and IEEE C95.1-2005 are harmonised in relation to the partial body exposure limits of 2W/kg over 10gm averaging mass. While C95-1 MPE values for general public exposure are identical to the ICNIRP reference levels for 30 MHz to 100 GHz, the differences at lower frequencies that do exist seem hardly sufficient to claim that it is not an internationally accepted consensus standard. The World Health Organization itself recommends adoption of either IEEE C95.1-2005 or ICNIRP and recognises them from a health protection standpoint as being equal. The recommendation of the World Health Organization should also go in no small part to addressing the second of the concerns raised in the 1997 proceeding, at least with respect to the adequacy of the standard. While the WHO is not a US health agency, its recommendations and advice are carefully considerable by US agencies in other policy areas.[60]

In view of the Congressional and Executive mandate for agencies to adopt consensus standards, the existence of a harmonized internationally accepted consensus standard, the FCC's prior acceptance of the IEEE C95.1 standard as fulfilling the necessary criteria in principle and that health agencies such as the World Health Organization recommend its adoption, the MMF would submit that there is very strong support for the adoption of IEEE C95.1-2005.

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[60] For example the US Environmental Protection Agency adoption of WHO Dioxin Toxicity Equivalence Factors for Human Health Risk Assessments – see http://www.epa.gov/raf/hhtefguidance/

In light of the above, and noting that the FCC has stated that it is "confident in its own ability to remain abreast of scientific developments and research…as is necessary to make an independent determination of its exposure limits in the absence of affirmative input from agencies with more health and safety expertise"[61], the MMF submits that in the absence of inputs from other health agencies to the contrary, that the FCC moves to align its standards with those of IEEE C95.1-2005, being as it is a voluntary consensus standard and one that is accepted internationally.

While the existing standards are partly based on ANSI/IEEE C95.1-1992 and that in the 1997 proceeding the FCC decided at that time that it was "impractical" to adopt the standards in their entirety,[62] the language and logic in that Order led to the unavoidable conclusion that the FCC was knowingly mandating a government unique standard ('GUS').[63] We are now in substantially changed circumstances from those conditions and there is no need to continue to maintain the current standard, either formally or informally, as a GUS. The FCC in the current proceeding does not present any reasons why the 2005 version of the C95.1 standard would or could be considered "inconsistent with law or otherwise impractical" for adoption.

In view of the overwhelming international support for a harmonized exposure standard, together with the very clear Congressional and Administration direction for agencies to adopt voluntary consensus standards, the MMF submits

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[61] Id. Paragraph 215
[62] Second Memorandum Opinion And Order And Notice Of Proposed Rulemaking FCC 97-303 at Paragraph 36
[63] The fact speaks for itself, notwithstanding that the Commission did not list the RF exposure limits as a GUS in its 2012 report on NTTAA compliance.

that the FCC should align its standards with those of IEEE C95.1-2005.

6 – BENEFITS TO CONSUMERS IN RURAL AND REGIONAL AREAS

Harmonization between the current FCC standard and the international standard would provide both coverage and quality of service benefits for consumers living in rural and regional areas as well as those in areas of limited coverage. Use of the harmonized standard allows handsets to operate within a greater power range when needed thereby increasing the ability to connect to cellular networks, extend cell coverage and to maintain call quality in areas where handsets designed to current US standards will struggle.

Adoption of the international standard would allow a device to utilize additional transmission power ('TX') when needed which current US models can't in order to ensure compliance with the FCC's current standards. We provide further technical details on the extent of this additional TX power in Annex D.

Importantly, this additional TX power would only be relevant when the handset was being asked to operate at its current maximum – and that only occurs in areas of very poor coverage or signal strength such as in rural and regional areas or in difficult urban areas such as a basement garage.

The additional TX power available within the handset as a result of harmonization would also have the added benefit of extending the effective coverage of a given cell by 35-40% or increasing its capacity by around 30%. In urban areas the additional capacity will be useful to handle greater data demands while in areas with marginal existing coverage the extended coverage will make a significant improvement to users experience. Calculations for this additional coverage and capacity are also included in Annex D.

It is also important to note though that the additional TX power that would come from a change in the standards does not imply that most consumers would be exposed to greater RF emissions. As for devices in use today, the power control in the network will only instruct the device to operate at the level needed to make or maintain a call. Therefore in areas with good coverage the actual TX level of both an existing handset and one designed to comply with the international standards would, in the same location and utilizing the same frequencies, be the same. The key difference though would be in areas where existing handsets are struggling to make and maintain a call or connection, whereby the additional TX power would make a noticeable difference for the consumer.

The reported maximum SAR for a given device is often the result of taking into account the impact of multiple transmitters being active simultaneously. For example, a US device with a maximum reported SAR of 1.50 W/kg, might have a 'cellular' component equating to 1W/kg on a particular band with the remaining 0.50W/kg being contributions from simultaneously active Wi-Fi and Bluetooth antennas. Thus even with the current standards, manufacturers are not able to fully utilize the available TX power for cellular bands as they must ensure compliance in situations where simultaneous transmissions can occur. Adoption of the international standards would not change the need to take into account multiple transmitters, but it would allow manufacturers to adjust TX power in the cellular bands while still ensuring compliance when testing with multiple transmitters.

Also, the FCC is aware of the complex nature of SAR measurement and the many factors that can influence it. It should not therefore be assumed that even if a change in the FCC's standards occurred that every handset would have a higher SAR. Constant innovation in device design, internal layout and improvements in antenna performance and design will all still continue to take place and will continue to have significant influence on the resulting SAR for a device.

While the exact impact of these changes involves rather complex modeling to ensure directly comparable results (the FCC's standards for both base stations and handsets differ from those adopted in IEEE C95.1- 2005 and those used elsewhere in the world), the data[64] clearly demonstrates that US consumers would enjoy a number of direct benefits from the international harmonization of the FCC's standards.

7 – HARMONIZATION HELPS MEET CONSUMER DEMAND FOR COVERAGE

In the US, trends in mobile wireless services continue to evolve from primarily voice-centric to data-centric according to the FCC's 16th Mobile Competition

[64] See Annex D for further details

Report.[65] U.S. mobile data traffic increased 270 per cent from 2010 to 2011 and has more than doubled each year for the past four years.

U.S. mobile networks carried 69 per cent more data traffic in 2012 than in the prior year, but roughly the same number of voice minutes and fewer SMS messages, according to the CTIA.[66] In 2012, smartphone adoption increased, with 55.5 per cent of mobile wireless consumers reported to have smartphones as of July 2012, up from 41 per cent in July 2011.

Around the world consumer expectations for mobile coverage are changing and this trend is also likely to become more evident in the United States as more users adopt smartphones and other wireless devices that require fast and reliable mobile broadband connections. As has been detailed in the preceding section, a key benefit for adopting the international standards is the improved coverage, greater network capacity and better data rates over an extended area – all of which will lead to a better wireless telephony and broadband experience for consumers.

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[65] FCC 16th Mobile Competition Report March 21, 2013: http://www.fcc.gov/document/16th-mobile-competition-report
[66] CTIA Semi-Annual Year-End 2012 Wireless Industry Survey: http://www.ctia.org/advocacy/research/index.cfm/AID/10316

8 – HARMINZONISATION STRENGTHENS US TECHNOLOGY LEADERSHIP

With the deployment of LTE, the United States currently enjoys a position of considerable technology leadership. The speed at which the technology has been deployed and the consumer uptake has been such that a recent report by the GSM Association estimates that by the end of 2013, 19% of US connections will be on LTE compared to only 2% in the European Union[67].

But as has often been seen, this technological lead can quickly be lost in this rapidly changing environment. Already manufacturers are finding the compliance framework established by the FCC for LTE devices exceptionally complicated and time consuming. Our concerns in this area are detailed separately, but standards harmonization would make the design and development of new devices much easier since there would only be one standard in the world to design for.

As the US Chamber of Commerce remarked recently, 95% of the world's consumers live outside of the United States[68], and harmonization can only help US companies gain greater access abroad. Manufacturers would clearly benefit from being able to design products for a global market and not just for the US market.

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[67] *Mobile Wireless Performance in the EU and the US*, GSM Association, May 2013
[68] U.S Chamber of Commerce, *U.S Chamber Welcomes Executive Order on International Regulatory Cooperation*, Press Release, May 01, 2012

Likewise, retention of the existing outdated standards also hurts US interests. India, recently decided to adopt the FCC's standards for handsets, but rather than this being a good development for US companies, it has caused considerable disruption and problems for all players in the market. India essentially uses European frequency bands, and thus by adopting the FCC standards for handsets, has effectively created a 'third' set of compliance requirements for the industry to design and test to. Despite the disruption that this has caused US and other manufacturers, the United States has no grounds upon which to complain since the Indian Government has adopted the FCC's standard - yet few would argue that this benefits anyone.

Thus if the FCC, and by extension the United States, wants to remain an influential and thought leader in this domain, international harmonization needs to be seen as being in the best interests of the United States.

C - CONSUMER INFORMATION

The MMF supports the FCC's statement that "[s]everal general strategies are available for users of portable devices that want to reduce their exposure." including "increasing distance from the device and decreasing time of use are obvious actions to reduce exposure"[69]. Information such as that already provided by the FCC is extremely helpful in reminding consumers that they can limit or reduce their exposure should they wish to. This advice is also consistent

[69] Id. Paragraph 233

with the statements made by the WHO[70]:

> *In addition to using "hands-free" devices, which keep mobile phones away from the head and body during phone calls, exposure is also reduced by limiting the number and length of calls…*

Members within the MMF also provide information consistent with the above to consumers within the SAR information section of their user guides and/or their websites. This includes the following statement:

> *Organizations such as the World Health Organization and the US Food and Drug Administration have stated that if people are concerned and want to reduce their exposure they could use a hands-free device to keep the phone away from the head and body during phone calls, or reduce the amount of time spent on the phone.*

In addition to the above information the MMF has also expanded our SAR reporting program – now known as SAR Tick. The SAR Tick initiative incorporates a number of elements:

(a) The introduction of a SAR Tick (see below) to provide a visual confirmation that the phone has been tested for SAR compliance and provides a link to a new consumer-oriented website on SAR issues; and

(b) The inclusion of additional information in the "health and safety section/important product information section" of the user manual; and

(c) The modification of the existing SAR information text to include a clear table of the maximum SAR values for the device and the operating conditions under which they were recorded.

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[70] http://www.who.int/mediacentre/factsheets/fs193/en/

With regards to (a & b) some manufacturers now include a new SAR Tick logo in the front section of the user manual or in the short guide that accompanies the phone, similar to the following:

www.sartick.com

This product meets the applicable FCC SAR guideline of 1.6W/kg when held against the head or at a distance of x.x cm or x/x of an inch from the body. The FCC SAR guideline includes a considerable safety margin designed to assure the safety of all persons, regardless of age and health. The specific maximum SAR values for this product can be found in the xxxx section of this user guide.

When using the product next to your body (other than in your hand or against your head), either use an approved accessory such as a holster or maintain a distance of x.x cm or x/x of an inch from the body to ensure your use is consistent with how the device is tested for compliance with FCC RF exposure requirements. Note that the product may be transmitting even if you are not making a phone call.

Figure 1: Example of SAR Tick logo and accompanying text.

The logo serves to visually reinforce the text, and provides a short summary of the essential compliance information for the device. The text also provides a reference to the full SAR compliance information that is often located elsewhere in the manual. This format meets the key outcomes raised by stakeholders for (a) greater visibility within the manual, and (b) providing key information in the safety or 'important product information' section that appears 'up front'. Such an approach also allows manufacturers the flexibility to provide a full explanation and proper context to SAR in the section of their user manual that best fits with the overall structure/layout of the document.

The SAR-tick logo also includes a link which directs consumers to www.sartick.com - a new comprehensive and dedicated website focussing on SAR which consolidates existing and new SAR resources for the general public.

With regard to element (c) discussed above, some MMF members are now including additional information in the full SAR compliance information section of the user manual. This information includes the maximum SAR recorded for both head and at the body and includes the operating conditions that this maximum was recorded at. The presentation of this information is clearer and again addresses concerns raised by stakeholders. The information is provided with explanatory text that helps consumers know more about what SAR is and how it is measured as well as the practical advice that the FCC and the FDA have provided for those consumers who wish to reduce their exposure – as mentioned above. The full text of this SAR explanatory text is provided in Annex E.

In addition to the information provided, we have also commissioned an international survey of consumer attitudes and knowledge about SAR issues. In 2011, the MMF along with other partner organizations including the GSMA, commissioned Circle Research in the United Kingdom to undertake a study in nine countries, including the United States. The purpose of the research project was to provide a robust measurement of understanding of safety compliance information for mobile phones that can be monitored over time, including:

- The importance of key factors determining the choice of mobile phone, including the SAR value;

- The extent to which people may be worried about possible health risks associated with using mobile phones;
- The incidence at which people may request information about the possible health risks that may be associated with using mobile phones;
- Awareness and understanding of SAR, a technical measure for mobile phone compliance;
- Understanding of SAR compliance testing;
- Determining how people might go about obtaining information about SAR;
- Understanding how people would go about reducing exposure to radio signals when using a mobile phone.

Two of the key findings from this study relevant to this proceeding include:

1. That the SAR value was the least important out of the 21 factors which determine the choice of mobile phone; and
2. There is slightly less concern in the US about possible health risks associated with using a mobile phone than elsewhere and fewer people in the US look at or request information about possible health risks.

In view of the above, and to answer the question posed by the FCC about whether additional disclosure of the SAR is required[71], the MMF submits that with information available from the FCC[72,73], the FDA[74], Manufacturer websites[75,76,77,78, 79,80] and user manuals, trade association websites such as the MMF[81,82], GSMA[83] and CTIA[84], as well as numerous third party sites including popular consumer sources such as CNET[85] – that information about SAR is readily available should a consumer have an interest in the issue. The above survey indicates that consumers in the United States are not that interested in the issue, indicating it as the least important factor in the purchasing decision, and that few people are concerned about the issue or ask for information on it.

The MMF also questions the rationale behind the FCC's statement that "there is inconsistency in the supplemental information voluntarily provided in the manuals provided with portable and mobile devices" and that "for a variety of reasons, the maximum SAR value that is normally supplied is not necessarily a reliable indicator of typical exposure and may not be useful for comparing

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[71] Id. Paragraph 234
[72] http://transition.fcc.gov/oet/rfsafety/rf-faqs.html and http://www.fcc.gov/guides/wireless-devices-and-health-concerns
[73] http://www.fcc.gov/guides/specific-absorption-rate-sar-cell-phones-what-it-means-you
[74] http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116282.htm
[75] http://www.nokia.com/global/about-nokia/people-and-planet/emf-health/sar/sar-information/
[76] http://rfhealth-sar.motorola.com/SAR/sar.html
[77] http://blogs.sonymobile.com/about-us/sustainability/health-and-safety/sar/
[78] http://www.ericsson.com/ericsson/corporate_responsibility/health/
[79] http://www.samsung.com/sar/sarMain.do?site_cd=global&prd_mdl_name=GT-I9100
[80] http://www.apple.com/legal/rfexposure/
[81] http://www.mmfai.org
[82] http://www.sartick.com
[83] http://www.gsma.com/publicpolicy/mobile-and-health
[84] http://www.ctia.org/consumer_info/safety/index.cfm/AID/10371
[85] http://reviews.cnet.com/cell-phone-radiation-levels/

different devices."[86]

The MMF considers that the FCC's own advice to consumers available on its website[87] indicates the purpose of SAR values and that they are not intended to show typical exposure:

> *..the SAR values collected by the FCC are intended only to ensure that the cell phone does not exceed the FCC's maximum permissible exposure levels even when operating in conditions which result in the device's highest possible – but not its typical - RF energy absorption for a user.*

The MMF considers that this explanation of what SAR is intended for, is important and helps to correct attempts to paint SAR as being some form of 'relative safety indicator', which is clearly wrong and inappropriate. As the FCC itself advises consumers:

> *Consequently, cell phones cannot be reliably compared for their overall exposure characteristics on the basis of a single SAR value for several reasons (each of these examples is based on a reported SAR value for cell phone A that is higher than that for cell phone B):*
>
> *- Cell phone A might have one measurement that was higher than any single measurement for cell phone B. Cell phone A would, therefore, have a higher reported SAR value than cell phone B, even if cell phone B has higher measurements than A in most other locations and/or usage configurations. In such a case, a user generally would receive more RF energy overall from cell phone B.*
>
> *- Cell phone A might communicate more efficiently than cell phone B, so that it operates at lower power than cell phone B would under comparable conditions. Consequently, a user would receive more RF energy overall from cell phone B.*
>
> *- The highest value from cell phone A might come from a position which the user seldom or never employs to hold a phone, whereas that user might usually hold a phone in the position that resulted in the highest value for cell phone B. Therefore, the user would receive the highest RF exposure that cell phone B delivers but would not receive the highest RF exposure that cell phone A delivers.*

Therefore the MMF does not support the FCC's contention of any

[86] Id. Paragraph 234
[87] http://www.fcc.gov/guides/specific-absorption-rate-sar-cell-phones-what-it-means-you

"inconsistency"[88], as the SAR values provided accurately reflect the conditions under which manufacturers are required to test by the FCC and that the values are not intended to be used for comparison purposes.

With regards to the question posed by the FCC as to whether it should also take actions to better enable consumers to correlate the make and model number of their device to an FCC ID[89] the MMF would support this action in principle. The MMF notes though that the current structure of the FCC's website in this regard reflects its process of granting authorizations and these are not directly related to the model names and numbers that a consumer would typically be searching for. While supporting efforts to improve consumer access to this information the MMF would be concerned if this change resulted in additional burdens or delays for manufacturers in obtaining the necessary authorizations. This would particularly be the case for manufacturers of radio modules. Ultimately the MMF prefers the FCC to encourage consumers to access the SAR information directly from manufacturers own sites, since then the information does not need to be duplicated and the FCC database can continue to serve the function that it was intended to.

With regards to the request for comment[90] on how consumers with disabilities can access this information the MMF notes that alternative formats of user manuals are already available to consumers with disabilities. These alternative user manuals include the same information as normal user manuals with regards to RF and are available upon request from manufacturers in different formats

[88] Id. Paragraph 234
[89] Id. Paragraph 235
[90] Id. Paragraph 231

including Braille, Large Print and Audio Cassette/CD.

The FCC also requests comment on what additional information should be developed relating to exposures from common fixed sources such as network infrastructure.[91] The MMF certainly supports the need for information sources to be available, and has itself developed a number of resources designed to address questions from the general public including the website EMF Explained[92] which has been developed in co-operation among the MMF, the GSM Association and the Australian Mobile Telecommunications Association (AMTA). Such resources reference national and international health agencies where possible to provide answers to common questions and to provide explanation on topical issues. The MMF notes that there also exists a large number of information resources on the topic[93,94,95,96] and while we would support the FCC further developing its own materials[97], we would encourage the FCC to adopt or collaborate with other bodies and agencies that have already produced materials to ensure timely development and consistency in the advice being provided.

D - EXPOSURE REDUCTION POLICIES

The MMF supports the FCC's statement that it "has a responsibility to provide a

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[91] Id. Paragraph 233
[92] http://www.emfexplained.info
[93] See for example: http://www.who.int/peh-emf/about/en/ and http://www.who.int/peh-emf/publications/facts/fs304/en/index.html
[94] http://www.arpansa.gov.au/pubs/eme/fact6.pdf
[95] http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields/RadioWaves/BaseStations/
[96] http://www.cancer.org/cancer/cancercauses/othercarcinogens/athome/cellular-phone-towers
[97] http://transition.fcc.gov/oet/rfsafety/rf-faqs.html

proper balance"[98] between protection for the public (and for workers) and allowing industry to provide telecommunications services to the public in the most efficient and practical manner possible. The MMF believes that this balance and the responsibility that accompanies it, is well met through the adoption of internationally harmonized science-based exposure standards which provide a high level of protection for all members of the community.

The comment that "[i]mposing additional precautionary restrictions on device design and/or on the siting of fixed transmitting facilities to reduce exposure may entail significant costs that licensees and equipment manufacturers would need to consider when developing communications systems or designing equipment"[99] is indeed true, which we summarize below.

1 - NETWORK INFRASTRUCTURE

There are a large number of unintended consequences from adopting additional precautionary measures and, as we have seen in Europe, in many cases these measures have been ineffectual in allaying concerns, and in some cases, have resulted in increased concerns. Recent research into these policies has likewise cast doubt on their effectiveness.

It is interesting to note that in Europe where the product standard EN 50360[100] applies under the Radio & Telecommunications Terminal Equipment (R&TTE)

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[98] Id. Paragraph 236
[99] Id. Paragraph 238
[100] EN 50360: product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300 MHz - 3 GHz). OJ C 208, 26.07.2001

Directive[101] and requires compliance with the exposure limits set out in Council Recommendation (1999/519/EC) of 12 July 1999[102] - i.e., ICNIRP values[103] - there is little concern about the devices. Contrast this with the varying national regulations that have been imposed on the deployment of base stations, which has resulted in a variety of 'precautionary' and restrictive siting policies and other measures – that have resulted in increased community concerns rather than less.

One of the main consequences of adopting maximum exposure values that are not based in science is that compliance distances quickly become unrealistically large, thereby restricting public access within a much larger area than what is otherwise required. Table 1 lists the changes to the calculated typical compliance distance for various antenna types caused by an arbitrary reduction in power density exposure limits below those recommended by ICNIRP.[104]

Table 1. Typical compliance distances at 1800 MHz

Antenna type	**Compliance distance (m) at ICNIRP limit (58 V/m)**	**Compliance distance (m) at a limit 10 times below ICNIRP (18 V/m)**
Sector antenna (~100 W)	8	25

[101] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity

[102] Council Recommendation (1999/519/EC) of 12 July 1999 on the limitation of the exposure of the general public to electromagnetic fields (0Hz – 300 GHz)

[103] see http://europa.eu/rapid/press-release_IP-01-1190_en.htm?locale=en

[104] Over the years many different limit values have been proposed by activists including 18,14, 6, 3 and 0.6V/m. Rather than document the implications of each, we have used 18V/m @1800 MHz to model the various implications. Compliance distances will therefore only expand further out from the base station with lower limit values.

Sector antenna (~20 W)	2	10
Microcell antenna (5 W)	0.5	3

As a result of the adoption of these arbitrary reductions site sharing often also becomes more difficult, if not impossible, to undertake, because the compliance boundaries for each antenna begin to overlap. The examples in Figures 2 & 3 highlight the difficulty of site sharing if limits of 18-19 V/m at 1800 MHz and 2100 MHz were implemented. The resulting compliance zone means that access would need to be restricted in areas where people normally reside, or more realistically, necessitate the antennas be installed on separate sites.

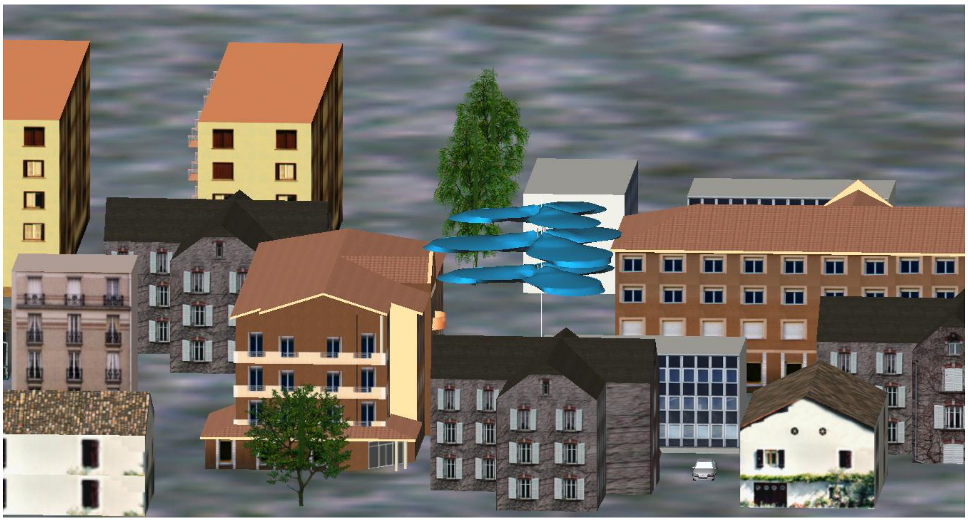

Figure 2: Two operators share a mast with a total of nine GSM1800 and WCDMA2100 antennas (80-120 W per antenna), which at ICNIRP levels results in one separate compliance boundary for each of the antennas.

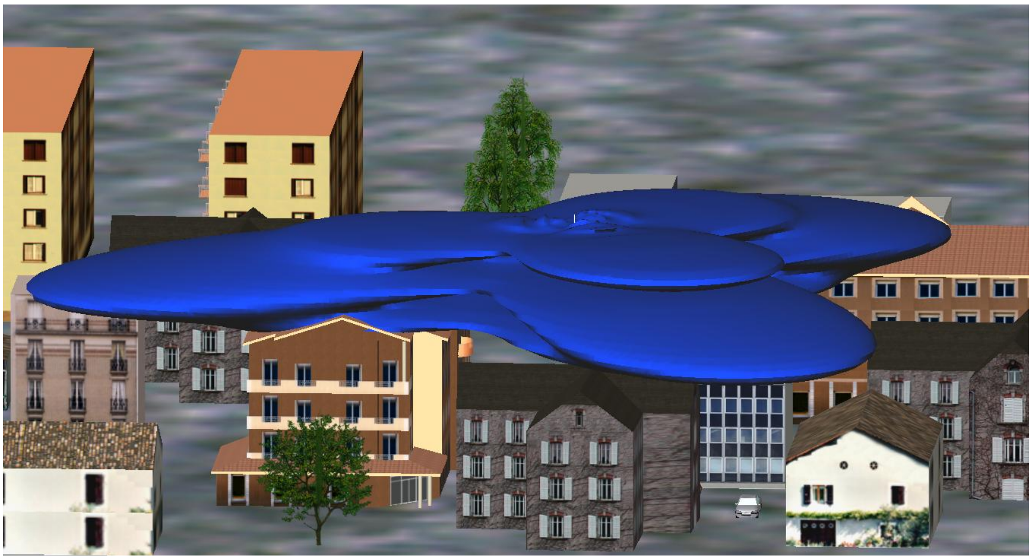

Figure 3: At lower limits (18 V/m at 1800 MHz and 19 V/m at 2100 MHz) the compliance boundaries of the antennas overlap, resulting in one very large compliance boundary extending about 40 meters from the mast.

In much the same way as site sharing would become a problem, operators who wish to deploy additional radio technologies or antennas at a given site would also find it difficult to ensure manageable compliance distances. Again, the compliance boundaries for each additional antenna that would be located on a site could overlap thereby extending the effective compliance boundary for the overall site. This may act as a barrier to the deployment of higher data rate mobile technologies that are integral to the policies of many governments to promote access to broadband.

This very problem is being experienced today in Brussels in Belgium, where as a result of a number of political decisions in recent years, the limits have been reduced to the point where the deployment of 4G services cannot be undertaken. This has resulted in the European Commission having written to the Brussels Environment Minister saying that the limits are insufficient to allow the mobile network operators to roll-out an effective 4G network in the capital and are "damaging the economy without protecting the population."[105]

The situation in Belgium, like other countries that have adopted similar 'precautionary' policies, has come about because of continued pressure to adopt lower and lower exposure limits. The Brussels region has reduced their limit values several times[106] in the last decade and, as is evident in some European countries today, it is essentially a race to the bottom. Further evidence of this on going push to lower the values can be seen in a 2012 report[107] by the BioInitiative group in which the two editors recommend a limit of just 0.0003 $\mu W/cm^2$. This level would result in typical compliance zones around base station sites that would extend about a hundred meters around pico sites, through to several hundred meters for micro base stations and through to several kilometers for a macro base station. Such a policy would thereby render wireless communications services including radio and TV broadcasting impossible to provide.

One of the few means of addressing arbitrary reductions, where they have been introduced, is to reduce the power output of antennas. This has the effect of reducing the compliance zone back within a manageable area. However in an established network, such reductions have a direct impact on network coverage, usually resulting in the need for additional base stations to fill gaps created by

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[105] http://www.deredactie.be/cm/vrtnieuws.english/Brussels/1303044G_Brussels+
[106] http://www.mmfai.org/public/docs/eng/MMF%5Fvp%5FBelgium%5FImpactLowLimits%5Ffinal2%2Epdf
[107] http://en.wikipedia.org/wiki/Bioinitiative_Report

the reduced cell coverage area. In a new network, it can result in the deployment of more base stations than would otherwise be needed.

Therefore one of the ironies of adopting arbitrary reductions below the levels recommended in the international standards is that it inevitably results in the need for more sites, and it is often site deployment that has created the community questions and concerns in the first place, since the pubic want the service but they often do not want the infrastructure.

In addition to the impacts mentioned above:

- Reductions in network coverage can adversely impact the emergency services as well as consumers who are relying on their mobile phone to contact emergency services;
- Arbitrary reductions can be interpreted by the public as evidence that there is something to be concerned about regarding the safety of base stations; and
- Lower limit values create the perception that base station emissions are now much higher when viewed as a percentage of the relevant limit compared with the international standard;
- The adoption of arbitrary values lack any scientific justification, and as such, resisting calls for further reductions becomes a matter of political will rather than of scientific merit;
- Arbitrary reductions to the international standards do not provide any measurable improvement with regards to the effects of EMF exposure, as both ICNIRP and the IEEE standard are already well below the threshold level that can cause adverse effects.

- Consistent international experience is that 'precautionary measures' can increase the level of concern within the public rather than reduce it.

Further to the last point, there is now a growing body of evidence that such 'precautionary measures' can actually heighten concern within communities. In 2010 the European Commission undertook EU wide survey of community attitudes relating to EMF and found that the countries that had lowered RF standards and/or adopted other precautionary measures actually had higher levels of community concern than those EU countries that had maintained ICNIRP guidelines for base stations[108].

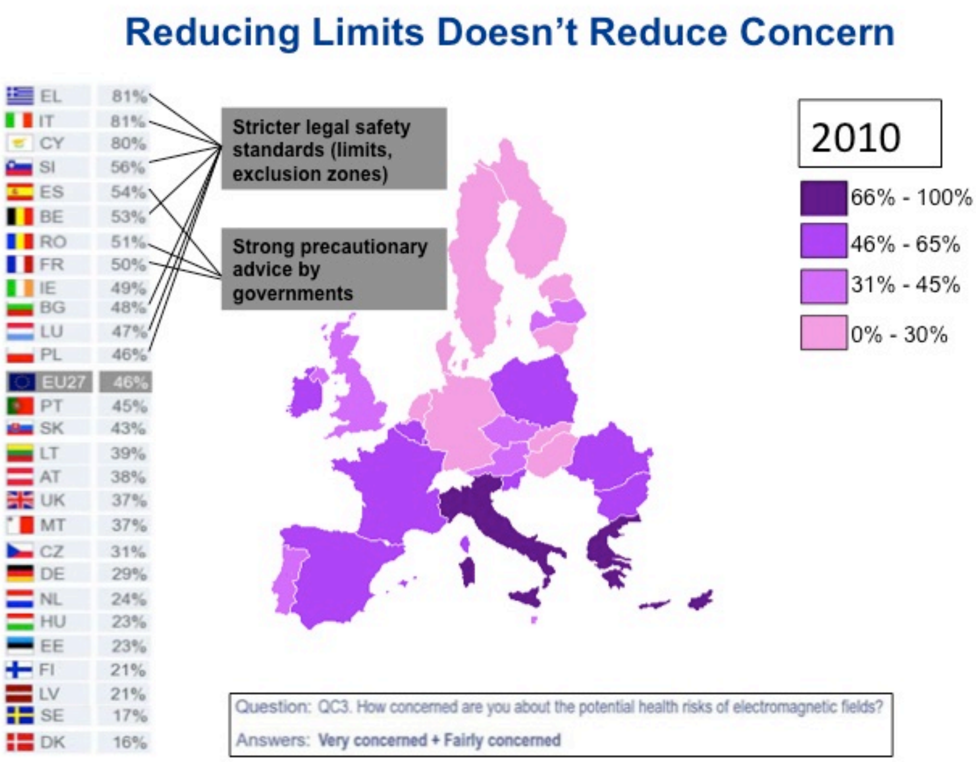

Figure 4: Data from Eurobarometer 73.3 Electromagnetic Fields[109],

[108] In the European Union, Council Recommendation (1999/519/EC) of 12 July 1999 adopts ICNIRP limit values

[109] Special Eurobarometer 347. Electromagnetic Fields. Brussels. 2010. Available at: http://ec.europa.eu/public opinion/ archives/ebs/ebs 347 en.pdf. Accessed on August 10, 2012.

Conducted by TNS Opinion & Social Directorate General for Health and Consumer Affairs. Country order here is rearranged from highest to lowest and additional explanatory notes added alongside results.

Interestingly a number of recent social science research papers[110,111] have suggested that, at least in the area of EMF, precautionary measures have often resulted in public misunderstanding and concern – or to put it in the language of the researchers, 'amplified risk perception'. In a nine country multinational experimental study, Wiedemann et al.[112] found that informing people about implemented precautionary measures did not decrease public concerns. Likewise "framing the information on precautionary measure as 'protecting public health' versus 'avoiding health risks' did not result in different risk perceptions."

Notwithstanding the above, the FCC also seeks comment on those jurisdictions that have adopted the concept of "prudent avoidance" and whether any technical approach to reduce exposure below the FCC's standards in some situations is appropriate or feasible, particularly in cases in which there is no specific quantitative goal for improvement.[113]

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110 Timotijevic L, Barnett J. Managing the possible health risks of mobile telecommunications: Public understandings of precautionary action and advice. Health, Risk & Society, 2006; 8(2): 143–164

111 Wiedemann PM, et al., The impacts of precautionary measures and the disclosure of scientific uncertainty on EMF risk perception and trust. Journal of Risk Research, 2006; 9(4): 361–372.

112 Wiedemann PM, et al., "When Precaution Creates Misunderstandings: The Unintended Effects of Precautionary Information on Perceived Risks, The EMF Case", DOI:10/1111/risa.12034

113 Id. Paragraph 238

The MMF notes that the approach adopted in Australia seeks to provide the sort of balance that the FCC has inherently recognized[114], whereby in addition to the ARPANSA Radiation Protection Standard "Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz" the Australian Communications and Media Authority (ACMA) also have registered an industry Code of Practice established by the Australian Communications Industry Forum (ACIF) called *Industry Code for the Deployment of Mobile Phone Network Infrastructure C564* (the "ACIF Code").

According to the ARPANSA[115]:

> *The Code supplements the requirements already imposed on carriers under the existing legislative scheme by requiring them to better inform and consult with the local community and to adopt a precautionary approach in planning, installing and operating telecommunications infrastructure.*

Therefore in the Australian context, a precautionary approach in relation to planning, installing and operating network infrastructure sits comfortably alongside the adoption of ICNIRP guidelines as part of their national standard. In response to misapplications of the precautionary principle, in 2000 the European Commission produced a *Communication on the Precautionary Principle*[116] that made it clear that a proper risk assessment was the basis of using the principle and safety measures such as exposure standards should not be arbitrary. The report concluded:

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[114] Id. Paragraph 236
[115] ARPANSA Fact Sheet No. 6: "About Mobile Phone Networks"
[116] http://ec.europa.eu/dgs/health_consumer/library/pub/pub07_en.pdf

> *The Commission also considers that every decision must be preceded by an examination of all the available scientific data and, if possible, a risk evaluation that is as objective and comprehensive as possible. A decision to invoke the precautionary principle does not mean that the measures will be adopted on an arbitrary or discriminatory basis.*

It is also useful to recall that the European Commission itself considers the adoption of the EU Council Recommendation (i.e., ICNIRP guidelines) as being an exercise in the application of the precautionary principle[117], which is enshrined in the Treaty on the European Union (also known as the Maastricht Treaty). In 2010 the European Commission published a meeting report[118] saying that, "the Council Recommendation already contains a certain level of precaution." The European Commission then went on to say that a revision of the exposure limits was not justified and concluded:

> *The Precautionary Principle excludes a purely hypothetical approach to risk. Safety factors must be applied to established facts in a consistent way to avoid an open ended process. So far, there are no new elements that would justify applying additional safety factors to the Council Recommendation.*
>
> *The differences in exposure limits between Member States are confusing for the public opinion. A common approach would be good for everybody, but this is in the hands of Member States.*

It should be noted that, consistent with the findings outlined above, that if a precautionary approach is to be adopted, then the manner in which it is communicated can in fact send mixed messages to the public and may risk increasing community concern.[119]

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[117] http://ec.europa.eu/health/archive/ph_risk/documents/ev_20090211_co01_en.pdf,
[118] http://ec.europa.eu/health/electromagnetic_fields/docs/ev_20100503_mi_en.pdf

[119] Dolan M & Rowley J: The Precautionary principle in the Context of Mobile Phone and Base Station Radiofrequency Exposures, Environ Health Perspectives. 2009 September; 117(9): 1329–1332 also cites Barnett J, et al., Public responses to precautionary information from the Department of Health (UK) about possible health risks from mobile phones., *Health Policy. 2007 Jul; 82(2):240-50,*

2 - DEVICES

In relation to the precautionary aspects of devices, the MMF notes that a recent analysis of the FCC's own data has shown that the maximum SAR for approved devices has decreased over time:

> *The FCC data also provide insights regarding some changing RF exposure factors over time. It is noteworthy that maximum SARs decreased over the period from 1999 to 2005, mainly reflecting a trend toward lower maximum power communication systems as well as lower SARs for bar-type phones with internal antennas and lower SARs from slider phones with all types of antennas….To the extent that the types of phones tested over the years approximate the use in the US population, these data would suggest a decrease in population exposures per unit time of use.* [120]

While the trend of decreasing SAR has been influenced by changes in form factors, technology, antenna design and performance, it is worthwhile noting in the context of the FCC's consideration of RF exposures, that the data shows a decrease in population exposure 'per unit of time of use' over the years.

And as we discuss further in Annex C, the impact of power control and discontinuous transmission on the devices also ensures that phones operate well below their maximum for the vast majority of time. The study by Persson et al.[121] for example, found that after assessing output power from more than

[120] Kuehn et al., Analysis of mobile phone design features affecting SAR in a human head *Bioelectromagnetics.*, Vol. 34, Pg. 479 - 488, 2013

[121] Persson et al., Output power distributions of terminals in a 3G mobile communication network *Bioelectromagnetics.*, Vol. 33, Pg. 320 - 325, 2012

800,000 hours of voice calls, the average level for 3G voice calls was below 1mW across all environments including rural, urban, and dedicated indoor networks. These results were consistent with the findings of an earlier study by Wiart et al.[122] of mobile phone use in everyday life, which found that when talking on a mobile phone while walking around a major city or inside city buildings, smartphones typically operate at less than one per cent of the phones maximum power output. This equates to 100 times less emissions than the maximum exposure level measured in SAR compliance tests. The researchers stated:

> *Finally, 90% of all collected measurements (indoor, outdoor) are less than 4dBm (1% under the maximum possible emitted power). The real exposure due to mobile phones in terms of Specific Absorption rate (SAR) is then well below (100 times below) the normative values given at the maximum powers.*

While mobile phones and network base stations have always reduced power output to the minimum level required to make a quality connection, 3G technologies have significantly improved this ability. The ability of the handset and network to adapt their power levels is now much faster and if one person is not talking during the conversation the phone stops transmitting – except for occasional handshake signals to let the network know they are still connected and still listening to the call – a technical feature known as discontinuous transmission.

Researchers have also investigated other factors, which might increase power output such as using a phone in less populated areas with less network coverage

[122] Wiart et.al. *Exposure induced by WCDMA Mobile Phones in Operating Networks*, IEEE Trans on wireless communications Vol. 8 No 12 2009

or while driving around the city where a phone has to regularly look for and handover the call to new cells in the network. However, this has not been shown to make a significant difference and average handset power did not rise beyond 2% of the phones maximum. This is because 3G networks now handle the handover connections between each cell in the network more efficiently and the phone does not need to use maximum power during handover to a new cell.

An earlier study in 2000 by Wiart et al.[123] looked at the impact of power control on 2G networks and found that these required more power during handover and average output increased to 20% to 50% of the phones' maximum for a short time. In that particular study, the average power output of a mobile phone operating on 2G networks was 35% of the phone's maximum power output.

A further analysis undertaken by Gati et al.[124] of more than 3.5 million power samples – made from specially designed 'trace mobiles' that can register the transmitted and received powers during a call – on both 2G and 3G networks confirmed these results. A further analysis by Persson et al.[125] concluded:

> *The average output power of a 3G WCDMA voice call was below 1 mW for any environment, which is less than 1 % of maximum available level.*
>
> *The typically very low output power puts it on an equal or even lower level than other commonly used wireless devices such as DECT and Bluetooth.*

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[123] Wiart, Dale et al. *Analysis of the Influence of the Power Control and Discontinuous Transmission on RF exposure with GSM Mobile Phones*, IEEE Transactions on Electromagnetic Compatibility, Vol 42, No 4, November 2000.
[124] Gati et al. *Duality Between Uplink Local and Downlink Whole-Body Exposures in Operating Networks*, IEEE Transactions On Electromagnetic Compatibility, 1-8, Published Online: 20 September 2010.
[125] Persson et al., Output power distributions of terminals in a 3G mobile communication network *Bioelectromagnetics.*, Vol. 33, Pg. 320 - 325, 2012

Therefore the existing environment in which the industry is operating within has seen both the maximum reported SAR for devices reduce over time, as well as the devices operating at average power levels of between 1% to 35% of their maximum as a result of power control and discontinuous transmission.

While some may argue that while the maximum SAR of devices may have decreased over time, average call use has substantially increased. However, the available data for average call duration and overall voice traffic suggests that voice traffic and call durations have remained relatively stable over time.

The CTIA's Semi-Annual Wireless Industry Survey includes data for 25 years of local call data and almost 20 years of roaming data, showing that the averages year-on year have remained relatively constant and overall average only 2.4 and 3.2 minutes respectively.[126]

Likewise, the CTIA's data also shows that, for example between 2008 and 2012, minutes of usage (MOU's) across all networks, has only modestly increased rising from 2,203 billion MOU's in 2008 to 2,300 billion in 2012. Taking into account the subscriber growth during this period then the number and duration of calls per user is not growing substantially.

Consumers are certainly making use of their devices for longer periods than ever before, reflecting the variety of uses other than for voice. It is interesting to note

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[126] http://files.ctia.org/pdf/CTIA_Survey_YE_2012_Graphics-FINAL.pdf

that the growing data usage as is shown in the graph below from Ericsson[127], which is also forecast to continue.

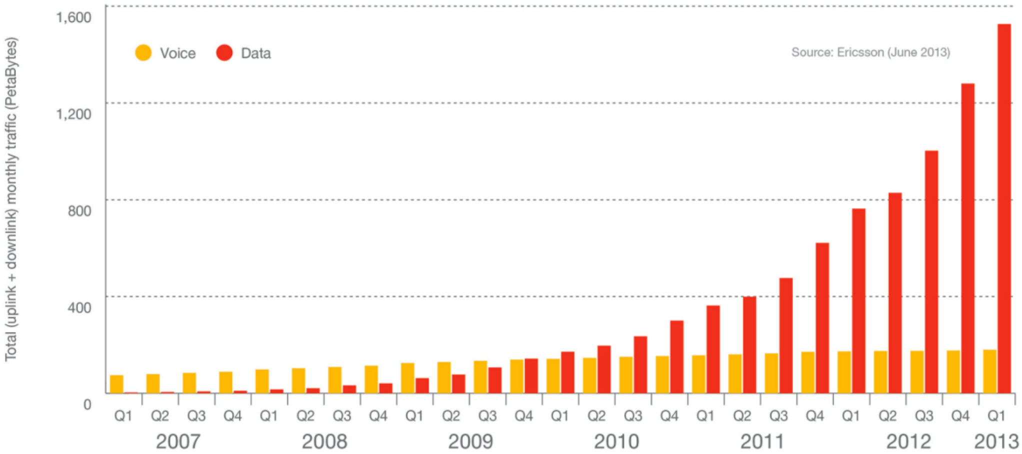

Figure 5: Global total data traffic in mobile networks, 2007-2013

It is useful to recall that when a user is accessing data services, they are not typically using the device against the head or even against the body. The more typical use for accessing wireless data is when the device is away from the body – either in the hand or on another surface – such as when accessing the internet and email, watching a streaming video or undertaking a video conference call. Ericsson in its latest report is forecasting that video will account for around half of global mobile data traffic by 2018.[128]

Therefore with the maximum reported SAR for devices having effectively reduced over the years through technical improvements to the design and efficiency of antennas and other factors, the substantial reduction on real output power of a device caused by power control and other network features that

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127 Ericsson Mobility Report, June 2013
128 Ericsson Mobility Report, June 2013, page 10.

ensure greater efficiency – coupled with the fact that voice call traffic has remained relatively constant over time, the MMF submits that there is no need for the FCC to consider additional measures to reducing exposures further. In fact, continued innovation in the technology and the push for greater network and device efficiency are effectively delivering this outcome.

For the above reasons, the mobile communications industry believes that the adoption of arbitrary reductions below the values recommended in the international standards represents a poor policy choice, and one that actually threatens the proven safety, security and economic benefits that mobile communications provides to the community at large. However, as has been shown in several cases, the adoption of internationally harmonised standards is also considered by several governments as being an application of precaution and consistent with a precautionary approach to the issue.

E – EVALUATION

The MMF agrees with the comment that "evaluation is a rapidly evolving area…most effectively guided by good engineering practice rather than specific regulations."[129]

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[129] Id. Paragraph 244

Wireless devices have become increasingly complex working over multiple frequency bands and communications technologies and with an ever-increasing demand by consumers for higher capacity and higher speed data services. The current state of the art technology supplied to consumers is LTE and commonly referred to as 4G services. However, the overly conservative FCC testing requirements mean a very significant increase in the number of SAR tests facing manufacturers and the associated time to market delays and costs. According to the current FCC SAR test procedures for LTE devices[130], some handsets are required to undergo in excess of 100 SAR tests for head and body exposure in only two LTE frequency bands, which equates to 4 – 6 weeks (double shifts) for type approval SAR testing and this figure is unreasonably high given that the typical product life cycle is 12 months or so.

Other national approaches[131,132,133] which are based on the international 3GPP standards[134] rely more on the initial screening of conducted power levels to ascertain which combination of channels, channel bandwidth, resource block (RB) allocation and offset, modulation and maximum power reduction will yield the highest SAR, thereby minimizing the amount of SAR testing required to show compliance. In fact the maximum SAR found by comparing the four international approaches have shown an average deviation of 5% or less.[135]

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[130] 941225 D05 SAR for LTE Devices v02r02
[131] ARIB STD-T56 ver. 3.1, 18 Dec. 2012. (in Japanese) http://www.arib.or.jp/english/html/overview/st_ej.html
[132] ARIB T56 ver. 3.2 In preparation
[133] Notice of National Radio Research Agency (No. 2012-43, December 6, 2012) "Technical details on SAR measurement procedure" Annex 3 Method of measuring SAR for LTE terminals
[134] 3GPP TS 36.521-1 Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Conformance testing
[135] Report to IEC 62209 MT Update of LTE SAR Ad-hoc WG, Newbury May 2013

Research sponsored by the MMF has shown that conducted power results and SAR are linearly related and that other factors (channel bandwidth, modulation, RB allocation and offset) are of lesser significance. Thus, the conducted power measurements are the key for the efficient identification of LTE modes resulting in highest SAR conditions. This principle is already implemented in several FCC KDBs related to other communication systems (CDMA, WLAN etc.), where only certain test mode is required to be SAR tested unless some other modes have significantly higher conducted power. This same approach should be expanded to LTE SAR testing, to avoid the excessive amount of SAR testing described above.

The MMF also notes that there are several standards committees that are constantly monitoring and reviewing the standards and preparing updates. The FCC is actively involved in many of these[136], (including the filing of numerous comments all of which are required to be addressed), yet the FCC does not adopt these standards when they are published[137], or worse, mandates contrary requirements[138]. The MMF believes that where the FCC is actively involved in a standards committee then there should be a presumption of adoption of these standards once published as they do represent, by their consensus approach, best engineering practice by which to ensure and measure compliance. Their formal adoption once published is also consistent with the requirements of the

[136] Including IEEE C95.1-2005, IEC 62209-1, IEC 62209-2, IEEE 1528.
[137] Such as IEC 62209-2 (2010)
[138] Such as the requirement to test using two fluids contrary to the requirements of IEC 62209-2 (2010)

NTTAA and OMB Circular A-119 discussed earlier in this submission. The MMF would further submit that these could be adopted via the KDB process.

IV – CONCLUSIONS

In response to the FCC's Further Notice of Proposed Rulemaking ("FNPRM") the MMF submits:

- That the development and use of the KDB's should be governed by a number of principles, including that KDB's:
  - Should be released in draft in order with an adequate notice period during which stakeholders can provide input;
  - When issued in final form should provide adequate time for an orderly transition of practices;
  - Must provide testing guidance that is consistent, as much as possible, both with current standards and international practices. (Where departure from international standards and practices are called for by a KDB, a clear rationale for such departure should be provided.); and
  - Should provide adequate flexibility to allow for innovation in both testing and technology.

- That the Commission should use the KDB process to embrace harmonization, consistent with the Commissions own stated objectives as well as those that are required of it via the Office of Management and Budget (OMB) Circular A-119.

- We support the inclusion of exceptions from SAR testing for various transmitters through reliance on maximum time-averaged power or ERP evaluations. This approach has a number of practical benefits while still ensuring inherent product compliance and that we encourages the FCC to adopt IEC 62479-2010 as part of this process.

In relation to the NOI, the MMF acknowledges the sensitivities involved in discussions around exposure guidelines and that there are many misconceptions surrounding the adoption of the international standards[139]. However the MMF would summarizes our submissions in relation to the current FCC standards as follows:

- The scientific basis of the existing FCC's standards is more than 20 years old and there is very strong policy, practical and scientific grounds to justify an alignment with the ICNIRP/IEEE C95.1- 2005 standard.

- The current standard was based on early dosimetry considerations alone, whereas the IEEE C95.1-2005 standard is based on a

[139] See Annex F that provides responses to many of the common misconceptions.

significantly improved understanding of RF and thermal dosimetry and biological/health effects.

- International and national health authorities and expert bodies continue to maintain the consensus view that there are no established health effects below the levels recommended by ICNIRP and IEEE C95.1-2005.

- These international standards are also recognised as providing ample protection for children and any other vulnerable groups in the community.

- The standards have taken issues such as lifetime exposure, increased absorption, increased penetration and stages of childhood development into account.

- IEEE C95.1-2005 provides a very conservative framework for the protection of persons exposed to RF fields. From the substantial safety margin inherent in the standards themselves, through to the specificity of SAR measurement protocols and how the devices are tested compared to how they typically operate.

- The adoption of consistent science based standards has been shown to increase consumer confidence and reduce community concerns. Likewise, any arbitrary reductions can have significant unintended consequences which would make the operation of telecommunication networks difficult or in most cases impossible to achieve as already demonstrated is some parts of Europe.

- The telecommunications network is inherently precautionary. Studies of cell phones in everyday use show that when talking on a mobile phone while walking around a major city or inside city buildings, smartphones operate at less than one per cent of the phones maximum power output.

- The best way for members of the community who have concerns about their exposure from cell phones is to follow the FCC's own advice, which in turn is consistent with the WHO's advice, and that is to use 'hands-free' devices which keep cell phones away from the head and body during calls and to limit the number and length of calls. This information along with other information on the topic is already made available by the industry as well as other stakeholders.

- Another benefit for adopting IEEE C95.1-2005 is the improved capacity and coverage benefits in rural and regional areas leading to improved user experiences, fewer dropped calls, sustained data rates over greater areas and expanded access to emergency services.

- Such benefits would also help meet consumer demand and expectations for mobile coverage as more users adopt smartphones and other wireless devices that require fast and reliable mobile broadband connections.

And finally, in relation to the evaluation of devices, the MMF submits that the FCC's current LTE testing requirements are unduly onerous and that alternative approaches based on initial screening of conducted power are being used internationally and have been shown to be as effective as the current FCC specified approach. These alternative processes involve considerably less testing time – an important factor for products that often have a market life cycle of 12 months or so. The MMF would also like to see a presumption of adoption operating where the FCC is actively involved in standards committees, rather than have all parties invest considerable time and resources into standards development only to see the FCC fail to adopt them or to mandate contradictory requirements.

The MMF wishes to thank the FCC for its consultation and the opportunity to provide our views on these important issues.

Respectfully submitted,

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September 3, 2013

ANNEX A: CONCLUSIONS OF RECENT EXPERT ADVISORY BODIES AND HEALTH AGENCIES ON EMF SAFETY

The following summaries are from recent relevant scientific reviews and reports.

2013

Sweden

Recent Research on EMF and Health Risk (Eighth report from SSM's Scientific Council on Electromagnetic Fields, 2010), Swedish Radiation Safety Authority[140]:

> *Recent research on exposure from transmitters has mainly focused on cancer and symptoms, using improved study designs. These new data do not indicate health risks for the general public related to exposure to radiofrequency electromagnetic fields from base stations for mobile telephony, radio and TV transmitters, or wireless local data networks at home or in schools.*

The Netherlands

Health Council of the Netherlands. Mobile phones and cancer. Part 1: Epidemiology of tumours in the head. The Hague: Health Council of the Netherlands, 2013; publication no. 2013/11 [141]

> *[T]he final conclusion from this systematic analysis is then: there is no clear and consistent evidence for an increased risk for tumours in the brain and other regions in the head in association with up to approximately 13 years use of a mobile telephone, but such risk can also not be excluded. It is not possible to pronounce upon longer term use.*

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[140] http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Stralskydd/2013/SSM-Rapport-2013-19.pdf

[141] http://www.gr.nl/en/publications/environmental-health/mobile-phones-and-cancer-part-1-epidemiology-tumours-head

2012

European Union – EFHRAN

Risk analysis of human exposure to electromagnetic fields (revised), European Health Risk Assessment Network on Electromagnetic Fields Exposure (EFHRAN)

> *6.3. High frequencies*
> *Inclusion of recent data regarding adult brain tumours (...) is now considered to be best described as being limited. However, this classification is subject to uncertainty, because the evidence for an increased risk of brain tumours is restricted to two large-scale case-control studies, and there are unresolved questions relating to possible biases and errors inherent to retrospective epidemiological studies. Further, the time-trend analyses are also not compatible with a large increase in brain tumour incidence in relation to mobile phone use.*
> *...*
> *Inclusion of recent data on other endpoints has not necessitated any revisions to the existing consensus opinions of EMF-NET (2009) or SCENIHR (2009a).*

United Kingdom

The possible harmful biological effects of low-level electromagnetic fields of frequencies up to 300 GHz, Institution of Engineering and Technology position statement, 8 May 8, 2012.[142]

> *In summary, the absence of robust new evidence of harmful effects of EMFs in the past two years is reassuring and is consistent with our findings over the past two decades. The widespread use of electricity and telecommunications has demonstrable value to society, including health benefits. BEPAG is of the opinion that these factors, along with the overall scientific evidence, should be taken into account by policy makers when considering the costs and benefits of both the implementation of precautionary approaches to public exposure and also in the development of public exposure guidelines.*

United Kingdom

142 http://www.theiet.org/factfiles/bioeffects/emf-position-page.cfm?type=pdf

Health Effects from Radiofrequency Electromagnetic Fields – RCE 20, Advisory Group on Non-ionising Radiation (AGNIR), Health Protection Agency, April 2012.[143]

> *In summary, although a substantial amount of research has been conducted in this area, there is no convincing evidence that RF field exposure below guideline levels causes health effects in adults or children.*

Sweden

Radiofrequency electromagnetic fields and risk of disease and ill health: Research during the last ten years, Swedish Council of Working Life and Social Research (FAS), 2012.[144]

> *Research on mobile telephony and health started without a biologically or epidemiologically based hypothesis about possible health risks. Instead the inducement was an unspecific concern related to a new and rapidly spreading technology. Extensive research for more than a decade has not detected anything new regarding interaction mechanisms between radiofrequency fields and the human body and has found no evidence for health risks below current exposure guidelines. While absolute certainty can never be achieved, nothing has appeared to suggest that the since long established interaction mechanism of heating would not suffice as basis for health protection.*

Norway

Low-level radiofrequency electromagnetic fields – an assessment of health risks and evaluation of regulatory practice, Folkehelseinstituttet Norwegian Institute for Public Health], FHI report, 12 September 2012.[145]

> *It is reasonable to assume that the gradually increasing and widespread use of mobile phones would have led to an increased cancer incidence over time,*

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143 http://www.hpa.org.uk/webw/HPAweb&HPAwebStandard/HPAweb_C/1317133826368
144 http://www.fas.se/
145 http://www.fhi.no/

> *if use was carcinogenic. …The results of the incidence studies show no evidence of increasing incidence of these cancers over time.*
>
> *…*
>
> *Exposure from base stations and radio and television transmitters is significantly lower than from using a mobile phone and the available data do not suggest that such low exposure could increase the risk of cancer.*

Germany

Biologische Auswirkungen des Mobilfunks Deutsche Strahlenschutzkommission (German Radiation Protection Commission)[146]

> *(Translation): The results of the DMF (German mobile communications research programme) show that the initial fears about health risks could not be confirmed. … In line with other international bodies (ICNIRP 2009, WHO 2011) can be determined that the underlying concepts of the existing protection limits are not in question.)*

2011

Spain

Report analysing the possible health effect of WiFi systems, Scientific Advisory Committee on Radio Frequencies and Health (CCARS)[147]

> *The Scientific Advisory Committee on Radio Frequencies and Health (CCARS) has drafted a report analysing the possible health effect of WiFi systems, which overwhelmingly concludes that, at least to date, there is absolutely no scientific evidence that exposure to the low emission levels of these systems produces adverse health effects in schoolchildren.*

Netherlands

Influence of radiofrequency telecommunication signals on children's brains. The Hague: Health Council of the Netherlands, 2011; publication no. 2011/20E:[148]

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[146] http://www.ssk.de/de/werke/2011/kurzinfo/ssk1109.htm

[147] http://www.ccars.es/en/news/there-no-scientific-evidence-wifi-systems-produce-adverse-health-effects-schoolchildren

> *In summary, the Committee concludes that there is no cause for concern based on the knowledge about short-term effects outlined in this advisory report. Available data do not indicate that exposure to radiofrequency electromagnetic fields affect brain development or health in children.*

International

International Commission for Non-Ionizing Radiation Protection Standing Committee on Epidemiology 2011. Mobile Phones, Brain Tumours and the Interphone Study: Where Are We Now? Environ Health Perspectives:-. doi:10.1289/ehp.1103693:[149]

> *Such evidence as it provides, combined with the results of biological and animal studies, other epidemiological studies, and brain tumour incidence trends, suggest that within the first 10-15 years after first mobile phone use there is unlikely to be a material increase in risk of adult brain tumours resulting from mobile phone use.*

South Africa

Health Effects Of Cellular Base Stations, Directorate 'Radiation Control, Department of Health

> *Measurement surveys conducted in South Africa and around the world have shown that the actual levels of public exposure, as a result of base station emissions, invariably are only a fraction of the ICNIRP guidelines….*
> *At present there is **no** confirmed scientific evidence that points to any health hazard associated with the very low levels of exposure that the general public would typically experience in the vicinity of a cellular base station. …*
> *The Department is therefore satisfied that the health of the general public is not being compromised by their exposure to the microwave emissions of cellular base stations.*

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[148] http://www.gezondheidsraad.nl/sites/default/files/201120E.pdf
[149] http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.1103693/

Spain

Report on Radio Frequencies and Health (2009-2010), Scientific Advisory

Committee on Radio Frequencies and Health (CCARS) (Published 2011):[150]

> *Present evidence from clinical and epidemiological studies indicates that there is no causal relationship between exposure to the radio frequency fields used in mobile telephony and adverse effects on health.*

[150] http://www.ccars.es/sites/default/files/Report_on_RF__health_2009-2010_EN.pdf

ANNEX B: AVERAGING TIMES

The IEEE C95.1-2005 recommends an averaging time of 30 minutes at 100 MHz – 5 GHz then ramping down to 25 minutes between 5 and 6 GHz for members of the general public. There has been considerable information published on what are the typical lengths of time for cell phone calls.

Vrijheid et al[151] published the following data as part of the 13 nation Interphone study:

Table 2 Description of software-modified phone (SMP) users and calls recorded by the SMPs by study centre

Study centre	Dates of SMP use	No of users	No of calls	No of operators	No of users per operator	No of days of SMP use		No of calls per day	Call duration (minutes)
					Min–max	Mean	Min–max	Mean	Mean
Australia	Nov 03–Jun 04	48	6782	1	48	32.8	17–49	4.5	1.71
Canada	Jan–Jul 05	37	3395	2	13–24	31.8	12–48	3.2	2.08
Denmark	Aug–Oct 03	46	3458	5	2–16	29.1	12–41	2.5	1.80
Finland	Feb–Mar 02	46	4581	4	1–29	27.2	11–38	3.9	2.80
France	Jan–May 01	24	3796	3	3–11	25.4	13–39	6.7	1.88
Germany	Nov–Dec 01	49	3023	2	22–27	25.8	8–42	2.7	1.51
Israel	Aug–Dec 02	41	15058	1	41	34.2	9–50	10.9	1.84
Italy	Feb–Mar 03	53	8049	3	16–20	27.6	19–33	5.4	1.67
New Zealand	Nov 03–Mar 04	27	2466	1	27	37.3	22–72	2.5	1.61
Norway	Sept–Nov 04	48	3946	3	2–24	31.3	14–52	2.7	2.42
Sweden	Apr–May 03	46	5461	5	1–24	27.3	8–42	4.5	1.78
UK North 1*	Feb–Mar 01	17	607	1	17	20.3	9–32	1.6	2.45
UK North 2	Apr–Jul 03	34	2529	5	3–14	27.0	10–35	2.9	2.17
Total		516	63151	36	1–48	29.3	8–72	4.2	1.96

*In the 2001 study in the UK, problems with the phones' software led to part of the collected data being lost, resulting in few included subjects; the study was therefore repeated in 2003 with a different set of volunteers.

This shows that across 13 nations, 516 users, 36 operators and a total number of calls in excess of 63,000 the mean call duration was approximately 2 minutes.

[151] M Vrijheid et al., Determinants of mobile phone output power in a multinational study: implications for exposure assessment Occup. Environ. Med. 2009;66:664-671

Based on US statistics[152] for 25 years of local call data and almost 20 years of roaming data the respective overall averages were 2.4 and 3.2 minutes respectively.

Based on either a 6 minute or a 30 minute averaging time there is considerable conservatism inherent in the exposure standards through behavior based time averaging. This is consistent with the messaging provided to consumers by government agencies, health authorities and industry – if you are concerned about exposure during cell phone use one can use a headset or limit the length and number of calls.

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[152] CTIA Semi-annual Wireless Industry Survey Results December 1985 – June 2012.

ANNEX C: EFFECT OF POWER CONTROL

Several features of cellular phones systems ensure that the network infrastructure and devices operate at the lowest power necessary to complete a quality connection both for voice and data transmissions. Whilst these features were designed primarily to limit interference and extend device battery life their impact in the context of personal exposure levels is to always ensure the lowest possible exposure levels to the individual.

There have been numerous studies[153,154,155,156,157] on the effect of power control on the uplink power of devices. Taking power regulation, discontinuous transmission (DTX) and 6 minutes time averaging into account, for 95% of the time the real output power is more than 10dB below maximum for 3G/WCDMA terminals, and around 4dB below maximum for 2G/GSM terminals. For 4G/LTE terminals, the output power is very similar as for 3G/WCDMA terminals.

This means that there is an additional 4dB to 10dB conservativeness built in to the measurement standard depending on the wireless technology being tested.

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[153] Persson et al., Output Power Distributions of Terminals in a 3G Mobile Communication Network, Bioelectromagnetics 2011 DOI 10.1002/bem.20710
[154] Wiart et al. Analysis of the Influence of the Power Control and Discontinuous Transmission on RF exposure with GSM Mobile Phones, IEEE Trans Electromagn Compatibility 2000;42(4):376–385.
[155] Gati et al., Exposure induced by WCDMA Mobile Phones in Operating Networks, IEEE Trans Wireless Commun 2009;8:5723–5727
[156] Vrijheid et al., Determinants of mobile phone output power in a multinational study implications for exposure assessment, Occup Environm Med 2009;66:664-671
[157] Joshi MSc Thesis "Assessment of realistic output power levels for LTE devices" Lund University 2012

This is also supported by the research of Kuehn et al.[158] who analyzed SAR data from the FCC database (1999-2005) that included 957 different phones, 2,188 operational modes and fourfold more SAR data when the tests made for touch/tilt and left/right configurations were reported. They found:

1. Service technology accounts for the greatest variability in compliance test SARs that ranged from AMPS (highest) to CDMA, iDEN, TDMA, and GSM (lowest); and
2. Time-line trend including both the 800 and 1900 MHz bands revealed a clear trend of decreasing SAR over time.

[158] Kuehn S et al., Analysis of Mobile Phone Design Features Affecting Radiofrequency Power Absorbed in a Human Head Phantom, *Bioelectromagnetics* Vol. 34, Pg. 479 - 488, 2013

ANNEX D: TECHNICAL IMPACTS OF HARMONIZATION

Adoption of the international standard would allow a device to utilize additional transmission power ('TX') when needed which current US models can't in order to ensure compliance with the FCC's current standards. Without taking into account the averaging mass, the change from 1.6W/kg to 2W/kg alone would allow for an effective 25% increase in the available TX power when operating at the handsets maximum power.

In addition, when one also takes into account the accompanying change from a 1g to 10g averaging volume, the additional TX power that would be available at maximum power would increase by around 50%. Although there is no fixed mathematical relationship between SAR measured in 1g compared to 10g cubic averaging volumes there is published numerical data that shows for 500 MHz and 1 GHz the SAR difference is between 45% and 53% respectively and higher for higher frequencies[159]. Measurements on modern smartphones also show an average of approximately 50% difference between the SAR measured using a 1g averaging mass and those measured against the 10g averaging mass when tested at the devices full power. The graph below shows some typical data from a recent FCC filing for a product type approval and compares the different recorded 1g to 10g SAR values. From these values, a ratio between the 1g and 10g values has also been plotted.

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[159] McIntosh R. and Anderson V. 2011. SAR Versus VAR, and the Size and Shape That Provide the Most Appropriate RF Exposure Metric in the Range of 0.5-6 GHz. *Bioelectromagnetics* 32:312-321.

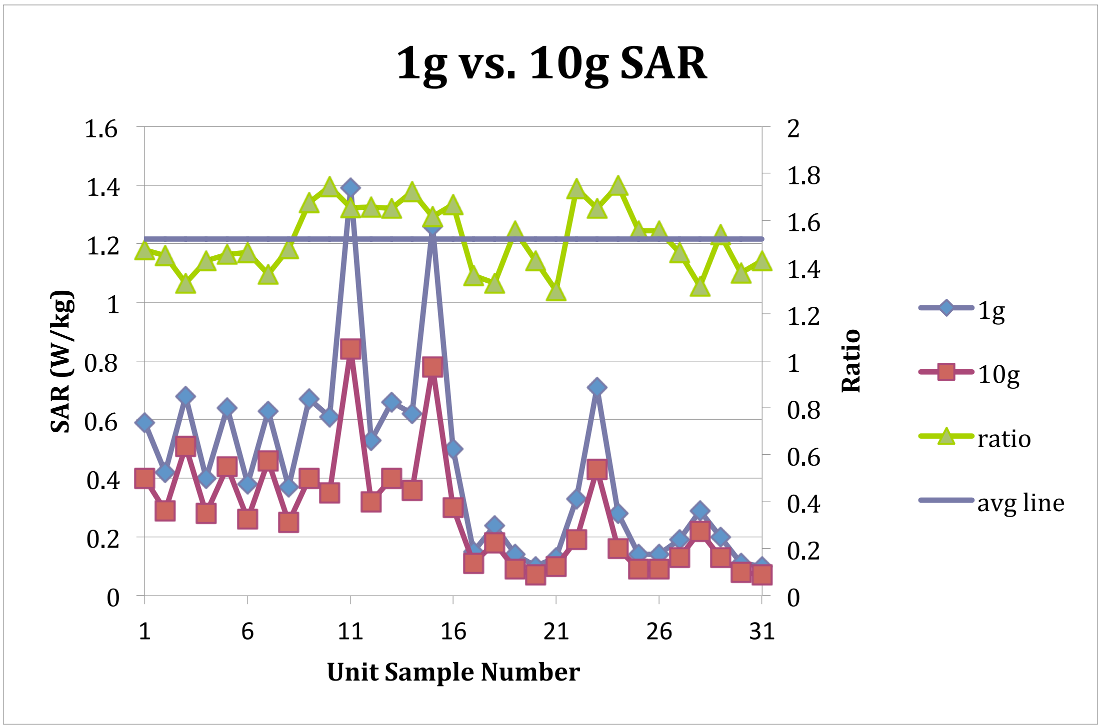

Figure 6: Sample of 1g and 10g SAR values along with the average relationship between the two sets of values.

From Figure 1 above, an average difference of 50% in the SAR values measured between 1g and 10g averages can be seen. This, in turn, means that an average 50% more TX power would be available from the use of 10g averaging versus 1g averaging while still ensuring compliance of the device with the international standards.

The combination of these two factors - the 25% increase in TX power resulting from the change from 1.6 W/kg to 2 W/kg and the 50% increase in TX power from the use of 10g averaging rather than 1g averaging – means that handsets could have an additional TX power increase of almost 90% (1.25 x 1.5), which corresponds to 2.7 dB, and still comply with the international standards.

The MMF is well aware that the FCC already has limits on the effective radiated power (EIRP) that restricts the maximum transmit power of cellular, PCS and AWS band mobile devices[160]. The MMF is not suggesting that any changes are required to these levels. However, we do note that the current 1.6W/kg in 1g SAR standard does restrict the effective maximum transmit power of a device to a level below that which could be utilized within the FCC's existing EIRP limits. In contrast, the adoption of 2.0W/kg in 10g SAR will more closely harmonize these two practical limits on maximum transmitter power within a device. Another way of viewing this point is as follows:

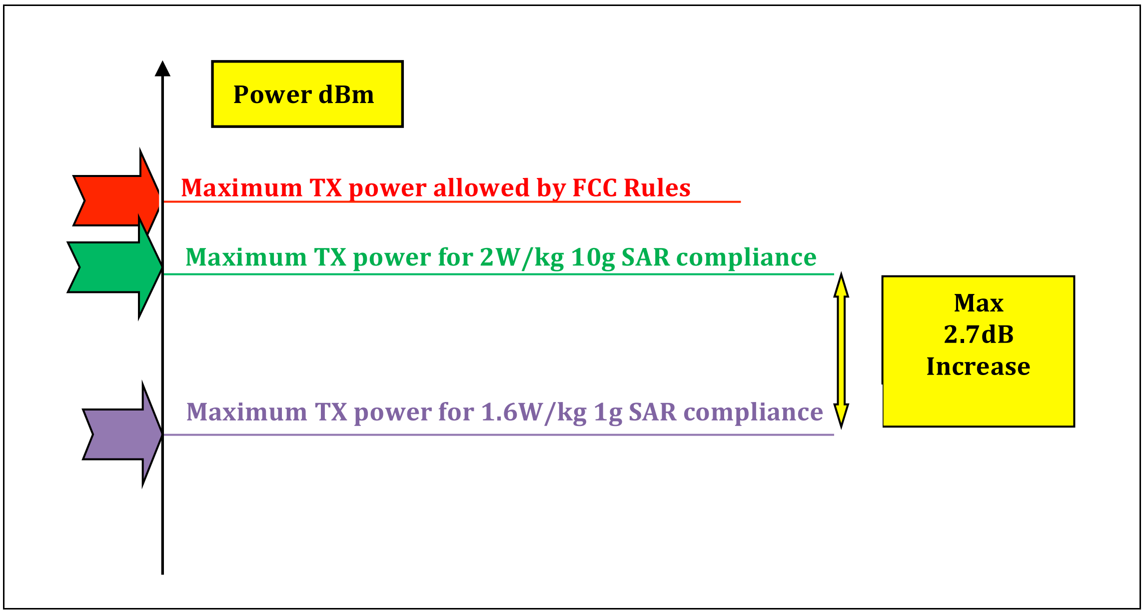

Figure 7: Effective Maximum TX Powers for Compliance Purposes[161] vs Maximum TX Power provided under Current FCC Rules.

The additional TX power available within the handset as a result of harmonization would also have the added benefit of extending the effective coverage or capacity of a given cell.

[160] CFR Title 47 Sections 22.913 (a)(2), 24.232 (c) and 27.50 (d)(4).
[161] The various transmitters that a device contains will influence the actual maximum TX power for that device.

An additional uplink power in the device of 2.5-3 dB, will increase the capacity of a 3G or 4G/LTE cellular network by about 30%, i.e. a cell in the system can handle 30% more traffic without any change of the bit rate performance at the cell edge.

This is illustrated in Figure 8, which for example shows that if a LTE network is designed to offer an uplink bit rate of 1 Mbps at the cell edge, then the system can deliver about 1.5 GB/user/month to users at the cell edge (lowest 5th percentile) assuming an uplink power of 21 dBm. If the power is increased by 3 dB, the traffic that can be handled increases to about 2.3 GB/user/month.

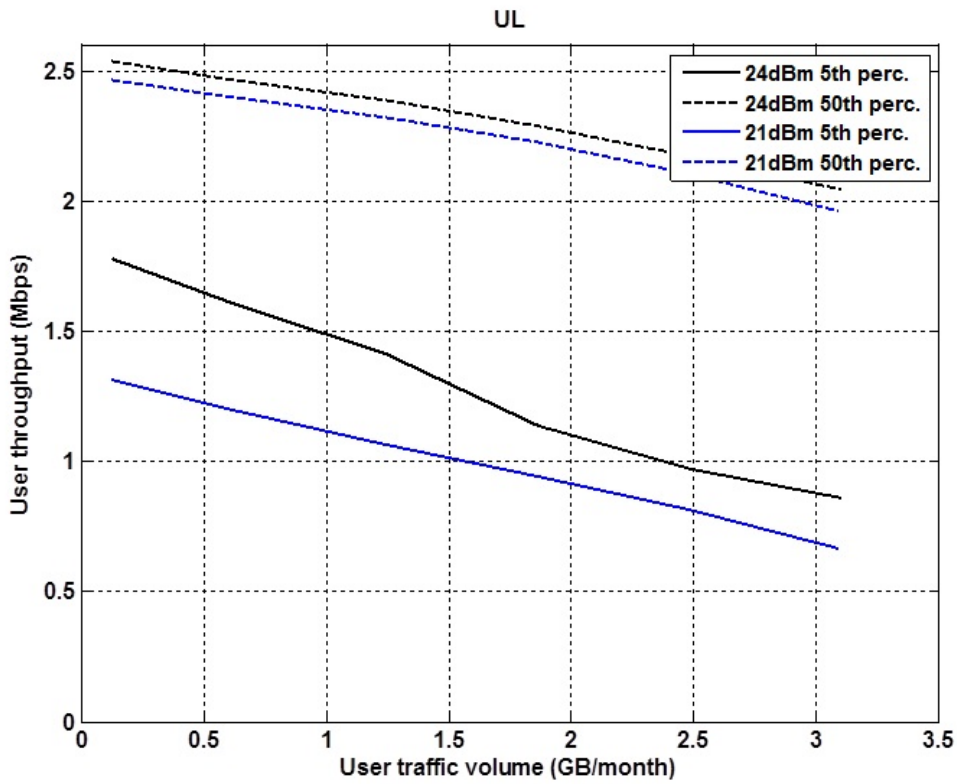

Figure 8: Simulations of uplink performance for a heterogeneous network (LTE) in the US, Source: Ericsson

Alternatively, as shown in Figures 9 & 10 the cell coverage could be expanded, meaning that the 1 Mbps cell edge data rate (for LTE) and (512kbps for WCDMA) would be pushed out a considerable distance and increasing the cell size by between 35-40% - equivalent to an estimated 30+ square miles of additional coverage in the Figures shown. This would provide continued data access for consumers over a greater geographical area and a better mobile broadband experience overall and provide access to services for those that currently may not have any.

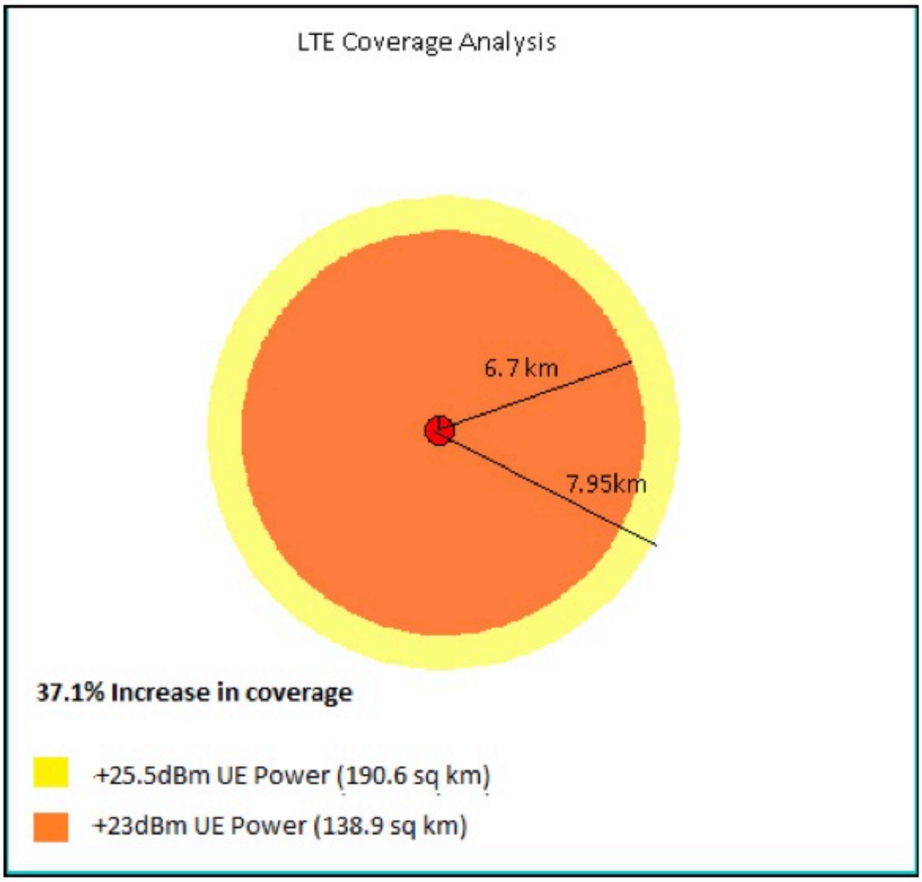

Figure 9: Coverage plot for LTE 9dBi Omni antenna at height of 20m from existing User Equipment ('UE') and additional +2.5dB Uplink from UE. Source: Telstra

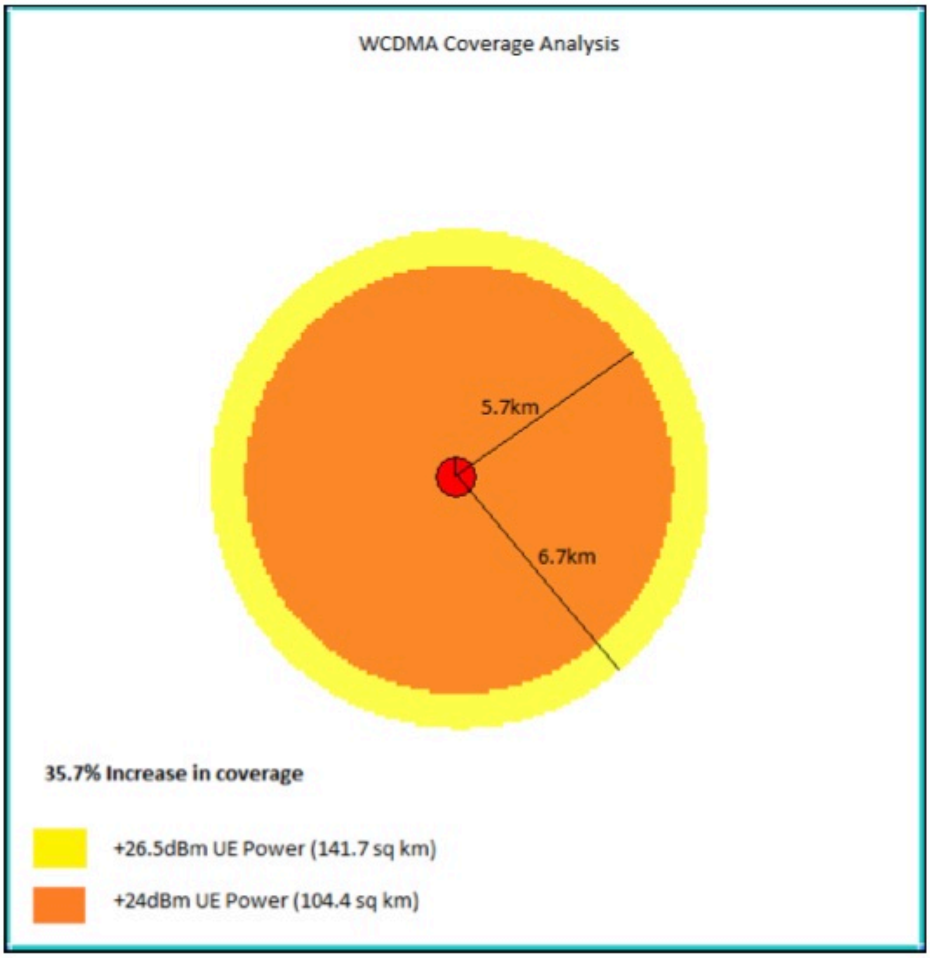

Figure 10: Coverage plot for WCDMA 9dBi Omni antenna at height of 20m from existing User Equipment ('UE') and additional +2.5dB Uplink from UE. Source: Telstra

ANNEX E: USER MANUAL/WEBSITE SAR EXPLANATORY TEXT

The following is the MMF's recommended SAR text language:

THIS DEVICE MEETS FCC GUIDELINES FOR EXPOSURE TO RADIO WAVES

Your mobile device is a radio transmitter and receiver. It is designed not to exceed the guidelines for safe exposure to radio frequency (RF) energy adopted by the FCC based on recommendations by independent scientific expert non-government organizations, such as the Institute of Electrical and Electronics Engineers and the National Counsel on Radiation Protection and Measurements, and input from federal health and safety agencies, such as the FDA. The guidelines include a considerable safety margin designed to assure the safety of all persons, regardless of age and health.

The FCC RF energy exposure guidelines use a unit of measurement known as the Specific Absorption Rate, or SAR. SAR is a measure of the rate of RF energy absorption from the source being measured -- in this case, a mobile device. The SAR limit for mobile devices is 1.6 W/kg. Tests for SAR are conducted using standardized models of the human head and body in various specific positions, including against the head and next to the body (body-worn), with the device transmitting at its highest certified power level in all tested frequency bands. The highest SAR values under the FCC guidelines for this device model are:

Maximum SAR for this model and conditions under which it was recorded.		
Head SAR	UMTS 1900 + Wi-Fi	x.xx
Body-worn SAR	GSM 1800 + Wi-Fi + Bluetooth	x.xx

During normal use, the actual SAR values for this device are usually well below the values stated above. This is because, for purposes of system efficiency and to minimize interference on the network, the operating power of your mobile device is automatically decreased when full power is not needed.

FCC guidelines require body-worn SAR testing to be carried out using an approved accessory or at a separation distance of x.x. cm. When using this product next to your body (other than in your hand or against you head), the device should be in an approved accessory or positioned at least x.x cm away from the body to ensure your use is consistent with how the device is tested for compliance with the FCC RF energy exposure guidelines. If you are not using an approved accessory, ensure that whatever product is used does not contain any metal and that it positions the phone at least x.x cm away from the body -- again, to ensure your use is consistent with how the device is tested.

The FCC and FDA have stated that present scientific information does not indicate the need for any special precautions for the use of mobile devices. But if you are interested in reducing your exposure they state that you can do so by limiting your usage, using a hands-free kit to keep the device away from the head, and by texting rather than talking -- **but don't text while you are driving**.

For more information, see FCC website links: http://transition.fcc.gov/cgb/cellular.html; http://www.fcc.gov/guides/wireless-devices-and-health-concerns; http://www.fcc.gov/guides/specific-absorption-rate-sar-cell-phones-what-it-means-you; and FDA website links: http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/default.htm.

ANNEX F: MISCONCEPTIONS ABOUT THE STANDARDS

The internet is awash with misconceptions about the RF exposure standards – many of which were first observed in the self-published 1999[162] and 2002[163] papers by Dr Neil Cherry which heavily criticised the ICNIRP Guidelines when they were adopted in New Zealand.

Many of these allegations continue to be made today, for example, a recent documentary[164] titled *Resonance: Beings of Frequency* alleges health effects from exposure to electromagnetic fields in the environment and makes a number of similar allegations about the ICNIRP Guidelines that were first made by Cherry.

Similarly, in the U.S, citizen activist groups have also alleged[165,166,167,168] the FCC's safety standards needed to be updated because of the recent IARC

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[162] Cherry N 1999, *Criticism of the proposal to adopt the ICNIRP Guidelines for cellsites in New Zealand,* viewed 1 July 2013, http://www.salzburg.gv.at/ICNIRP-Kritik1.pdf
[163] Cherry N 2002, *Criticism of the health assessment in the ICNIRP Guidelines for radiofrequency and microwave radiation* (100 kHz – 300 GHz), viewed 1 July 2013, http://neilcherry.com/documents/90_m4_EMR_ICNIRP_critique_09-02.pdf
[164] Resonance: Beings of Frequency 2013, online documentary, Patient Zero Productions, produced by James Russell, viewed 1 July 2013, http://www.youtube.com/watch?v=IF_rorl5LRQ
[165] Media Release 26 July 2011, Health & Environmental Advocates Ask Congress to Request the U.S. Federal Communications Commission (FCC) to Update Its Obsolete Cell Tower Safety Regulations, viewed 1 July 2013, http://electromagnetichealth.org/electromagnetic-health-blog/take-action/
[166] Childs, D 2011, FCC Test to Measure Cellphone Radiation Flawed, Group Says*, ABC News*, viewed 1 July 2013, http://abcnews.go.com/Health/fcc-test-measure-cellphone-radiation-cancer-risk-flawed/story?id=14750275#.
[167] Davis, D 2013, Cicadas and Cell Phones: Welcome to the 21st Century, *The Huffington Post,* viewed 1 July 2013, http://www.huffingtonpost.com/devra-davis-phd/cell-phones-cancer_b_3157171.html
[168] Media Release 2013, New study shows cell phones exceed FCC exposure limits by as much as double for children, viewed 1 July 2013, http://ehtrust.org/press-release-new-study-shows-cell-phones-exceed-fcc-exposure-limits-by-as-much-as-double-for-children/

classification, claims about harm from "non-thermal" effects and suggestions that the SAM phantom is unrepresentative of the general population.

As many of these claims will no doubt be made in submissions to the FCC in response to the current proceeding, and in the interests of providing a comprehensive and considered view of the standards some of the most common criticisms and allegations are addressed below.

RESPONSE TO COMMON CLAIMS ABOUT THE STANDARDS

Claim 1:
The ICNIRP guidelines are out of date

Response:
The ICNIRP guidelines are set by an independent committee of international experts – who carefully review all relevant scientific literature and keep the guidelines under regular review.

In 2009, ICNIRP released a two-page statement[169] to reconfirm that their exposure guidelines are still valid until further notice and which said:

> *It is the opinion of ICNIRP that the scientific literature published since the 1998 guidelines has provided no evidence of any adverse effects below the basic restrictions and does not necessitate an immediate revision of its guidance on limiting exposure to high frequency electromagnetic fields.*

Although the guidelines are dated 1998 this simply reflects the last time the standards needed to be changed, it does not mean that ICNIRP have not reviewed or ignored the latest scientific evidence.

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[169] ICNIRP statement 2009, *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)*,.Health Phys. 2009 Sep;97(3):257-8. doi: 10.1097/HP.0b013e3181aff9db.

Claim 2:
The guidelines ignore biological based scientific evidence such as genotoxic evidence and the epidemiological evidence of cancer effects and reproductive effects

Response:
RF Exposure standards above 100 kHz are based on heating effects because it is a known established mechanism for harm.

However, biological effects (at levels not known to be caused by heating) are not disregarded.

More importantly, ICNIRP and IEEE C95.1- 2005 do consider both thermal and non-thermal effects as outlined in the guidelines[170] themselves:

> *Overall, the literature on athermal effects on AM (amplitude modulated) electromagnetic fields is so complex, the validity of reported effects so poorly established, and the relevance of effects to human health so uncertain, that it is impossible to use this body of information as a basis for setting limits on human exposure to these fields.*

ICES also reviewed extensively biological effects ascribed to exposure to low-level fields, i.e., at or below the corresponding basic restrictions in the frequency range 3 kHz to 300 GHz. ICES's position on the low levels effects is:

> *Despite more than 50 years of RF research, low-level biological effects have not been established. No theoretical mechanism has been established that supports the existence of any effect characterized by trivial heating other than microwave hearing. Moreover, the relevance of reported low-level effects to health remains speculative and such effects are not useful for standard setting.*[171]

Also the WHO supports the ICNIRP's comprehensive evaluation process as currently shown on their EMF Project website[172]:

> *The exposure limits for EMF fields developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) - a non-governmental organization formally recognised by WHO, were developed following reviews of all the peer-reviewed scientific literature, including thermal and non-thermal effects. The standards are based on evaluations of biological effects that have been established to have health consequences.*

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[170] ICNIRP (International Commission on Non-Ionizing Radiation Protection) Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz) Health Phys.1998;74(4):494–522.
[171] Annex C.1.2, page 82 of C95.1-2005
[172] World Health Organization 2013, EMF Project, Standards and Guidelines, viewed 1 July 2013, http://www.who.int/peh-emf/standards/en/

The main conclusion from the WHO reviews is that EMF exposures below the limits recommended in the ICNIRP international guidelines do not appear to have any known consequence on health.

An in-depth scientific review of possible genetic damage by the Irish Government Expert Group[173] concluded:

The scientific evidence suggests that RF fields do not cause mutation in the DNA or initiate, progress or promote tumour formation.

Another review by US National Council on Radiation Protection (NCRP)[174] on possible biological effects of modulated RF fields concluded that:

…there is no established mechanism by which RF fields modulated or not, can produce observable biological effects at electric field levels within tissue that correspond to exposure levels permitted by present safety guidelines.

Claim 3:
ICNIRP systematically rejects or ignores all epidemiological and animal evidence of non-thermal effects, for which there is a large body.

Response:
A large number of studies have looked for non-thermal biological effects. Most of these studies have reported negative results. Some studies have reported various biological effects but these are generally small in magnitude.

Furthermore, these findings have generally not been replicated, and in some cases attempts at replication have been unsuccessful.

Biological systems respond to many stimuli, and in most cases these responses (or "biological effects") are simply fluctuations typical of normal living and represent no increased health risk[175].

ICNIRP continues to review all available scientific evidence under review and recently said[176]:

With regard to non-thermal interactions, it is in principle impossible to disprove their possible existence but the plausibility of the various non-thermal mechanisms that have been proposed is very low.

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173 *Health Effects of Electromagnetic Fields*, Expert Group on Health Effects of Electromagnetic Fields, Department of Communications, Marine and Natural Resources, March 2007

174 "Biological effects of modulated radiofrequency fields" NCRP Commentary, National Council on Radiation Protection and Measurements, Bethesda, Maryland, USA December 2003

175 Repacholi, MH, ed. 1998, *Low-level exposure to radiofrequency fields: Health effects and research needs*. Bioelectromagnetics 19: 1-19. 69

176 ICNIRP statement 2009, *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)*,.Health Phys. 2009 Sep;97(3):257-8. doi: 10.1097/HP.0b013e3181aff9db

All major reviews of the available scientific database have carefully considered biological effects and their implications for human health.

For example, the UK Government's Mobile Telecommunications and Health Research Programme concluded[177]:

> *None of the research supported by the Programme and published so far demonstrates that biological or adverse health effects are produced by radiofrequency exposure from mobile phones.*

In fact, the Committee considered that there was no need for further investigation of biological effects.

The 2012 statement[178] by the Institution of Engineering and Technology (IET) – Europe's largest body of engineering and technology professionals – said:

> *The ubiquitous nature of our exposure to mobile phones means that, even if the risk to individuals is low, a large number of people could still experience health effects. However, experimental studies have failed to demonstrate consistent effects and no mechanism has been established whereby low-level exposure to radio-frequency fields can cause biological effects.*

Claim 4:
The guidelines are only based on the view that only possible and only established effect of RF exposure is tissue heating (the RF-Thermal View) and ICNIRP rejects or omits all evidence that conflicts with this view

Response:
Recently the former leader of the World Health Organisation's International EMF Project and Chairman Emeritus of ICNIRP – Dr Michael Repacholi – explained[179] there is a widespread misunderstanding about the 'weight of evidence' approach used for health risk assessments.

"Weight of evidence is NOT counting the number of positive and negative studies and then concluding there are more positive study results than negative, or vice versa," Dr Repacholi said.

A true weight of evidence approach requires that each study, both positive and negative, be evaluated for quality, he said.

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[177] *Mobile Telecommunications and Health Research Programme (MTHR) Report* 2007, MTHR Programme Management Committee, September 2007
[178] *The possible harmful biological effects of low-level electromagnetic fields of frequencies up to 300 GHz*, Institution of Engineering and Technology position statement, 8 May 8, 2012.
[179] Repacholi, M 2013 *Guest Blog from Mike Repacholi*, viewed 1 July 3013, http://betweenrockandhardplace.wordpress.com/2013/03/16/guest-blog-from-mike-repacholi/

"Quality assessment criteria for all study types are well known and studies can be given more or less weight, where those studies that conducted experiments correctly according to these criteria are given more weight or believability in the outcome, than those deemed low quality," Dr Repacholi said.

"All 'blue-ribbon' reviews use this approach. WHO has used this approach for over 50 years and it is a very well accepted, tried and true method for assessing health risks from any biological, chemical or physical agent."

Claim 5:
WHO'S International Agency for Research on Cancer has classified RF Radiation as a "Possible Carcinogen" based on new research.

Response:
The IARC working group undertook a hazard identification process, which is designed by default to red flag any potential concerns. This is especially useful for agents we don't know much about and might need to start taking precautions with.

However, this is not the case for mobile phones, which have been studied and reviewed extensively and already have added precautions, such as the 50-fold safety margin built into the standards.

An editorial[180] in the *Journal of The National Cancer Institute* explained the significance of the classification:

> *The change from "no conclusive evidence" to "possibly carcinogenic" was not new research, and it has understandably led to widespread public as well as media concern and confusion. The footnote accompanying the IARC press release is often missed—that a "possibly carcinogenic to humans" (2B) classification by IARC is based on "limited evidence of carcinogenicity" and that "chance, bias, or confounding could not be ruled out with reasonable confidence" for the few positive associations reported in the literature. A published summary of the IARC Working Group conclusions noted that some members found the epidemiologic evidence to be inadequate to support the 2B classification. Viewed in this context, "possibly carcinogenic" is not a signal to abandon mobile phones and return to landline phones. Rather, it is a signal that there is very little scientific evidence as to the carcinogenicity of cell phone use.*

IARC did not quantify the risk or likelihood of cancer. The assessment of health risks is the responsibility of another part of the WHO - the International Electromagnetic Fields (EMF) Project, which was set up in 1996

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[180]Boice JD, Tarone RE, 2011, *Editorial: Cell Phones, Cancer, and Children* JNCI J Natl Cancer Inst, doi:10.1093/jnci/djr285

to assess the scientific evidence of possible adverse health effects from electromagnetic fields.

This group also provide information to governments around the world and produces the fact sheets on mobile phones and health as expert advice for the public.

Following the IARC announcement in early June 2011 the WHO updated its factsheet[181] on electromagnetic fields and public health in mid-June 2011 and while acknowledging the IARC classification have said mobile phones were not known to cause any health problems:

> *A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use.*

The factsheet also explains why there appears to be a fundamental difference between the positions of IARC and another part of the WHO - the International Electromagnetic Fields (EMF) Project – who publish the factsheet.

The factsheet says the INTERPHONE project did not find any overall increase between the most common types of brain cancer and mobile phone use:

> *The international pooled analysis of data gathered from 13 participating countries found no increased risk of glioma or meningioma with mobile phone use of more than 10 years.*

However, the indications of a link with heavy users, which IARC largely based its classification, was inconsistent and the researchers could not rule out with any confidence that these indications were caused by biases or errors in the study:

> *There are some indications of an increased risk of glioma for those who reported the highest 10% of cumulative hours of cell phone use, although there was no consistent trend of increasing risk with greater duration of use. The researchers concluded that biases and errors limit the strength of these conclusions and prevent a causal interpretation.*
>
> *Based largely on these data, IARC has classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B), a category used when a causal association is considered credible, but when chance, bias or confounding cannot be ruled out with reasonable confidence.*

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[181] World Health Organization (WHO) Fact Sheet No. 193. Electromagnetic fields and public health: mobile phones, May 2010, viewed 1 July 2013, http://www.who.int/mediacentre/factsheets/fs193/en/index.html

Additional validation studies also found evidence that people diagnosed with a brain tumour over-reported their past mobile phone use and that this 'recall bias' may be more likely if subjects perceive that mobile phone use is associated with brain tumours, as has been widely speculated in the media.

Professor Patricia McKinney, epidemiologist at the University of Leeds and leader of the UK North part of the study, said in a statement:

> *For the estimated total (cumulative) hours of phone use there was an apparently increased risk of glioma seen in the highest ten percent of users. However, some of these had reported improbable levels of use, for instance 12 or more hours every day; there was no trend of increasing risk with greater phone use for people in the nine lower use categories; and there was no relation to risk for the cumulative number of phone calls made. These factors suggest that the apparently increased risk with the highest cumulative hours of use cannot be interpreted as evidence of mobile phones causing brain tumours.*

This extreme result is no more plausible than the results which showed users were protected by their mobile phone use – both are related to biases which are common in this type of study which is based on subjects' long-term recall of phone use.

IARC define evidence in human studies in which these sorts of biases cannot be ruled out as 'limited' – one level below sufficient evidence.

Although the authors of the Interphone study had highlighted these potential errors this evidence even if considered 'limited' it automatically put mobile phones in the 'possible' category.

Put simply, this comprehensive scientific review identified some suggestive evidence in the human studies but no consistent support from animal and cell studies.

Claim 6:
Evidence for RF Damage to the Ecosystem is Mounting

Response:
There is no solid evidence of RF damage to the environment and it is definitely not increasing – perhaps the allegations in the media and on the internet are increasing but these invariably found to be false or unsupported by scientific evidence.

A comprehensive review[182] of the research on environmental impacts of RF concluded:

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[182] Foster KR, Osepchuk JM, and Repacholi MH , 2002 *Environmental impacts of electromagnetic fields from major electrical technologies*. Environmental Health Perspectives

> *Overall, it appears that the human EMF exposure limits recommended by the International Commission on Non-Ionizing Radiation (ICNIRP, 1998) would also be protective of the environment.*

The World Health Organisation (WHO) investigated the effects of electromagnetic fields (EMF) on the environment in their 2005 information sheet[183]. The WHO concluded:

> *The limited number of published studies addressing the risk of EMF to terrestrial and aquatic ecosystems show little or no evidence of a significant environmental impact, except for some effects near very strong sources. From current information the exposure limits in the ICNIRP guidelines for protection of human health are also protective of the environment.*

A more recent review[184] by the German Federal Office for Radiation Protection (BfS) also concluded that there is no reliable scientific evidence of RF damage on animals and plants below existing standards.

Claim 7:
The process to determine RF exposure from cellphones involves the use of a mannequin model that they say approximates a 6-foot-2, 220-pound person. Because the model represents only about 3 percent of the population, the test will not accurately predict the RF exposure of the other 97 percent of the population, including children.

Response:
The SAM phantom was developed by IEEE ICES TC34 during the development of IEEE 1528-2003[185]. SAM model was designed to provide a conservative result to cover the user population, including children of various ages. The combination of higher tissue conductivities, a large head size, a thin ear and the exclusion of a hand holding the handset were chosen to provide a conservative estimate of the peak spatial-average SAR associated for the operating configurations expected by typical wireless handset users. Both a large head with a relatively flat cheek and thin ear bring the mobile phone closer to the head simulating liquid and therefore to induce conservatively higher peak SAR. A 14 laboratory

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[183] International EMF Project, Information Sheet, February 2005 Effects of EMF on the Environment, viewed 1 July 2013, http://www.who.int/peh-emf/publications/facts/envimpactemf_infosheet.pdf

[184] German Federal Office for Radiation Protection (BfS) Opinion on the question of possible effects of high frequency and low frequency electromagnetic fields on animals and plants, viewed 1 July 2013, http://www.bfs.de/de/bfs/forschung/stellungnahmen/EMF_Tiere_und_Pflanzen.html

[185] IEEE Std 1528-2003 *Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices – Measurement Techniques,* Institute of Electrical and Electronics Engineers, New York. 19 December 2003

comparison[186] and several other simulation studies on MRI-based realistic human models of various head sizes have shown that the SAM phantom is conservative for the user population.

> *This leads us to conclude that the SAM does produce a conservative estimate of SAR in the head and assures compliance with respect to the international exposure guidelines. The larger (adult) head resulted in a statistically higher peak SAR than did the smaller (child) head for all conditions[83].*

Therefore all phones tested using the SAM phantom that are found to be within the standards are approved for all users, including children.

Claim 8:
The standards do not consider long-term side effects, such as infertility in males who carry phones in their pockets.

Response:
It is simply incorrect to say that the exposure for carrying phones next to the body was 'unaccounted for' in the certification process.

Initially the tests were only done to make sure mobile phones cannot exceed the exposure standards when they are held close to sensitive organs such as the brain and eyes when making a voice call.

However, as mobile phones developed uses beyond voice calls and began to download and send data, a procedure was also developed to test 'smartphones' when they are being held near to the body and could be sending data, resulting in the development of IEC 62209-2 (2010).

Claim 9:
Computer simulation of RF penetration, in contrast to estimating RF exposure using the fluid-filled plastic mannequin, demonstrates much greater exposures, particularly for children and small adults, than previously understood.

Response:
The computer simulation methodology, known as Finite Difference Time Domain (FDTD) while an approved SAR assessment methodology doesn't provide any major benefit to existing compliance methodologies. Extensive studies have shown that when the FDTD computer modeling methodology is

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[186] Beard et al., 2006 *Comparisons of computed mobile phone induced SAR in the SAM phantom to that in anatomically correct models of the human head*, IEEE Transactions On Electromagnetic Compatibility Vol. 48, Pg. 397 - 407, 2006.

compared to the current test method – the current method covers all people including children.

One study compared computer models of an anatomically correct virtual family, based on MRI scans of real humans (including a 7-year-old child) and the current test method that uses an oversized SAM phantom model.

Because of the on-going interest in the media about this issue, an international task force of experts from 14 government, academic, and industrial research institutions was set-up to conduct independent test of both methods. The tests specifically looked at the influence of the smaller head size of the 7-year-old child model compared to the adult models and the SAM phantom model.

When all the data from all 14 labs was combined the study found the variations of results from the computer modelling and the experimental measurements made in phantoms were comparable and the computer modelling did not provide significant improvements in test methodology or accuracy.

When the exposure test results using both methods were compared the study[187] found:

> *This leads us to conclude that the SAM does produce a conservative estimate of SAR in the head and assures compliance with respect to the international exposure guidelines. The larger (adult) head resulted in a statistically higher peak SAR than did the smaller (child) head for all conditions.*

Therefore, international test procedures used to make sure mobile phones meet exposure standards cover all users including children.

It should also be remembered that the exposure standards for the general public includes an added safety factor of 50 fold or 5000%.

Claim 10:
Because billions of young children and adults with heads smaller than SAM are now using cell phones extensively, and because they absorb proportionally greater cell phone radiation, it is essential and urgent that governments around the world revise approaches to setting standards for cell phone radiation, to include sufficient protection of children

Response:
It is entirely understandable that some parents may be concerned about mobile phone safety and their children's use of mobiles. Concerns have also been raised about the possibility of greater vulnerability for children because

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[187] Beard et al. Comparisons of computed mobile phone induced SAR in the SAM phantom to that in anatomically correct models of the human head in IEEE Transactions On Electromagnetic Compatibility Vol. 48, Pg. 397 – 407 2006

of an increased susceptibility to health risks during developmental stages and because young people will use mobile phones for most of their lives.

However, a number of independent reviews of all available science by international health authorities and governments have carefully considered this concern and found no evidence of any additional risk to children from mobile phone technologies. The reviews have also considered the 1996 paper which forms the basis of this question.

The most recent independent review to specifically look at this issue, conducted in 2009 by seven internationally recognised experts, found:

> *Overall, the review of the existing scientific literature does not support the assumption that children's health is affected by RF EMF exposure from mobile phones or base stations.*

Similarly a 2007 review by the Irish Government Expert Group, which conducted an in-depth scientific review of all the science on mobile phones and children, found:

> *There is no data available to suggest that the use of mobile phones by children is a health hazard.*

Also, international safety standards have taken these concerns and potential risks into account when developing their recommendations. The guidelines have been developed using worst-case scenarios and include added safety margins to ensure children are protected.

For example, the Chairman of the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which developed the international safety standard, has concluded:

> *The protection system using basic restrictions and reference levels makes the ICNIRP guidelines flexible and applicable to virtually any exposure condition, and any group of population. Therefore, there is no need, or justification, for a special approach to the protection of children.*

FCC; Mobile Manufacturers Forum Reply Comments,
ET Docket No. 13-84 (Nov. 18, 2013)

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

Federal Communications Commission FCC 13-39

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

REPLY COMMENTS BY MOBILE MANUFACTURERS FORUM

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I - INTRODUCTION AND SUMMARY

The Mobile Manufacturers Forum (MMF) submits these reply comments in response to the above-referenced proceedings.

The MMF is an international association of telecommunications equipment manufacturers with an interest in mobile or wireless communications, including the manufacturers of mobile handsets and devices as well as the manufacturers of the network infrastructure. Established to support research into the health and safety of radio frequency electromagnetic fields, the MMF has worked with national and international health agencies to support identified research. Further information on the MMF can be found on our website at www.mmfai.org.

In our initial comments[1] the MMF argued that the rationale for continuing to maintain two separate standards in a world that has largely harmonized SAR and MPE limits is increasingly difficult to justify and, on the contrary, that there are strong policy, practical and scientific grounds to justify an alignment of the FCC standards with those adopted by IEEE C95.1-2005 (which for the present purposes are essentially the same as those recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP)). This is a position that has been supported by many parties to this proceeding.[2] For those parties that do oppose such an alignment, the reasoning and support they offered in their comments[3] has been found to be wanting and contradicted by credible expert reviews, more recent

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[1] *See* Comments of the Mobile Manufacturers Forum, ET Docket Nos. 13-84, 03-137, at 15-17 (filed Sept. 3, 2013) ("MMF Comments")

[2] *See for example* Comments of the Consumer Electronics Association, ET Docket Nos. 13-84, 03-137, at 5-6 (filed Sept. 3, 2013) ("CEA Comments"); Comments of the International Committee on Electromagnetic Safety (ICES) of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), ET Docket Nos. 13-84, 03-137, at 1-2 (filed Sept. 3, 2013) ("ICES Comments"); Comments of Motorola Solutions, Inc., ET Docket Nos. 13-84, 03-137, at 10-13 (filed Sept. 3, 2013) ("Motorola Solutions Comments"); Comments of Nokia Corporation, ET Docket Nos. 13-84, 03-137, at 3-5 (filed Sept. 3, 2013) ("Nokia Comments"); Comments of the Telecommunications Industry Association, ET Docket Nos. 13-84, 03-137, at 3 (filed Sept. 3, 2013) ("TIA Comments"); Comments of Wi-Fi Alliance, ET Docket Nos. 13-84, 03-137, at 4-7 (filed Sept. 3, 2013) ("Wi-Fi Alliance Comments")

[3] *See for example* Comments by Jonathan D. Libber for Maryland Smart Meter Awareness ET Docket Nos. 103-137, at 1 (filed Feb. 6, 2013) ("MSMA Comments"); Comments by B. Blake Levitt ET Docket Nos. 03-137 at 3 (filed Feb. 7, 2013) ("B.B Levitt Comments"); Comments by Om P. Gandhi ET Docket Nos. 13-84, 03-137, at 2 (filed June 2, 2013) ("Om Gandhi Comments"); Reply Comments by Center for Electrosmog Prevention ET Docket No.03-137 and WT Docket No. 1-357, at 4 (filed March 4, 2013) ("CEP Comments")

studies and the overall weight of scientific opinion. Thus we believe that there are indeed strong grounds for the FCC to harmonize their current standards with IEEE C95.1-2005.

A – SCIENTIFIC, POLICY, AND PRACTICAL RATIONAL FOR HARMONIZATION OF FCC'S RF STANDARDS

The MMF has indicated in our initial comments[4] that we believe that there are strong scientific, policy and practical grounds to justify an alignment of the FCC's standards with the IEEE C95.1- 2005 standard. Foremost, we agree with the comments filed by International Committee on Electromagnetic Safety ('ICES') of the Institute of Electrical and Electronics Engineers Inc. ('IEEE') where they state that IEEE C95.1- 2005 "is the most up-to-date international exposure standard and incorporates many science-based improvements over IEEE C95.1-1991 and the ICNIRP guidelines."[5]

1– SCIENTIFIC CONSENSUS OF OPINION SUPPORTS HARMONIZATION

As the MMF outlined in our initial comments, there have been several recent statements by national and international health agencies and expert bodies that provide a solid basis for the adoption of international standards.[6] Essentially those statements demonstrate that health agencies and expert bodies do not consider that there are any established health effects below the levels recommended by ICNIRP and IEEE C95.1-2005.

Several parties in this proceeding also highlighted that the World Health Organization (WHO) also recommends national authorities to adopt either the ICNIRP guidelines or the IEEE C95.1-2005 standard. Such a recommendation from

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[4] *See* MMF Comments at 18-19
[5] *See* ICES Comments at 2
[6] *See* MMF Comments at 18-19

the WHO highlights the degree to which there is consensus in scientific opinion on the appropriateness of the international standards for the protection of all members of the community. As commenting parties have noted[7], these standards are conservative in nature and provide a high level of protection for everyone, including children, through the incorporation of a substantial safety margin.

Such is the consensus of scientific opinion that ICES stated in their comments: "(t)oday, there are no international standards or guidelines that support a partial-body exposure basic restriction of 1.6 W/kg, averaged over 1 g of tissue, adopted by FCC in 1996."[8]

A – ARGUMENTS AGAINST HARMONIZATION ARE UNSUPPORTED

While the consensus of scientific opinion clearly favors harmonization, some commenting parties to this proceeding attempted to argue against harmonization, although their arguments ultimately are unsupported.

For example the Environmental Working Group claimed that children are more vulnerable to RF emissions[9] and that limits on the specific absorption rates (SAR) should be different for adults and children.[10] However, as the MMF already highlighted in our initial comments[11] a number of independent reviews of all the available science by international health authorities and governments have carefully considered these concerns and found no evidence of any additional risk to children from mobile phone technologies. As we also mentioned[12], the Health Council of the Netherlands also specifically addressed the question of whether or not there needed to be different exposure limits for children or other vulnerable groups in the community and concluded:

The answer to this question is: no, because the potential additional sensitivity of

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[7] *See for example* CEA Comments at 12, Nokia Comments at 9, TIA Comments at 7,9 and 21,
[8] *See* ICES Comment at 4
[9] Environmental Working Group ET Docket No. 13-84 and 03-137 at 3 (filed Sept. 3, 2013)
[10] *See* Environmental Working Group Comments at 5-6
[11] *See* MMF Comments at 20-25
[12] *See* MMF Comments at 24-25

> *children and other vulnerable groups was explicitly accounted for in setting the exposure limits.*
>
> *It is one of the reasons why the exposure limits for the general population include an ample uncertainty margin of a factor of 50. Based on the data presented in this report, the Committee sees no reason to recommend different exposure limits for children than for adults.* [13]

Likewise, the EM Radiation Policy Institute (EMRPI) urged RF safety limits be based on harms demonstrated in the 2007 BioInitiative Report[14], despite the fact that this self-published report has been heavily criticized as being selective, not presenting a balanced analysis and for making claims which lacked a scientific basis. The Health Council of the Netherlands reviewed the report in 2008[15] and concluded:

> *In view of the way the BioInitiative report was compiled, the selective use of scientific data and the other shortcomings mentioned above, the Committee concludes that the BioInitiative report is not an objective and balanced reflection of the current state of scientific knowledge.*

The IEEE Committee on Man and Radiation also published a paper in 2009[16] and concluded:

> *the weight of scientific evidence in the RF bioeffects literature does not support the safety limits recommended by the BioInitiative group. For this reason, COMAR recommends that public health officials continue to base their policies on RF safety limits recommended by established and sanctioned international organizations such as the Institute of Electrical and Electronics Engineers International Committee on Electromagnetic Safety and the International Commission on Non-Ionizing Radiation Protection, which is formally related to the World Health Organization.*

As we noted in our original comments[17], the recommendations of the BioInitiative authors in their 2012 paper of a limit of just 0.0003 $\mu W/cm^2$ would result in typical compliance zones around base station sites that would extend about a hundred meters around pico sites, through to several hundred meters for micro base stations and through to several kilometers for a macro base station. The MMF submits that such recommendations are both scientifically and practically flawed.

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[13] Health Council of the Netherlands, 2011, *Influence of radiofrequency telecommunication signals on children's brains*. The Hague: Health Council of the Netherlands, 2011; publication no. 2011/20E. ISBN 978-90-5549-859-8

[14] Comments of the EM Radiation Policy Institute ET Docket No. 13-84 and 03-137 at 3 (filed Aug. 30, 2013)

[15] http://www.gr.nl/sites/default/files/200817E_0.pdf

[16] COMAR Technical Information Statement: Expert reviews on potential health effects of radiofrequency electromagnetic fields and comments on the BioInitiative Report. Health Phys. 97(4):348 –356, 2009.

[17] *See* MMF Comments at 56

In our original comments[18] we also dealt with EMRPI's assertions that RF is damaging the ecosystem[19], claims which are at odds with comprehensive reviews of the subject and statements by the World Health Organization. [20]

Several submissions claimed that the existing FCC standards do not take account of the studies showing biological harm at levels below what the standards allow.[21] However, as we noted in our original comments[22] ICES has extensively reviewed the biological effects ascribed to exposure to low-level fields, i.e., at or below the corresponding basic restrictions in the frequency range 3 kHz to 300 GHz and they have stated:

> *Despite more than 50 years of RF research, low-level biological effects have not been established. No theoretical mechanism has been established that supports the existence of any effect characterized by trivial heating other than microwave hearing. Moreover, the relevance of reported low-level effects to health remains speculative and such effects are not useful for standard setting.*[23]

Other submissions tried to argue that the 'precautionary principle' should be applied to lower the FCC standards[24], however these comments failed to point out, as we mentioned in our original comments[25] that such calls have often resulted in the adoption of arbitrary reductions in the exposure limits at a national level and resulted in a number of unintended consequences particularly for network infrastructure such as:

- Increased compliance zones around existing base station sites which can require output power to be reduced creating gaps in network coverage that

[18] *See* MMF Comments at 101
[19] *See* EMRPI Comments at 12
[20] *See* MMF Comments at 101, particularly the WHO International EMF Project, Information Sheet, February 2005 *Effects of EMF on the Environment* http://www.who.int/peh-emf/publications/facts/envimpactemf_infosheet.pdf
[21] See EMRPI Comments at 4, Consumers for Safe Cell Phones (CSCP) ET Docket No. 13-84 and 03-137 at 2-3 (Filed Sep. 3, 2013), Cindy Sage and David O. Carpenter ET Docket No. 13-84 and 03-137 at 2-3 (filed Aug. 27, 2013), B. Blake Levitt and Henry C. Lai ET Docket No. 13-84 and 03-137 at 5 (filed Aug. 26, 2013)("Levitt Lai Comments"), Ellen K. Marks for California Brain Tumor Association ET Docket No. 03-137 at 1 (filed Feb. 2, 2013)
[22] *See* MMF Comments at 95
[23] IEEE C95.1-2005 - Annex C.1.2, page 82
[24] *See* Olle Johansson Comments ET Docket No. 13-84 at 1 (filed Feb. 6, 2013) and Dariusz Leszczynski Comments ET Docket No. 13-84 and 03-137 at 2 (filed Apr. 12, 2013)

[25] *See* MMF Comments at 51-67

result in the need for more sites than otherwise required;

- Adverse impacts for emergency services as well as consumers who are relying on their mobile phone to contact emergency services;
- Arbitrary reductions can be interpreted by the public as evidence that there is something to be concerned about regarding the safety of base stations;
- Lower limit values create the perception that base station emissions are now much higher when viewed as a percentage of the relevant limit compared with the international standard;
- The adoption of arbitrary values lack any scientific justification, and as such, resisting calls for further reductions becomes a matter of political will rather than of scientific merit;
- Arbitrary reductions to the international standards do not provide any measurable improvement with regards to the effects of EMF exposure, as both ICNIRP guidelines and the IEEE standard are already well below the threshold level that can cause adverse effects.
- Consistent international experience is that 'precautionary measures' can increase the level of concern within the public rather than reduce it.

The issues that we raised above in relation to the increase in compliance areas and the increased level of concern that are often seen in relation to the adoption of such arbitrary measures has been recently confirmed in an ITU-T submission by India.[26] In that submission they outlined the various problems that they have experienced as a result of adopting lower limits out of "abundant caution"[27] in 2012. These include compliance distances around base stations that have increased more than 200%[28] making it difficult for operators to ensure compliance in publicly accessible areas

[26] ITU-T: T13-SG05-C-0097: *Issues in implementation of new Electro Magnetic Field Emission norms with 1/10th of ICNIRP norms*
[27] Id. 1.6
[28] Id. 2.1.1

without reducing power and therefore cell coverage[29] – causing degraded quality of service issues for consumers[30]. Above all, India states that "the reduced limits have also increased concern among the public about EMF radiation."[31]

Likewise, as we argued in our original comments[32], such calls for the application of the precautionary principle are at odds with the approach of the European Commission which has the principle enshrined in the Treaty on the European Union (also known as the Maastricht Treaty). In response to misapplications of the precautionary principle, in 2000 the European Commission produced a *Communication on the Precautionary Principle* that made it clear that a proper risk assessment was the basis of using the principle and safety measures such as exposure standards should not be arbitrary. The report concluded:

> *The Commission also considers that every decision must be preceded by an examination of all the available scientific data and, if possible, a risk evaluation that is as objective and comprehensive as possible. A decision to invoke the precautionary principle does not mean that the measures will be adopted on an arbitrary or discriminatory basis.*

And, it is also useful to recall as we pointed out in our original comments[33], that the European Commission itself considers the adoption of the EU Council Recommendation (i.e., ICNIRP guidelines) as being an exercise in the application of the precautionary principle.

Other commenting parties suggested that existing standards were not appropriate as there is an increased incidence of specific tumors in the population resulting from RF exposure.[34] However this has been contradicted by several reviews of brain cancer incidence data undertaken in different countries. As the MMF highlighted in our original comments[35], the 2012 Norwegian Institute for Public Health report[36]

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[29] Id. 2.1.2
[30] Id. 2.1.3
[31] Id. 3
[32] *See* MMF Comments at 60
[33] *See* MMF Comments at 61
[34] *See* Joel M. Moskowitz Comments ET Docket No. 13-84 and 03-137 at 2 (filed Sept. 3,2013)
[35] *See* MMF Comments at 77

stated:

> *It is reasonable to assume that the gradually increasing and widespread use of mobile phones would have led to an increased cancer incidence over time, if use was carcinogenic. ...The results of the incidence studies show no evidence of increasing incidence of these cancers over time.*

This is also consistent with the findings from a 2012 examination of United States cancer incidence data by investigators at the National Cancer Institute (NCI). In that study they found the trend for glioma – the most common type of brain cancer –has remained roughly constant during the period cell phone use grew rapidly.

According to the NCI's press release associated with the publication of the study:

> "*The researchers found that while cell phone use increased substantially over the period 1992 to 2008 (from nearly zero to almost 100 per cent of the population), the US trends in glioma incidence did not mirror that increase,*" [37]

In the study itself published in the *British Medical Journal*, the researchers said:

> "*If phone use was associated with glioma risk, we expected glioma incidence rates to be higher than those observed, even with a latency period of 10 years and low relative risks,*" [38]

The NCI results are consistent with a study undertaken of incidence trends in the Nordic countries, which were the first to launch cell phone networks and where usage has been the longest. In that paper, which covered the period 1979-2008, the researchers found:

> "*Incidence rates were generally stable over the whole period, and increased gradually among older persons. A slight decrease in incidence rates was observed after the late 1980s among the younger men overall and in Denmark and Sweden, but not in Finland and Norway,*" [39]

Therefore the claim made by some commentators that incidence trends of brain

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[36] http://www.fhi.no/

[37] http://www.cancer.gov/newscenter/newsfromnci/2012/GliomaCellPhoneUse
[38] Little M P et al., Mobile phone use and glioma risk: comparison of epidemiological study results with incidence trends in the United States, *BMJ 2012; 344*
[39] Deltour I et al., Mobile phone use and incidence of glioma in the Nordic countries 1979-2008: consistency check, *Epidemiology. 2012 Mar;23(2):301-7*

cancers are increasing is simply not supported by the published studies[40] or by the expert reviews of the literature.

Several other commenting parties[41] objected to a change in the standards citing studies undertaken near or around base stations that claimed links to cancer. However, the international consensus of expert bodies and health authorities such as the World Health Organization (WHO) is that there is no convincing scientific evidence of health effects from living or working near a mobile phone base station. For example, the current WHO fact sheet on base stations and wireless networks[42] says:

> *"Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects.*
> *Recent surveys have indicated that RF exposures from base stations and wireless technologies in publicly accessible areas (including schools and hospitals) are normally thousands of times below international standards.*
>
> *From all evidence accumulated so far, no adverse short- or long-term health effects have been shown to occur from the RF signals produced by base stations."*

It is also interesting to note that several of the studies specifically relied upon[43] such as two studies by Eger H. et al.[44],[45] were "excluded" from the systematic analysis conducted by the World Health Organization[46] in 2010 on this issue, because they did not meet the standard quality criteria. Other studies such as those undertaken by Gerd Oberfeld[47] have also been controversial.[48]

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[40] See also de Vocht F. et al., Time trends (1998–2007) in brain cancer incidence rates in relation to mobile phone use in England, *Bioelectromagnetics 32(5) 334-339* July 2011 and Deltour I et al, Time Trends in Brain Tumor Incidence Rates in Denmark, Finland, Norway, and Sweden, 1974–2003*, J Natl Cancer Inst (2009) 101 (24): 1721-1724*.

[41] *See* Andrew Goldsworthy Comments ET Docket No. 13-84 at 8 (filed Feb. 4, 2013)**,** Levitt Lai Comments at 28-29**,** Magda Havas Comments ET Docket No. 13-84 and 03-137 at 4 (filed Feb. 4, 2013), and EMRPI Comments at 13

[42] http://www.who.int/mediacentre/factsheets/fs304/en/index.html

[43] *See* Magda Havas Comments at 4,

[44] Eger H, Hagen KU, Lucas B, Vogel P, Voit H. Einfluss der räumlichen Nähe von Mobilfunksendeanlagen auf die Krebsinzidenz [Influence of proximity to mobile phone base stations on cancer incidence]. *Umwelt - Medizin - Gesellschaft* 2004;17:326-32. German

[45] Eger H, Neppe F. Krebsinzidenz von Anwohnern im Umkreis einer Mobilfunksendeanlage in Westfalen; Interview-basierte Piloterhebung und Risikoschätzung [Cancer incidence among people living near a mobile phone base station in Westphalia: an interview-based pilot survey and risk estimation]. *Umwelt - Medizin - Gesellschaft* 2009;22:55-60. German.

[46] Martin Röösli, Patrizia Frei, Evelyn Mohler & Kerstin Hug, Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations, *Bulletin of the World Health Organization* 2010;88:887-896F

[47] *See* Levitt and Lai Comments at 28

After completing its analysis, the WHO systematic review arrived at the following conclusion:

> "*In conclusion, our review does not indicate an association between any health outcome and radiofrequency electromagnetic field exposure from MPBSs [mobile phone base stations] at levels typically encountered in people's everyday environment.*"[49]

Taking this into account and the WHO's current advice, one again finds that the issues raised are unsupported, and should not be a barrier to a harmonization of the FCC standards.

2 – POLICY CONSIDERATIONS SUPPORT HARMONIZATION

There are many policy grounds that speak in favor of harmonization of the current FCC standards, not least of which is that the current standards are more than 20 years old, with an underlying scientific rationale that has since been updated twice – a key point that was highlighted in our initial comments[50] and echoed by other commenting parties[51].

Another key consideration, put forward by several parties is that the IEEE C95.1-2005 standard's recommendation of a 2W/kg over a 10gram average mass SAR limit, like ICNIRP's, has been widely adopted throughout the world, and is specifically recommended for national adoption by the World Health Organization.[52] As we highlighted in our own comments[53], there are currently at least 115 countries, territories and regions that use the ICNIRP 2W/kg 10 gram averaging mass SAR limits as the basis of national safety standards for mobile devices and 105 that follow ICNIRP's recommendations for mobile phone networks. This is in stark contrast to only nine that follow the FCC for mobile networks and thirteen for mobile devices. Therefore the MMF's view, outlined in our initial comments[54], is that the rationale for continuing to maintain two separate standards in a world that has

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[48] A 2008 study by Gerd Oberfeld had to be withdrawn when it was disclosed that no C-Net base station existed at the site claimed and therefore the claims of an increased cancer risk were without foundation.
[49] http://www.who.int/bulletin/volumes/88/12/09-071852/en/
[50] *See* MMF Comments at 4
[51] *See* Nokia Comments at 8, CEA Comments at 5, TIA Comments at 3
[52] *See* CTIA Comments at 32-33; ICES Comments at 6; and Nokia Comments at 8-9.
[53] *See* MMF Comments at 5
[54] See MMF Comments at 4

in the main adopted the international standards is increasing difficult to maintain.

Furthermore, the FCC has already recognized the IEEE as an expert consensus standards development body, as illustrated by the adoption in its current standards, based in part on C95.1-1991. Likewise as the ICES submission has demonstrated the development of C95.1-2005 was "developed by an international committee of more than 125 members representing 25 countries" including "members of the government, military, academia, industry, and general public".[55] It was also development through an "open consensus process with oversight by the IEEE Standards Association under the principles of transparency and due process afforded to all".[56] This voluntary consensus approach is also consistent with Congressional and Executive branch policies favoring reliance on standards developed through such bodies, which was also highlighted by several parties.[57] The ICES also noted in their comments that representatives of agencies of the Federal RF Interagency Working Group, e.g., FCC, FDA, NIOSH and OHSA, were also involved in the development of C95.1-2005.[58]

Considering the recognition that the FCC has given to the IEEE C95.1 standard in the past and that the revisions processe involves an open consensus approach that has Congressional and Executive branch support, the MMF reaffirms our view that it should be appropriate and reasonable from a policy perspective to update the current FCC standards to harmonize with the C95.1-2005 Standard.

3 – HARMONIZATION BENEFITS CONSUMERS, INDUSTRY AND GOVERNMENT

In our initial comments we outlined the significant benefits that would result from harmonization, particularly in terms of coverage and quality of service for consumers living in rural and regional areas.[59] In addition to these considerations,

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[55] *See* ICES Comments at 2
[56] *See* ICES Comments at 2
[57] *See* MMF Comments at 34-38, CEA Comments at 6; and TIA Comments at 7
[58] *See* ICES Comments footnote 8
[59] *See* MMF Comments 38-41,

we agree with the comments of the TIA whereby harmonizing limits would allow for a "build once, test once, sell everywhere" effect for manufacturers that would remove unnecessary trade barriers and improve the time-to-market for new products while reducing costs to consumers[60], comments that were also echoed by Motorola Solutions[61] and the CTIA.[62] The CTIA comments also highlight the benefits of harmonization to government, the economy and to the community at large. The CTIA cites the Office of Management and Budget *Circular A-119 (Revised),* which states that harmonization "can increase productivity and efficiency in Government and industry, expand opportunities for international trade, conserve resources, improve health and safety, and protect the environment."[63] The MMF is certainly in agreement with these comments.

Harmonization of the FCC standards also will address the "disparities of EMF standards" that has "caused increasing public anxiety about EMF". [64] The continuation of these disparities leads to the problems that we highlighted in our initial comments[65] and above in relation to the recent decision on regulations in India, which was held up as an example by other commenting parties[66] to oppose adoption of the science-based standards recommended by the WHO. On the contrary, as we detailed in our initial comments, harmonization increases consumer confidence and reduces community concerns.[67]

In view of the benefits to consumers, industry and government, the MMF reaffirms its recommendation that the current FCC standards be harmonized with IEEE C95.1-2005.

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[60] *See* TIA Comments at 6-7.
[61] *See* Motorola Solutions Comments at 13
[62] *See* CTIA Comments at 31-32.
[63] *See* CTIA Comments at 32
[64] *See* CTIA Comments at 32 quoting the WHO *Electromagnetic Fields – Standards & Guidelines*, available at http://www.who.int/peh-emf/standards/en/
[65] *See* MMF Comments at 43
[66] *See* MSMA Comments at 2
[67] *See* MMF Comments at 5

II - CONCLUSION

As commenting parties to this proceeding have highlighted the degree to which there is a consensus of scientific opinion that the international standards provide an appropriate level of protection for all members of the community, including children, through the incorporation of large safety margins, and that there are strong policy justifications as well as practical benefits for consumers, industry and government that would arise from harmonization, there is a compelling case for harmonization of the FCC standards with IEEE C95.1-2005.

Respectfully submitted,

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November 18, 2013

Research Compilation; Abstracts of over 2,100 studies published between 1990-2017; Prof. Henry Lai.
(Tab 7 Part 1)

December 14, 2017

The following is a list of research publications (1990-2017) on the biological effects of radiofrequency and cell phone radiation. Use the 'Find' command to search for keywords, e.g., sleep, melatonin, micronucleus, etc.

Aalto S, Haarala C, Bruck A, Sipila H, Hamalainen H, Rinne JO. Mobile phone affects cerebral blood flow in humans. J Cereb Blood Flow Metab. 26(7):885-890, 2006.

Mobile phones create a radio-frequency electromagnetic field (EMF) around them when in use, the effects of which on brain physiology in humans are not well known. We studied the effects of a commercial mobile phone on regional cerebral blood flow (rCBF) in healthy humans using positron emission tomography (PET) imaging. Positron emission tomography data was acquired using a double-blind, counterbalanced study design with 12 male subjects performing a computer-controlled verbal working memory task (letter 1-back). Explorative and objective voxel-based statistical analysis revealed that a mobile phone in operation induces a local decrease in rCBF beneath the antenna in the inferior temporal cortex and an increase more distantly in the prefrontal cortex. Our results provide the first evidence, suggesting that the EMF emitted by a commercial mobile phone affects rCBF in humans. These results are consistent with the postulation that EMF induces changes in neuronal activity.

Abdel-Rassoul G, El-Fateh OA, Salem MA, Michael A, Farahat F, El-Batanouny M, Salem E. Neurobehavioral effects among inhabitants around mobile phone base stations. Neurotoxicology. 28(2):434-40, 2007.

BACKGROUND: There is a general concern on the possible hazardous health effects of exposure to radiofrequency electromagnetic radiations (RFR) emitted from mobile phone base station antennas on the human nervous system. AIM: To identify the possible neurobehavioral deficits among inhabitants living nearby mobile phone base stations. METHODS: A cross-sectional study was conducted on (85) inhabitants living nearby the first mobile phone station antenna in Menoufiya governorate, Egypt, 37 are living in a building under the station antenna while 48 opposite the station. A control group (80) participants were matched with the exposed for age, sex, occupation and educational level. All participants completed a structured questionnaire containing: personal, educational and medical histories; general and neurological examinations; neurobehavioral test battery (NBTB) [involving tests for visuomotor speed, problem solving, attention and memory]; in addition to Eysenck personality questionnaire (EPQ). RESULTS: The prevalence of neuropsychiatric complaints as headache (23.5%), memory changes (28.2%), dizziness (18.8%), tremors (9.4%), depressive symptoms (21.7%), and sleep disturbance (23.5%) were significantly higher among exposed inhabitants than controls: (10%), (5%), (5%), (0%), (8.8%) and (10%), respectively ($P<0.05$). The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory [Paced Auditory Serial Addition Test (PASAT)]. Also, the inhabitants opposite the station exhibited a lower performance in the problem solving test (block design) than those under the station. All inhabitants exhibited a better performance in the two tests of visuomotor speed (Digit symbol and Trailmaking B) and one test of attention (Trailmaking A) than controls. The last available measures of RFR emitted from the first mobile phone base station antennas in Menoufiya governorate were less than the allowable standard level. CONCLUSIONS AND RECOMMENDATIONS: Inhabitants living nearby mobile phone base stations are at risk for developing neuropsychiatric problems and some changes in the performance of neurobehavioral functions either by facilitation or inhibition. So, revision of standard guidelines for public exposure to RER from mobile phone base station antennas and using of NBTB for regular assessment and early detection of biological effects among inhabitants around the stations are recommended.

Aboul Ezz HS, Khadrawy YA, Ahmed NA, Radwan NM, El Bakry MM. The effect of pulsed electromagnetic radiation from mobile phone on the levels of monoamine neurotransmitters in four different areas of rat brain. Eur Rev Med Pharmacol Sci. 17(13):1782-1788, 2013.

BACKGROUND: The use of mobile phones is rapidly increasing all over the world. Few studies deal with the effect of electromagnetic radiation (EMR) on monoamine neurotransmitters in the different brain areas of adult rat. AIM: The aim of the present study was to investigate the effect of EMR on the concentrations of dopamine (DA), norepinephrine (NE) and serotonin (5-HT) in the hippocampus, hypothalamus, midbrain and medulla oblongata of adult rats. MATERIALS AND METHODS: Adult rats were exposed daily to EMR (frequency 1800 MHz, specific absorption rate 0.843 W/kg, power density 0.02 mW/cm2, modulated at 217 Hz) and sacrificed after 1, 2 and 4 months of daily EMR exposure as well as after stopping EMR for 1 month (after 4 months of daily EMR exposure). Monoamines were determined by high performance liquid chromatography coupled with fluorescence detection (HPLC-FD) using their native properties. RESULTS: The exposure to EMR resulted in significant changes in DA, NE and 5-HT in the four selected areas of adult rat brain. CONCLUSIONS: The exposure of adult rats to EMR may cause disturbances in monoamine neurotransmitters and this may underlie many of the adverse effects reported after EMR including memory, learning, and stress.

Abramson MJ, Benke GP, Dimitriadis C, Inyang IO, Sim MR, Wolfe RS, Croft RJ. Mobile telephone use is associated with changes in cognitive function in young adolescents. Bioelectromagnetics. 30(8):678-686, 2009.

As part of the Mobile Radiofrequency Phone Exposed Users' Study (MoRPhEUS), a cross-sectional epidemiological study examined cognitive function in secondary school students. We recruited 317, 7th grade students (144 boys, 173 girls, median age 13 years) from 20 schools around Melbourne, Australia. Participants completed an exposure questionnaire based on the Interphone study, a computerised cognitive test battery, and the Stroop colour-word test. The principal exposure metric was the total number of reported mobile phone voice calls per week. Linear regression models were fitted to cognitive test response times and accuracies. Age, gender, ethnicity, socio-economic status and handedness were fitted as covariates and standard errors were adjusted for clustering by school. The accuracy of working memory was poorer, reaction time for a simple learning task shorter, associative learning response time shorter and accuracy poorer in children reporting more mobile phone voice calls. There were no significant relationships between exposure and signal detection, movement monitoring or estimation. The completion time for Stroop word naming tasks was longer for those reporting more mobile phone voice calls. The findings were similar for total short message service (SMS, also known as text) messages per week, suggesting these cognitive changes were unlikely due to radiofrequency (RF) exposure. Overall, mobile phone use was associated with faster and less accurate responding to higher level cognitive tasks. These behaviours may have been learned through frequent use of a mobile phone.

Abu Khadra KM, Khalil AM, Abu Samak M, Aljaberi A. Evaluation of selected biochemical parameters in the saliva of young males using mobile phones. Electromagn Biol Med. 2014 Feb 5. [Epub ahead of print]

The biochemical status in the saliva of 12 males before/after using mobile phone has been evaluated. Radio frequency signals of 1800 MHz (continuous wave transmission, 217 Hz modulate and Global System for Mobile Communications [GSM - non-DTX]) with 1.09 w/kg specific absorption rate (SAR) value were used for 15 and 30 min. Cell phone radiation induced a significant increase of superoxide dismutase (SOD); there was a statistically significant effect of talking time on the levels of SOD, $F(2, 33) = 8.084$, $p < 0.05$, $\omega = 0.53$. The trend analysis suggests a significant quadratic trend, $F(1, 33) = 4.891$, $p < 0.05$; indicating that after 15 min of talking the levels of SOD increased, but as talking time increased the SOD activity started to drop. In contrast to this, there was no statistically significant effect of talking time on the level of salivary albumin, cytochrome c, catalase or uric acid. Results suggest that exposure to electromagnetic radiation may exert an oxidative stress on human cells as evidenced by the increase in the concentration of the superoxide radical anion released in the saliva of cell phone users.

Acar GO, Yener HM, Savrun FK, Kalkan T, Bayrak I, Enver O. Thermal effects of mobile phones on facial nerves and surrounding soft tissue. Laryngoscope. 119(3):559-562, 2009.

OBJECTIVE: To investigate the possible thermal effects of microwaves from mobile phones on facial nerves (FN) and surrounding soft tissue. STUDY DESIGN:: A prospective study. METHODS: We studied FN conduction rate and compound muscle action potentials (CMAP) on 12 rabbits before exposure to radiofrequency radiation (RFR) emitted from a mobile phone. Also, the temperature change in the soft tissues around the FN was investigated by a four channel Luxtron fiber optic system. A mobile phone with 1900 MHz frequency was placed over the ipsilateral ear of the rabbit for 25 minutes, and FN and surrounding tissues were exposed to a 1.5 watts pulse modulated (217 packets/s) electromagnetic field. During exposure to RFR, immediately after turning off the mobile phone, and 25 minutes after the exposure temperature change in the surrounding tissue of the FN was recorded and compared to preexposure values. Additionally, another recording regarding the FN functions was done and the data were compared to preexposure values. RESULTS: The average temperature of the surrounding soft tissues was 0.39 K higher than the preexposure values during the exposure and immediately after turning off the mobile phone, and decreased to normal levels 25 minutes after the exposure, which was statistically significant. The amplitudes of FN CMAP after radiofrequency radiation exposure were significantly smaller than the preexposure amplitudes and the amplitudes were normal in the 25 minute measurement. CONCLUSION: The RFR emitted from a mobile phone can cause temporary FN dysfunction that can be due to temporary temperature increase in the soft tissue around the FN.

Achudume A, Onibere B, Aina F, Tchokossa P. Induction of oxidative stress in male rats subchronically exposed to electromagnetic fields at non-thermal intensities. J Electromagnetic Analysis and Applications 2(8), 482-487, 2010.

To investigate the oxidative stress-inducing potential of non-thermal electromagnetic fields in rats. Male Wister rats were exposed to electrical field intensity of 2.3 ± 0.82 µV/m . Exposure was in three forms: continuous waves, or modulated at 900 MHz or modulated GSM-nonDTX. The radio frequency radiation (RFR) was 1800 MHz, specific absorption radiation (SAR) (0.95-3.9 W/kg) for 40 and/or 60 days continuously. Control animals were located > 300 m from base station, while sham control animals were located in a similar environmental conditions, but in the vicinity of a non-functional base station. The rats were assessed for thiobarbituric and reactive species (TBARS), reduced glutathione (GSH) content, catalase activity, glutathione reductase (GR) and glucose residue after 40 and 60 days of exposure. At 40 days, electromagnetic radiation failed to induce any significant alterations. However, at 60 days of exposure various attributes evaluated decreased. The respective decreases in both nicotinamide adenine dinucleotide phosphate (NADPH) and Ascorbate- linked lipid peroxidation (LPO) with concomitant diminution in enzymatic antioxidative defense systems resulted in decreased glucose residue. The present studies showed some biochemical changes that may be associated with a prolong exposure to electromagnetic fields and its relationship to the activity of antioxidant system in rat. Regular assessment and early detection of antioxidative defense system among people working around the base stations are recommended.

Adachi-Mejia AM, Edwards PM, Gilbert-Diamond D, Greenough GP, Olson AL.TXT Me I'm Only Sleeping: Adolescents With Mobile Phones in Their Bedroom. Fam Community Health. 37(4):252-257, 2014.

The purpose of this study was to determine if mobile phones interfere with adolescent sleep. We conducted a pilot test in a pediatric primary care practice of 454 patients, half female (51.2%), 12 to 20 years old (mean = 15) attending a well-child visit. Adolescents completed paper-and-pencil surveys in the waiting room. More than half took their mobile phone to bed (62.9%) and kept it turned on while sleeping (56.8%). Almost half used their phone as their alarm (45.7%). More than one-third texted after going to bed (36.7%). Two or more times per week, 7.9% were awakened by a text after going to sleep.

Adair ER, Adams BW, Hartman SK, Physiological interaction processes and radio-frequency energy absorption. Bioelectromagnetics 13(6):497-512, 1992.

Because exposure to microwave fields at the resonant frequency may generate heat deep in the body, hyperthermia may result. This problem has been examined in an animal model to determine both the thresholds for response change and the steady-state thermoregulatory compensation for body heating during exposure at resonant (450 MHz) and supra-resonant (2,450 MHz) frequencies. Adult male squirrel monkeys, held in the far field of an antenna within an anechoic chamber, were exposed (10 min or 90 min) to either 450-MHz or 2,450-MHz CW fields (E polarization) in cool environments. Whole-body SARs ranged from 0-6 W/kg (450 MHz) and 0-9 W/kg (2,450 MHz). Colonic and several skin temperatures, metabolic heat production, and evaporative heat loss were monitored continuously. During brief RF exposures in the cold, the reduction of metabolic heat production was directly proportional to the SAR, but 2,450-MHz energy was a more efficient stimulus than was the resonant frequency. In the steady state, a regulated increase in deep body temperature accompanied exposure at resonance, not unlike that which occurs during exercise. Detailed analyses of the data indicate that temperature changes in the skin are the primary source of the neural signal for a change in physiological interaction processes during RF exposure in the cold.

Adair ER, Kelleher SA, Mack GW, Morocco TS, Thermophysiological responses of human volunteers during controlled whole-body radio frequency exposure at 450 MHz. Bioelectromagnetics 19(4):232-245, 1998.

Thermoregulatory responses of heat production and heat loss were measured in seven adult volunteers (four women and three men, aged 21-57 yr) during 45-min dorsal exposures of the whole body to 450 MHz continuous wave radio frequency (RF) fields. Two power densities (PD) (local peak PD = 18 and 24 mW/cm2; local peak specific absorption rate = 0.320 [W/kg]/[mW/cm2]) were tested in each of three ambient temperatures (Ta = 24, 28, and 31 degrees C) plus Ta controls (no RF). No changes in metabolic heat production occurred under any exposure conditions. Vigorous increases in sweating rate on back and chest, directly related to both Ta and PD, cooled the skin and ensured efficient regulation of the deep body (esophageal) temperature to within 0.1 degrees C of the normal level. Category judgments of thermal sensation, comfort, sweating, and thermal preference usually matched the measured changes in physiological responses. Some subtle effects related to gender were noted that confirm classic physiological data. Our results indicate that dorsal exposures of humans to a supraresonant frequency of 450 MHz at local peak specific absorption rates up to 7.68 W/kg are mildly thermogenic and are counteracted efficiently by normal thermophysiologic heat loss mechanisms, principally sweating.

Adair ER, Cobb BL, Mylacraine KS, Kelleher SA, Human exposure at two radio frequencies (450 and 2450 MHz): similarities and differences in physiological response. Bioelectromagnetics Suppl 4:12-20, 1999.

Thermoregulatory responses of heat production and heat loss were measured in two different groups of seven adult volunteers (males and females) during 45-min dorsal exposures of the whole body to 450 or 2450 MHz continuous-wave radio frequency (RF) fields. At each frequency, two power densities (PD) were tested at each of three ambient temperatures (T(a) = 24, 28, and 31 degrees C) plus T(a) controls (no RF). The normalized peak surface specific absorption rate (SAR), measured at the location of the subject's center back, was the same for comparable PD at both frequencies, i.e., peak surface SAR = 6.0 and 7.7 W/kg. No change in metabolic heat production occurred under any exposure conditions at either frequency. The magnitude of increase in those skin temperatures under direct irradiation was directly related to frequency, but local sweating rates on back and chest were related more to T(a) and SAR. Both efficient sweating and increased local skin blood flow contributed to the regulation of the deep body (esophageal) temperature to within 0.1 degrees C of the baseline level. At both frequencies, normalized peak SARs in excess of ANSI/IEEE C95.1 guidelines were easily counteracted by normal thermophysiological mechanisms. The observed frequency-related response differences agree with classical data concerning the control of heat loss mechanisms in human beings. However, more practical dosimetry than is currently available will be necessary to evaluate realistic human exposures to RF energy in the natural environment.

Adair ER, Blick DW, Allen SJ, Mylacraine KS, Ziriax JM, Scholl DM.Thermophysiological responses of human volunteers to whole body RF exposure at 220 MHz. Bioelectromagnetics. 26(6):448-461, 2005

Since 1994, our research has demonstrated how thermophysiological responses are mobilized in human volunteers exposed to three radio frequencies, 100, 450, and 2450 MHz. A significant gap in this frequency range is now filled by the present study, conducted at 220 MHz. Thermoregulatory responses of heat loss and heat production were measured in six adult volunteers (five males, one female, aged 24-63 years) during 45 min whole body dorsal exposures to 220 MHz radio frequency (RF) energy. Three power densities (PD = 9, 12, and 15 mW/cm(2) [1 mW/cm(2) = 10 W/m(2)], whole body average normalized specific absorption rate [SAR] = 0.045 [W/kg]/[mW/cm(2)] = 0.0045 [W/kg]/[W/m(2)]) were tested at each of three ambient temperatures (T(a) = 24, 28, and 31 degrees C) plus T(a) controls (no RF). Measured responses included esophageal (T(esoph)) and seven skin temperatures (T(sk)), metabolic rate (M), local sweat rate, and local skin blood flow (SkBF). Derived measures included heart rate (HR), respiration rate, and total evaporative water loss (EWL). Finite difference-time domain (FDTD) modeling of a seated 70 kg human exposed to 220 MHz predicted six localized 'hot spots' at which local temperatures were also measured. No changes in M occurred under any test condition, while T(esoph) showed small changes (</=0.35 degrees C) but never exceeded 37.3 degrees C. As with similar exposures at 100 MHz, local T(sk) changed little and modest increases in SkBF were recorded. At 220 MHz, vigorous sweating occurred at PD = 12 and 15 mW/cm(2), with sweating levels higher than those observed for equivalent PD at 100 MHz. Predicted 'hot spots' were confirmed by local temperature measurements. The FDTD model showed the local SAR in deep neural tissues that harbor temperature-sensitive neurons (e.g., brainstem, spinal cord) to be greater at 220 than at 100 MHz. Human exposure at both 220 and 100 MHz results in far less skin heating than occurs during exposure at 450 MHz. However, the exposed subjects thermoregulate efficiently because of increased heat loss responses, particularly sweating. It is clear that these responses are controlled by neural signals from thermosensors deep in the brainstem and spinal cord, rather than those in the skin.

Adang D, Remacle C, Vorst AV. Results of a long-term low-level microwave exposure of rats. IEEE Trans Microwave Theor Tech 57: 2488-2497, 2009.

This paper summarizes the results of experimental research on biological effects induced by electromagnetic exposure to low-level microwaves. We exposed four-month-old Wistar albino rats during 21 months to two different microwave frequencies and exposure modes, 2 h a day, seven days a week. In order to assess possible biological effects of microwaves, we selected among others the following parameters: leucocytes, erythrocytes, monocytes, neutrophils, lymphocytes, hemoglobin, mean corpuscular hemoglobin concentration, and mortality rate. After three and eight months of exposure, we found a statistically significant difference of about 20% between the 970-MHz continuous wave group and sham-exposed group regarding the monocytes in both considered periods. After 14 and 18 months of exposure, we observed a significant increase in white blood cells and neutrophils of about 15% and 25%, respectively. Lymphocytes fell down after 18 months of exposure with about 15% compared to the sham-exposed group. No other statistically significant differences were found, except for minor changes with little biological significance. The most obvious effect we detected is the increase in mortality rate of the exposed groups with respect to the sham-exposed group after 21 months of exposure at the age of 25 months. This increase even increases when observing rats until the age of 28 months: mortality in exposed groups then reaches almost twice the value observed in the sham-exposed group.

Adey WR, Byus CV, Cain CD, Higgins RJ, Jones RA, Kean CJ, Kuster N, MacMurray A, Stagg RB, Zimmerman G, Phillips JL, Haggren W, Spontaneous and nitrosourea-induced primary tumors of the central nervous system in Fischer 344 rats chronically exposed to 836 MHz modulated microwaves. Radiat Res 152(3):293-302, 1999.

We have tested an 836.55 MHz field with North American Digital Cellular (NADC) modulation in a 2-year animal bioassay that included fetal exposure. In offspring of pregnant Fischer 344 rats, we tested both spontaneous tumorigenicity and the incidence of induced central nervous system (CNS) tumors after a single dose of the carcinogen ethylnitrosourea (ENU) in utero, followed by intermittent digital-phone field exposure for 24 months. Far-field exposures began on gestational day 19 and continued until weaning at age 21 days. Near-field exposures began at 35 days and continued for the next 22 months, 4 consecutive days weekly, 2 h/day. SAR levels simulated localized peak brain exposures of a cell phone user. Of the 236 original rats, 182 (77%) survived to the termination of the whole experiment and were sacrificed at age 709-712 days. The 54 rats (23%) that died during the study ("preterm rats") formed a separate group for some statistical analyses. There was no evidence of tumorigenic effects in the CNS from exposure to the TDMA field. However, some evidence of tumor-inhibiting effects of TDMA exposure was apparent. Overall, the TDMA field-exposed animals exhibited trends toward a reduced incidence of spontaneous CNS tumors ($P < 0.16$, two-tailed) and ENU-induced CNS tumors ($P < 0.16$, two-tailed). In preterm rats, where primary neural tumors were determined to be the cause of death, fields decreased the incidence of ENU-induced tumors ($P < 0.03$, two-tailed). We discuss a possible approach to evaluating with greater certainty the possible inhibitory effects of TDMA-field exposure on tumorigenesis in the CNS.

Adey WR, Byus CV, Cain CD, Higgins RJ, Jones RA, Kean CJ, Kuster N, MacMurray A, Stagg RB, Zimmerman G. Spontaneous and nitrosourea-induced primary tumors of the central nervous system in Fischer 344 rats exposed to frequency-modulated microwave fields. Cancer Res 60(7):1857-1863, 2000.

In a 2-year bioassay, we exposed Fischer 344 rats to a frequency-modulated (FM) signal (836.55 MHz +/- 12.5 KHz deviation) simulating radiofrequency exposures in the head of users of hand-held mobile phones. We tested for effects on spontaneous tumorigenicity of central nervous system (CNS) tumors in the offspring of pregnant rats and also for modified incidence of primary CNS tumors in rats treated with a single dose of the neurocarcinogen ethylnitrosourea (ENU) in utero. ENU dosage (4 mg/kg) was selected to give an expected brain tumor incidence of 10-15% over the mean life span of 26 months. Pregnant dams (n = 102) were randomly assigned to six groups. Their offspring were treated as cohorts in each of the six groups (n = 90 per group; total, n = 540): Sham ENU/Sham Field, Sham ENU/Field Exposed, ENU/Sham Field, ENU/Field Exposed, ENU/Cage Control, and Sham ENU/Cage Control. Intermittent field exposures began on gestation day 19 and continued until weaning at 21 days, resuming thereafter at 31 days and continuing until experiment termination at 731-734 days. Energy absorption rates (SARs) in the rats' brains were similar to localized peak brain exposures of a phone user (female, 236 g, 1.0 W/kg; male, 450 g, 1.2 W/kg). Of the original 540 rats, 168 died before the termination of the experiment. In these rats, ENU significantly reduced survival from a mean of 708 days in three groups without ENU treatment to 645 days in three groups treated with ENU (P < 0.0005). <u>There were no effects on survival attributable to FM field exposure in either ENU-treated or in sham-treated groups</u>. Spontaneous CNS tumor incidence in control groups was 1.1-4.4% but sharply higher in rats receiving ENU (14.4-22.2%; P < 0.0001). <u>No FM field-mediated changes were observed in number, incidence, or histological type of either spontaneous or ENU-induced brain tumors, nor were gender differences detected in tumor numbers.</u> These negative findings with FM fields contrast with our study using standard digital phone fields pulsed on and off at 50/se, where a trend was noted toward reduced incidence of both spontaneous and ENU-induced CNS tumors (W. R. Adey et al., Radiat. Res., 152: 293-302, 1999). Although consistent but not attaining significance in the experiment overall (spontaneous CNS tumors, P < 0.08 one-tailed; P < 0.16 two-tailed; ENU-induced CNS tumors, P < 0.08 one-tailed, P < 0.16 two-tailed), the trend was significant (P < 0.015 one-tailed, P < 0.03, two-tailed) in rats that received ENU and died prior to experiment termination, with a primary brain tumor as the cause of death. We discuss differences in the signaling structure of digital and FM fields. Certain bioeffects induced by either amplitude-modulated or pulsed radiofrequency fields at athermal levels have not been seen with fields of similar average power but unvarying in intensity (continuous wave or frequency-modulated fields).

Adibzadeh F, Bakker JF, Paulides MM, Verhaart RF, van Rhoon GC. Impact of head morphology on local brain specific absorption rate from exposure to mobile phone radiation. Bioelectromagnetics. 2014 Nov 15. doi: 10.1002/bem.21885. [Epub ahead of print]

Among various possible health effects of mobile phone radiation, the risk of inducing cancer has the strongest interest of laymen and health organizations. Recently, the

Interphone epidemiological study investigated the association between the estimated Radio Frequency (RF) dose from mobile phones and the risk of developing a brain tumor. Their dosimetric analysis included over 100 phone models but only two homogeneous head phantoms. So, the potential impact of individual morphological features on global and local RF absorption in the brain was not investigated. In this study, we performed detailed dosimetric simulations for 20 head models and quantified the variation of RF dose in different brain regions as a function of head morphology. Head models were exposed to RF fields from generic mobile phones at 835 and 1900 MHz in the "tilted" and "cheek" positions. To evaluate the local RF dose variation, we used and compared two different post-processing methods, that is, averaging specific absorption rate (SAR) over Talairach regions and over sixteen predefined 1 cm^3 cube-shaped field-sensors. The results show that the variation in the averaged SAR among the heads can reach up to 16.4 dB at a 1 cm^3 cube inside the brain (field-sensor method) and alternatively up to 15.8 dB in the medulla region (Talairach method). In conclusion, we show head morphology as an important uncertainty source for dosimetric studies of mobile phones. Therefore, any dosimetric analysis dealing with RF dose at a specific region in the brain (e.g., tumor risk analysis) should be based upon real morphology.

Aerts S, Deschrijver D, Joseph W, Verloock L, Goeminne F, Martens L, Dhaene T. Exposure assessment of mobile phone base station radiation in an outdoor environment using sequential surrogate modeling. Bioelectromagnetics. 34(4):300-311, 2013.

Human exposure to background radiofrequency electromagnetic fields (RF-EMF) has been increasing with the introduction of new technologies. There is a definite need for the quantification of RF-EMF exposure but a robust exposure assessment is not yet possible, mainly due to the lack of a fast and efficient measurement procedure. In this article, a new procedure is proposed for accurately mapping the exposure to base station radiation in an outdoor environment based on surrogate modeling and sequential design, an entirely new approach in the domain of dosimetry for human RF exposure. We tested our procedure in an urban area of about 0.04 km(2) for Global System for Mobile Communications (GSM) technology at 900 MHz (GSM900) using a personal exposimeter. Fifty measurement locations were sufficient to obtain a coarse street exposure map, locating regions of high and low exposure; 70 measurement locations were sufficient to characterize the electric field distribution in the area and build an accurate predictive interpolation model. Hence, accurate GSM900 downlink outdoor exposure maps (for use in, e.g., governmental risk communication and epidemiological studies) are developed by combining the proven efficiency of sequential design with the speed of exposimeter measurements and their ease of handling.

Aerts S, Deschrijver D, Verloock L, Dhaene T, Martens L, Joseph W. Assessment of outdoor radiofrequency electromagnetic field exposure through hotspot localization using kriging-based sequential sampling. Environ Res. 126:184-191, 2013.

In this study, a novel methodology is proposed to create heat maps that accurately pinpoint the outdoor locations with elevated exposure to radiofrequency electromagnetic fields (RF-EMF) in an extensive urban region (or, hotspots), and that would allow local authorities and epidemiologists to efficiently assess the locations and spectral composition of these hotspots, while at the same time developing a global picture of the exposure in the area. Moreover, no prior knowledge about the presence of radiofrequency radiation sources (e.g., base station parameters) is required. After building a surrogate model from the available data using kriging, the proposed method makes use of an iterative sampling strategy that selects new measurement locations at spots which are deemed to contain the most valuable information-inside hotspots or in search of them-based on the prediction uncertainty of the model. The method was tested and validated in an urban subarea of Ghent, Belgium with a size of approximately 1 km2. In total, 600 input and 50 validation measurements were performed using a broadband probe. Five hotspots were discovered and assessed, with maximum total electric-field strengths ranging from 1.3 to 3.1 V/m, satisfying the reference levels issued by the International Commission on Non-Ionizing Radiation Protection for exposure of the general public to RF-EMF. Spectrum analyzer measurements in these hotspots revealed five radiofrequency signals with a relevant contribution to the exposure. The radiofrequency radiation emitted by 900 MHz Global System for Mobile Communications (GSM) base stations was always dominant, with contributions ranging from 45% to 100%. Finally, validation of the subsequent surrogate models shows high prediction accuracy, with the final model featuring an average relative error of less than 2dB (factor 1.26 in electric-field strength), a correlation coefficient of 0.7, and a specificity of 0.96.

Aerts S, Plets D, Thielens A, Martens L, Joseph W. Impact of a Small Cell on the RF-EMF Exposure in a Train. Int J Environ Res Public Health. 12(3):2639-2652, 2015.

The deployment of a miniature mobile-phone base station or small cell in a train car significantly improves the coverage and the capacity of a mobile network service on the train. However, the impact of the small cell on the passengers' exposure to radio-frequency electromagnetic fields (RF-EMF) is unknown. In this study, we assessed experimentally the RF-EMF exposure of a mobile-phone user who is either connected to the outdoor macrocell network or to an in-train small cell, while traveling on the train, by means of the absorbed-dose concept, which combines the base station downlink exposure with the mobile-phone uplink exposure. For Global System for Mobile Communications (GSM) technology at 1800 MHz, we found that by connecting to a small cell, the brain exposure of the user could realistically be reduced by a factor 35 and the whole-body exposure by a factor 11.

Aerts S, Wiart J, Martens L, Joseph W. Assessment of long-term spatio-temporal radiofrequency electromagnetic field exposure. Environ Res. 2017 Nov 13;161:136-143. doi: 10.1016/j.envres.2017.11.003.

As both the environment and telecommunications networks are inherently dynamic, our exposure to environmental radiofrequency (RF) electromagnetic fields (EMF) at an arbitrary location is not at all constant in time. In this study, more than a year's worth of measurement data collected in a fixed low-cost exposimeter network distributed over an urban environment was analysed and used to build, for the first time, a full spatio-temporal surrogate model of outdoor exposure to downlink Global System for Mobile Communications (GSM) and Universal Mobile Telecommunications System (UMTS) signals. Though no global trend was discovered over the measuring period, the difference in measured exposure between two instances could reach up to 42dB (a factor 12,000 in power density). Furthermore, it was found that, taking into account the hour and day of the measurement, the accuracy of the surrogate model in the area under study was improved by up to 50% compared to models that neglect the daily temporal variability of the RF signals. However, further study is required to assess the extent to which the results obtained in the considered environment can be extrapolated to other geographic locations.

Afromeev VI, Tkachenko VN, [Change in the percent of lactate dehydrogenase isoenzyme level in testes of animals exposed to superhigh frequency radiation]. Biofizika 44(5):931-932, 1999. [Article in Russian]

The content of six lactate dehydrogenase isoenzymes in testes of rats exposed to electromagnetic field of 3-cm wavelength range was studied. The changes in their percent contents were found to be inhomogeneous compared with control. It is assumed that electromagnetic radiation affects the organs of the human urinogenital system. The results can be used for estimating the safety of persons professionally exposed to electromagnetic radiation of the industrial frequency range and in the therapy of diseases of the urinogenital system.

Agarwal A, Deepinder F, Sharma RK, Ranga G, Li J. Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. Fertil Steril. 89(1):124-128, 2008.

OBJECTIVE: To investigate the effect of cell phone use on various markers of semen quality. DESIGN: Observational study. SETTING: Infertility clinic. PATIENT(S): Three hundred sixty-one men undergoing infertility evaluation were divided into four groups according to their active cell phone use: group A: no use; group B: <2 h/day; group C: 2-4 h/day; and group D: >4 h/day. INTERVENTION(S): None. MAIN OUTCOME MEASURE(S): Sperm parameters (volume, liquefaction time, pH, viscosity, sperm count, motility, viability, and morphology). RESULT(S): The comparisons of mean sperm count, motility, viability, and normal morphology among four different cell phone user groups were statistically significant. Mean sperm motility, viability, and normal morphology were significantly different in cell phone user groups within two sperm count groups. The laboratory values of the above four sperm parameters decreased in all four cell phone user groups as the duration of daily exposure to cell phones increased. CONCLUSION(S): Use of cell phones decrease the semen quality in men by decreasing the sperm count, motility, viability, and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality.

Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R.

Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril. 92(4) 1318-1325, 2009.

OBJECTIVE: To evaluate effects of cellular phone radiofrequency electromagnetic waves (RF-EMW) during talk mode on unprocessed (neat) ejaculated human semen. DESIGN: Prospective pilot study. SETTING: Center for reproductive medicine laboratory in tertiary hospital setting. SAMPLES: Neat semen samples from normal healthy donors (n = 23) and infertile patients (n = 9). INTERVENTION(S): After liquefaction, neat semen samples were divided into two aliquots. One aliquot (experimental) from each patient was exposed to cellular phone radiation (in talk mode) for 1 h, and the second aliquot (unexposed) served as the control sample under identical conditions. MAIN OUTCOME MEASURE(S): Evaluation of sperm parameters (motility, viability), reactive oxygen species (ROS), total antioxidant capacity (TAC) of semen, ROS-TAC score, and sperm DNA damage. RESULT(S): Samples exposed to RF-EMW showed a significant decrease in sperm motility and viability, increase in ROS level, and decrease in ROS-TAC score. Levels of TAC and DNA damage showed no significant differences from the unexposed group. CONCLUSION(S): Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility.

Aguirre E, Iturri PL, Azpilicueta L, de Miguel-Bilbao S, Ramos V, Gárate U, Falcone F. Analysis of estimation of electromagnetic dosimetric values from non-ionizing radiofrequency fields in conventional road vehicle environments. Electromagn Biol Med. 2014 Jan 24. [Epub ahead of print]

A high number of wireless technologies can be found operating in vehicular environments with the aim of offering different services. The dosimetric evaluation of this kind of scenarios must be performed in order to assess their compatibility with current exposure limits. In this work, a dosimetric evaluation inside a conventional car is performed, with the aid of an in-house 3D Ray Launching computational code, which has been compared with measurement results of wireless sensor networks located inside the vehicle. These results can aid in an adequate assessment of human exposure to non-ionizing radiofrequency fields, taking into account the impact of the morphology and the topology of the vehicle for current as well as for future exposure limits.

Ahlbom A, Feychting M, Green A, Kheifets L, Savitz DA, Swerdlow AJ; ICNIRP (International Commission for Non-Ionizing Radiation Protection) Standing Committee on Epidemiology. Epidemiologic Evidence on mobile phones and tumor risk: a review. Epidemiology. 20(5):639-652, 2009.

This review summarizes and interprets epidemiologic evidence bearing on a possible causal relation between radiofrequency field exposure from mobile phone use and tumor risk. In the last few years, epidemiologic evidence on mobile phone use and the risk of brain and other tumors of the head in adults has grown in volume, geographic diversity of study settings, and the amount of data on longer-term users. However, some key methodologic problems remain, particularly with regard to selective nonresponse and inaccuracy and bias in recall of phone use. Most studies of glioma show small increased or decreased risks among users, although a subset of studies show appreciably elevated risks. We considered methodologic features that might explain the deviant results, but found no clear explanation. Overall the studies published to date do not demonstrate an increased risk within approximately 10 years of use for any tumor of the brain or any other head tumor. Despite the methodologic shortcomings and the limited data on long latency and long-term use, the available data do not suggest a causal association between mobile phone use and fast-growing tumors such as malignant glioma in adults (at least for tumors with short induction periods). For slow-growing tumors such as meningioma and acoustic neuroma, as well as for glioma among long-term users, the absence of association reported thus far is less conclusive because the observation period has been too short.

Ahlers MT, Ammermüller J. No influence of acute RF exposure (GSM-900, GSM-1800, and UMTS) on mouse retinal ganglion cell responses under constant temperature conditions. Bioelectromagnetics. 2013 Sep 21. doi: 10.1002/bem.21811. [Epub ahead of print]

Possible non-thermal effects of radio frequency electromagnetic fields (RF-EMF) on retinal ganglion cells were studied in vitro under conditions of constant temperature. Isolated mouse retinae were exposed to GSM-900, GSM-1800, and universal mobile telecommunication system (UMTS) RF-EMF applying specific absorption rates (SAR) of 0 (sham), 0.02, 0.2, 2, and 20 W/kg. Temperature was kept constant within ±0.5 to 1 °C for GSM-900 and ±0.5 °C for GSM-1800 and UMTS. Responses of retinal ganglion cells to light stimuli of three intensities (0.5, 16, and 445 lx) were recorded before, during, and up to 35 min after exposure. Experiments were performed under double-blind conditions. Changes in light responses during and after exposure were determined for each condition (RF-EMF; SAR value; light intensity) with respect to the responses before exposure, respectively. Changes were calculated using the Euclidian distance of the n-dimensional response vectors, respectively. Some changes already occurred during sham (0 W/kg) exposure, reflecting the intrinsic variability in retinal ganglion cell responses. Comparison of the distance values from sham exposure with those from actual exposure yielded no significant differences. In addition, linear regression analysis of the distance values versus SAR values yielded no consistent dependence of light response changes. From these results we conclude that RF-EMF exposure at three mobile phone frequencies (GSM-900, GSM-1800, UMTS) and SARs up to 20 W/kg has no acute effects on retinal ganglion cell responses under constant temperature conditions.

Ahmed NA, Radwan NM, Aboul Ezz HS, Salama NA. The antioxidant effect of Green Tea Mega EGCG against electromagnetic radiation-induced oxidative stress in the hippocampus and striatum of rats. Electromagn Biol Med. 36(1):63-73, 2017.

Electromagnetic radiation (EMR) of cellular phones may affect biological systems by increasing free radicals and changing the antioxidant defense systems of tissues, eventually leading to oxidative stress. Green tea has recently attracted significant attention due to its health benefits in a variety of disorders, ranging from cancer to weight loss. Thus, the aim of the present study was to investigate the effect of EMR (frequency 900 MHz modulated at 217 Hz, power density 0.02 mW/cm^2, SAR 1.245 W/kg) on different oxidative stress parameters in the hippocampus and striatum of adult rats. This study also extends to evaluate the therapeutic effect of green tea mega EGCG on the previous parameters in animals exposed to EMR after and during EMR exposure. The experimental animals were divided into four groups: EMR-exposed animals, animals treated with green tea mega EGCG after 2 months of EMR exposure, animals treated with green tea mega EGCG during EMR exposure and control animals. EMR exposure resulted in oxidative stress in the hippocampus and striatum as evident from the disturbances in oxidant and antioxidant parameters. Co-administration of green tea mega EGCG at the beginning of EMR exposure for 2 and 3 months had more beneficial effect against EMR-induced oxidative stress than oral administration of green tea mega EGCG after 2 months of exposure. This recommends the use of green tea before any stressor to attenuate the state of oxidative stress and stimulate the antioxidant mechanism of the brain.

Aït-Aïssa S, Billaudel B, Poulletier de Gannes F, Ruffié G, Duleu S, Hurtier A, Haro E, Taxile M, Athané A, Geffard M, Wu T, Wiart J, Bodet D, Veyret B, Lagroye I. In utero and early-life exposure of rats to a Wi-Fi signal: screening of immune markers in sera and gestational outcome. Bioelectromagnetics. 33(5):410-420, 2012.

An experimental approach was used to assess immunological biomarkers in the sera of young rats exposed in utero and postnatal to non-ionizing radiofrequency fields. Pregnant rats were exposed free-running, 2 h/day and 5 days/week to a 2.45 GHz Wi-Fi signal in a reverberation chamber at whole-body specific absorption rates (SAR) of 0, 0.08, 0.4, and 4 W/kg (with 10, 10, 12, and 9 rats, respectively), while cage control rats were kept in the animal facility (11 rats). Dams were exposed from days 6 to 21 of gestation and then three newborns per litter were further exposed from birth to day 35 postnatal. On day 35 after birth, all pups were sacrificed and sera collected. The screening of sera for antibodies directed against 15 different antigens related to damage and/or pathological markers was conducted using enzyme-linked immunosorbent assay (ELISA). No change in humoral response of young pups was observed, regardless of the types of biomarker and SAR levels. This study also provided some data on gestational outcome following in utero exposure to Wi-Fi signals. Mass evaluation of dams and pups and the number of pups per litter was monitored, and the genital tracts of young rats were observed for abnormalities by measuring anogenital distance. Under these experimental conditions, our observations suggest a lack of adverse effects of Wi-Fi exposure on delivery and general condition of the animals.

Aït-Aïssa S, de Gannes FP, Taxile M, Billaudel B, Hurtier A, Haro E, Ruffié G, Athané A, Veyret B, Lagroye I. In Situ Expression of Heat-Shock Proteins and 3-Nitrotyrosine in Brains of Young Rats Exposed to a WiFi Signal In Utero and In Early Life. Radiat Res. 179:707-716, 2013.

The bioeffects of exposure to Wireless High-Fidelity (WiFi) signals on the developing nervous systems of young rodents was investigated by assessing the in vivo and in situ expression levels of three stress markers: 3-Nitrotyrosine (3-NT), an oxidative stress marker and two heat-shock proteins (Hsp25 and Hsp70). These biomarkers were measured in the brains of young rats exposed to a 2450 MHz WiFi signal by immunohistochemistry. Pregnant rats were first exposed or sham exposed to WiFi from day 6 to day 21 of gestation. In addition three newborns per litter were further exposed up to 5 weeks old. Daily 2-h exposures were performed blind in a reverberation chamber and whole-body specific absorption rate levels were 0, 0.08, 0.4 and 4 W/kg. 3-NT and stress protein expression was assayed in different areas of the hippocampus and cortex. No significant difference was observed among exposed and sham-exposed groups. These results suggest that repeated exposure to WiFi during gestation and early life has no deleterious effects on the brains of young rats.

Aitken RJ, Bennetts LE, Sawyer D, Wiklendt AM, King BV. Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. Inter J Androl 28:171-179, 2005.

Concern has arisen over human exposures to radio frequency electromagnetic radiation (RFEMR), including a recent report indicating that regular mobile phone use can negatively impact upon human semen quality. These effects would be particularly serious if the biological effects of RFEMR included the induction of DNA damage in male germ cells. In this study, mice were exposed to 900 MHz RFEMR at a specific absorption rate of approximately 90 mW/kg inside a waveguide for 7 days at 12 h per day. Following exposure, DNA damage to caudal epididymal spermatozoa was assessed by quantitative PCR (QPCR) as well as alkaline and pulsed-field gel electrophoresis. The treated mice were overtly normal and all assessment criteria, including sperm number, morphology and vitality were not significantly affected. Gel electrophoresis revealed no gross evidence of increased single- or double-DNA strand breakage in spermatozoa taken from treated animals. However, a detailed analysis of DNA integrity using QPCR revealed statistically significant damage to both the mitochondrial genome ($p < 0.05$) and the nuclear -globin locus ($p < 0.01$). This study suggests that while RFEMR does not have a dramatic impact on male germ cell development, a significant genotoxic effect on epididymal spermatozoa is evident and deserves further investigation.

Akar A, Karayiğit MO, Bolat D, Gültiken ME, Yarım M, Castellani G. Effects of low level electromagnetic field exposure at 2.45 GHz on rat cornea. Int J Radiat Biol. 2012 Dec 3. [Epub ahead of print]

Abstract Purpose: To investigate the effects of low level Electromagnetic Field (low level-EMF) exposure, as frequently encountered in daily life, on the yesmal rat cornea using histological and stereological method. Methods: Twenty-two adult male Wistar rats were randomly divided into two groups: study group (n=11) and control group (n=11). Rats in the study group were exposed to 2.45 GHz Microwave (MW) radiation (11.96±0.89V/m), 0.25 W/kg specific absorption rate (SAR) for 2 hours each day for 21 days. The corneal thickness and the anterior epithelium corneal thickness were measured using two different methods. Results: Using the histological method, the mean corneal thicknesses in the control and study group were 278.9±54.5 µm, and 272.4±85.6 µm, respectively. There was no statistically significant difference between the groups ($p>0.05$). The anterior corneal epithelium thickness was 28.1±4.9 µm in the control group and 31.7±5.5 µm in the study group. There were statistically differences between the groups with regard to the thickness of anterior epithelium ($p<0.05$). In the measurement made by the stereological method, the percentage of the cornea occupied by anterior corneal epithelium was 15.94% in the control group and 17.9% in the study group. Despite the fact that there was a relation between increased anterior epithelial area (AEA) and radiation exposure, no statistically significant relationship in area fraction of each compartment was found between the control and study groups. Conclusions: Results of this preliminary study show that exposure to MW radiation might cause alterations in the rat cornea.

Akbari A, Jelodar G, Nazifi S. Vitamin C protects rat cerebellum and encephalon from oxidative stress following exposure to radiofrequency wave generated by a BTS antenna model. Toxicol Mech Methods. 24(5):347-352, 2014.

Radio frequency wave (RFW) generated by base transceiver station has been reported to produce deleterious effects on the central nervous system function, possibly through oxidative stress. This study was conducted to evaluate the effect of RFW-induced oxidative stress in the cerebellum and encephalon and the prophylactic effect of vitamin C on theses tissues by measuring the antioxidant enzymes activity, including: glutathione peroxidase, superoxide dismutase, catalase, and malondialdehyde (MDA). Thirty-two adult male Sprague-Dawley rats were randomly divided into four equal groups. The control group; the control-vitamin C group received L-ascorbic acid (200 mg/kg of body weight/day by gavage) for 45 days. The RFW group was exposed to RFW and the RFW+ vitamin C group was exposed to RFW and received vitamin C. At the end of the experiment, all groups were killed and encephalon and cerebellum of all rats were removed and stored at -70 °C for measurement of antioxidant enzymes activity and MDA. The results indicate that exposure to RFW in the test group decreased antioxidant enzymes activity and increased MDA compared with the control groups ($p < 0.05$). The protective role of vitamin C in the treated group improved antioxidant enzymes activity and reduced MDA compared with the test group ($p < 0.05$). It can be concluded that RFW causes oxidative stress in the brain and vitamin C improves the antioxidant enzymes activity and decreases MDA.

Akbarnejad Z, Esmaeilpour K, Shabani M, Asadi-Shekaari M, Saeedi-Goraghani M, Ahmadi M. Spatial memory recovery in Alzheimer's rat model by electromagnetic field exposure. Int J Neurosci. 2017 Nov 29:1-14. doi: 10.1080/00207454.2017.1411353.

INTRODUCTION: Although studies have shown a potential association between extremely low frequency electromagnetic fields (ELF-EMFs) exposure and

Alzheimer's disease (AD), few studies have been conducted to investigate the effects of weak magnetic fields on brain functions such as cognitive functions in animal models. Therefore, this study aimed to investigate the effect of ELF-EMF exposure (50 Hz, 10 mT) on spatial learning and memory changes in AD rats. METHODS: Amyloid-β (Aβ) 1-42 (5 µl/ bilateral, single-dose) was injected into lateral ventricle to establish an AD rat model. The rats were divided into six groups: Group I (control); Group II (surgical sham); Group III (AD) Alzheimer's rat model; Group IV (MF) rats exposed to ELF-MF for 14 consecutive days; Group V (Aβ injection+M) rats exposed to magnetic field for 14 consecutive days from day 0-14 days after the Aβ peptide injection; Group VI (AD+M) rats exposed to magnetic field for 14 consecutive days after 2 weeks of Aβ peptide injection from 14th to 28th day. Morris water maze investigation were implemented and performed 24 h after termination of ELF-MF, respectively. RESULTS: AD rats showed a significant impairment in learning and memory compared to control rats. The results showed that ELF-MF improved the learning and memory impairments in Aβ injection+M and AD+M groups. CONCLUSION: Our results showed that application of ELF-MF not only has improving effect on different cognitive disorder signs of AD animals, but also disrupts the processes of AD rat model formation.

Akdag MZ, Dasdag S, Canturk F, Karabulut D, Caner Y, Adalier N. Does prolonged radiofrequency radiation emitted from Wi-Fi devices induce DNA damage in various tissues of rats? J Chem Neuroanat. 2016 Jan 8. pii: S0891-0618(16)00005-3. doi: 10.1016/j.jchemneu.2016.01.003. [Epub ahead of print]

Wireless Internet (Wi-Fi) providers have become essential in our daily lives, as wireless technology is evolving at a dizzying pace. Although there are different frequency generators, one of the most commonly used Wi-Fi devices are 2.4GHz frequency generators. These devices are heavily used in all areas of life but the effect of radiofrequency (RF) radiation emission on users is generally ignored. Yet, an increasing share of the public expresses concern on this issue. Therefore, this study intends to respond to the growing public concern. The purpose of this study is to reveal whether long term exposure of 2.4GHz frequency RF radiation will cause DNA damage of different tissues such as brain, kidney, liver, and skin tissue and testicular tissues of rats. The study was conducted on 16 adult male Wistar-Albino rats. The rats in the experimental group (n=8) were exposed to 2.4GHz frequency radiation for over a year. The rats in the sham control group (n=8) were subjected to the same experimental conditions except the Wi-Fi generator was turned off. After the exposure period was complete the possible DNA damage on the rat's brain, liver, kidney, skin, and testicular tissues was detected through the single cell gel electrophoresis assay (comet) method. The amount of DNA damage was measured as% tail DNA value. Based on the DNA damage results determined by the single cell gel electrophoresis (Comet) method, it was found that the% tail DNA values of the brain, kidney, liver, and skin tissues of the rats in the experimental group increased more than those in the control group. The increase of the DNA damage in all tissues was not significant ($p > 0.05$). However the increase of the DNA damage in rat testes tissue was significant ($p < 0.01$). In conclusion, long-term exposure to 2.4GHz RF radiation (Wi-

Fi) does not cause DNA damage of the organs investigated in this study except testes. The results of this study indicated that testes are more sensitive organ to RF radiation.

Akhavan-Sigari R, Baf MM, Ariabod V, Rohde V, Rahighi S. Connection between Cell Phone use, p53 Gene Expression in Different Zones of Glioblastoma Multiforme and Survival Prognoses. Rare Tumors. 2014 Aug 8;6(3):5350. doi: 10.4081/rt.2014.5350.

The aim of this paper is to investigate p53 gene expression in the central and peripheral zones of glioblastoma multiforme using a real-time reverse transcription polymerase chain reaction (RT-PCR) technique in patients who use cell phones ≥3 hours a day and determine its relationship to clinicopathological findings and overall survival. Sixty-three patients (38 males and 25 females), diagnosed with glioblastoma multiforme (GBM), underwent tumor resection between 2008 and 2011. Patient ages ranged from 25 to 88 years, with a mean age of 55. The levels of expression of p53 in the central and peripheral zone of the GBM were quantified by RT-PCR. Data on p53 gene expression from the central and peripheral zone, the related malignancy and the clinicopatholagical findings (age, gender, tumor location and size), as well as overall survival, were analyzed. Forty-one out of 63 patients (65%) with the highest level of cell phone use (≥3 hours/day) had higher mutant type p53 expression in the peripheral zone of the glioblastoma; the difference was statistically significant (P=0.034). Results from the present study on the use of mobile phones for ≥3 hours a day show a consistent pattern of increased risk for the mutant type of p53 gene expression in the peripheral zone of the glioblastoma, and that this increase was significantly correlated with shorter overall survival time. The risk was not higher for ipsilateral exposure. We found that the mutant type of p53 gene expression in the peripheral zone of the glioblastoma was increased in 65% of patients using cell phones ≥3 hours a day.

Akimoto S, Nagaoka T, Saito K, Watanabe S, Takahashi M, Ito K. Comparison of SAR in realistic fetus models of two fetal positions exposed to electromagnetic wave from business portable radio close to maternal abdomen.Conf Proc IEEE Eng Med Biol Soc. 2010:734-737, 2010.

Since the diversification of the electromagnetic (EM) environment is spreading, it is essential to estimate the EM energy absorption rate [specific absorption rate (SAR)] of a pregnant woman's body and her fetus under various exposure situations. For example, if pregnant women work in jobs where they might wear business portable radios around their abdomens, they should also be concerned about this issue, because the fetuses are in their abdomens. In this paper, in order to evaluate the SAR in the pregnant woman and her fetus when wearing the wireless radio terminal on her abdomen, the SAR distribution in the fetus is calculated using the numerical model of the pregnant woman by exposed to near-field of a normal mode helical antenna (NHA) with a metallic case at 150 MHz. In addition, the SAR in the fetus will be evaluated under two fetal positions. It was found that the fetal SARs are greatly affected by the distance and penetration path from the antenna to the fetal surface. In addition, the fetal SARs are lower than the RF safety guidelines for occupational exposure.

Akoev IG, Mel'nikov VM, Usachev AV, Kozhokaru AF, [Modification of lethal radiation injury in mice by postradiation exposure to low-intensity centimeter-band radio frequency waves]. Radiats Biol Radioecol 34(4-5):671-674, 1994. [Article in Russian]

A clearly pronounced modification of acute radiation injury of mice has been obtained by prolonged action (for up to 23 hours) of low-intensity (5 +/- 1.5 mu Wt/cm2) radiofrequency radiation in the ranges of 2-8, 8-18 and 19-27 GHz with a swing frequency of 12-14 Hz, applied immediately after exposure to lethal dose of gamma-radiation. Survival of mice and average life duration of killed mice were increased.

Akoev IG, Pashovkina MS, Dolgacheva LP, Semenova TP, Kalmykov VL. [Enzymatic activity of some tissues and blood serum from animals and humans exposed to microwaves and hypothesis on the possible role of free radical processes in the nonlinear effects and modification of emotional behavior of animals] Radiats Biol Radioecol 42(3):322-330, 2002. [Article in Russian]

The dependence of activities of actomyosin ATPase, alkaline phosphatase, aspartataminotranspherase, monoaminoxidase and that of affective rat behavior on frequency of modulation of microwaves (0.8-10 microW/cm2) was explored at short-time actions. Series of nonlinear phenomenons, inexplicable from positions of the energy approaches are revealed, The working hypothesis explaining opportunity of high performance of weak and super-weak microwaves and other revealed phenomena by resonance interaction of such electromagnetic radiofrequency radiation with paramagnetic molecules of biological tissues was proposed. This resonance interaction activate free radicals and initiate auto-supporting and auto-intensifying of chain chemical reactions. The spontaneous autocatalytic oxidation of catecholamines enlarges a common pool of free radicals, capable to participate in such enhanced generating. The protective role of monoaminoxidase is postulated. Monoaminoxidase is basically located on an outer surface of mitochondrias and it is deaminating monoamines. The deaminating prevents penetration of catecholamines inside of mitochondrias and their quinoid oxidation there with formation of free-radical semi-quinons, capable to destroy system of ATP synthesis. These inferences are obliquely confirmed by the experimentally revealed correlation between activity of monoaminoxidase and integrative activity of the rat brain.

Aksen F, Dasdag S, Akdag MZ, Askin M, Dasdag MM. The effects of whole body cell phone exposure on the t1 relaxation times and trace elements in the serum of rats. Electromag Biol Med. 23:7-11, 2004.

The objective of this study was to investigate the effects of radiofrequency radiation emitted from cellular phones on: (1) trace elements such as manganese, iron, copper, zinc, (2) T1 relaxation times in serum, and (3) rectal temperature of rats exposed to microwave radiation emitted from cellular phones. Sixteen Spraque–Dawley rats were separated into two groups of eight, one sham-exposed (control) and one exposed (experimental). The rats were confined in Plexiglas cages and a cellular phone was placed 0.5 cm under the cage. For the experimental group, cellular phones were activated 20 min per day, 7 days a week, for 1 month. For the control group, a cellular phone placed beneath the cage for 20 min a day was turned off. Rectal temperatures were measured weekly. For 250-mW-radiated powers, the whole body average specified absorption rate (SAR) (rms) is 0.52 W/kg and 1-g-averaged peak SAR (rms) is 3.13 W/kg. The Mann-Whitney U test was used for statistical comparisons of groups. T1 relaxation time and the values of iron and copper in the serum of the experimental group were not changed compared to the control group ($p > 0.05$). However, manganese and zinc values in the serum of the experimental group were significantly different from the control group ($p < 0.05$). The difference in rectal temperature measured before and after exposure in the experimental groups was not statistically different from control ($p > 0.05$).

Aksoy U, Sahin S, Ozkoc S, Ergor G. The effect of electromagnetic waves on the growth of Entamoeba histolytica and Entamoeba dispar. Saudi Med J. 26(9):1388-1390, 2005.

OBJECTIVE: The aim of this study was to investigate the influence of electromagnetic radiation of a digital Global System for Mobile Communication mobile telephone (900 MHz) on Entamoeba histolytica (E. histolytica) and Entamoeba dispar (E. dispar) (cysts or trophozoites, or both) in a 24-hour period. METHODS: This study was carried out from April 2004 to May 2004 at the Department of Parasitology, Medical Faculty of Dokuz Eylul University in Izmir, Turkey. The cultivated isolate tubes, which were exposed to electromagnetic field at 37OC, were evaluated as study group, whereas the tubes without exposure were assessed as control group. Finally, only living parasites in all tubes were counted using a hemacytometer. The effect of the temperature was evaluated for both control and study groups. RESULTS: The influence of electromagnetic field and temperature was assessed separately for the study group. The parasite number of E. histolytica decreased after exposure at 37OC and room temperature (p=0.009) compared to the decrease in the control group (p=0.009). The parasite number of E. dispar also decreased after exposure at 37OC and room temperature (p=0.009). In comparison to control tubes, this was a significant decrease (p=0.008). In the case of exposure of E. histolytica the results did not reveal any significant difference between temperature degrees to magnetic field (p=0.459) and E. dispar (p=0.172). CONCLUSION: Our findings show that exposure to electromagnetic field for a certain period of time may cause damage that can lead to death in single-cell organisms.

Aksu R, Uğur F, Bicer C, Menkü A, Güler G, Madenoğlu H, Canpolat DG, Boyaci A. The efficiency of pulsed radiofrequency application on L5 and l6 dorsal roots in rabbits developing neuropathic pain. Reg Anesth Pain Med. 35(1):11-15, 2010.

BACKGROUND: Injury of a peripheral nerve may lead to neuropathic pain, a form of chronic pain that does not respond to traditional pain therapies. The aim of this study was to investigate the effect of pulsed radiofrequency (PRF) applied to the L5 and L6 dorsal roots on the neuropathic pain that develops after sciatic nerve injury in rabbits.
METHODS: In this study, 18 New Zealand rabbits were used. These were divided into 3 groups. In groups 1 and 2, the left sciatic nerve was tightly ligated as a partial ligation model with 4-0 silk sutures. Group 3 was a sham group. Pulsed radiofrequency was applied to group 1 rabbits on both dorsal roots at 42 degrees C for 8 mins. The responses of all the groups to thermal and mechanical stimuli were measured for a period of 4

weeks after this process. **RESULTS:** Ten days after ligation of the left sciatic nerve and before PRF application, neuropathic pain occurred; the responses of groups 1 and 2 to the hot plate test and to the mechanical stimulus were lower ($P < 0.005$) when compared with the baseline values. There were no statistically significant differences between baseline values and group 1 rabbits' responses to the hot plate test 2 weeks after the application of PRF or to the mechanical stimulus 3 weeks after RF application. The decrease seen in group 2 persisted after 4 weeks ($P < 0.001$). **CONCLUSIONS:** The hyperalgesia that develops as a result of neuropathic pain in rabbits was observed to be reduced by PRF application.

Akyel Y, Hunt EL, Gambrill C, Vargas C Jr, Immediate post-exposure effects of high-peak-power microwave pulses on operant behavior of Wistar rats. Bioelectromagnetics 12(3):183-195, 1991.

Behavioral effects of high-peak-power microwave pulses on Wistar rats were studied by operant schedules. Each of twelve rats that had been trained to press a lever to receive food pellets was assigned randomly in groups of four to three different schedules of reinforcement: fixed-ratio (FR), variable-interval (VI), and differential-reinforcement-of-low-rates (DRL). After achieving a steady baseline performance, each animal was exposed for 10 min to 1.25-GHz microwave radiation at 1-MW peak-power (10-microseconds pulse width). Each pulse produced a peak whole-body SA and SAR of 2.1 J/kg and 0.21 MW/kg. Total doses (SAs) were set to 0.50, 1.5, 4.5, and 14 kJ/kg by adjusting the pulse-repetition rate. The corresponding time-averaged whole-body SARs were 0.84, 2.5, 7.6, and 23 W/kg. A microwave-transparent animal holder was used to keep the animal's body axis parallel to the E-field. Exposures at the highest dose caused an average colonic temperature rise of 2.5 degrees C and these animals failed to respond at all for about 13 minutes after the exposure. Their colonic temperatures had decreased to 1.1 degrees C, or less, above their pre-exposure (normal) temperature level when they began to respond. The FR and VI animals failed to reach their baseline levels of performance thereafter, while those on the DRL schedule displayed variable effects. No behavioral effects were found at the lower dose levels. It is concluded that the behavioral perturbations produced by pulsed microwave irradiation were thermal in nature.

Al-Ali BM, Patzak J, Fischereder K, Pummer K, Shamloul R. Cell phone usage and erectile function. Cent European J Urol. 66(1):75-77, 2013.

INTRODUCTION: The objective of this pilot study was to report our experience concerning the effects of cell phone usage on erectile function (EF) in men. MATERIAL AND METHODS: We recruited 20 consecutive men complaining of erectile dysfunction (ED) for at least six months (Group A), and another group of 10 healthy men with no complaints of ED (Group B). Anamnesis, basic laboratory investigations, and clinical examinations were performed. All men completed the German version of the Sexual Health Inventory for Men (SHIM) for evaluation of the International Index of Erectile Function (IIEF), as well as another questionnaire designed by our clinicians that assessed cell phone usage habits. RESULTS: There was no significant difference between both groups regarding age, weight, height, and total testosterone (Table 1). The SHIM scores of Group A were significantly lower than that of Group B, 11.2 ±5 and 24.2 ±2.3, respectively. Total time spent talking on the cell phone per week was not significantly higher in Group A over B, 17.6 ±11.1 vs. 12.5 ±7 hours. Men with ED were found to carry their 'switched on' cell phones for a significantly longer time than those without ED, 4.4 ±3.6 vs. 1.8 ±1 hours per day. CONCLUSIONS: We found a potential correlation with cell phone usage and a negative impact on EF. Further large-scale studies confirming our initial data and exploring the mechanisms involved in this phenomenon are recommended.

Alanko T, Hietanen M Occupational Exposure To Radiofrequency Fields In Antenna Towers. Radiat Prot Dosimetry. 123(4):537-539,2007.

Exposure of workers to radiofrequency fields was assessed in two medium-sized antenna towers. Towers had transmitting antennas from different networks, e.g. mobile phone networks, radio and digital TV sub-stations and amateur radio. The levels of radiofrequency fields were measured close to the ladders of the towers. All measured values were below ICNIRP occupational reference levels.

Aldad TS, Gan G, Gao XB, Taylor HS.Fetal radiofrequency radiation exposure from 800-1900 mhz-rated cellular telephones affects neurodevelopment and behavior in mice. Sci Rep. 2:312, 2012.

Neurobehavioral disorders are increasingly prevalent in children, however their etiology is not well understood. An association between prenatal cellular telephone use and hyperactivity in children has been postulated, yet the direct effects of radiofrequency radiation exposure on neurodevelopment remain unknown. Here we used a mouse model to demonstrate that in-utero radiofrequency exposure from cellular telephones does affect adult behavior. Mice exposed in-utero were hyperactive and had impaired memory as determined using the object recognition, light/dark box and step-down assays. Whole cell patch clamp recordings of miniature excitatory postsynaptic currents (mEPSCs) revealed that these behavioral changes were due to altered neuronal developmental programming. Exposed mice had dose-responsive impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex. We present the first experimental evidence of neuropathology due to in-utero cellular telephone radiation. Further experiments are needed in humans or non-human primates to determine the risk of exposure during pregnancy.

Al-Damegh MA. Rat testicular impairment induced by electromagnetic radiation from a conventional cellular telephone and the protective effects of the antioxidants vitamins C and E. Clinics (Sao Paulo). 67(7):785-792, 2012.

OBJECTIVE: The aim of this study was to investigate the possible effects of electromagnetic radiation from conventional cellular phone use on the oxidant and antioxidant status in rat blood and testicular tissue and determine the possible protective role of vitamins C and E in preventing the detrimental effects of electromagnetic radiation on the testes. MATERIALS AND METHODS: The treatment groups were exposed to an electromagnetic field, electromagnetic field plus vitamin C (40 mg/kg/day) or electromagnetic field plus vitamin E (2.7 mg/kg/day). All groups were exposed to the same electromagnetic frequency for 15, 30, and 60 min daily for two weeks. RESULTS:

There was a significant increase in the diameter of the seminiferous tubules with a disorganized seminiferous tubule sperm cycle interruption in the electromagnetism-exposed group. The serum and testicular tissue conjugated diene, lipid hydroperoxide, and catalase activities increased 3-fold, whereas the total serum and testicular tissue glutathione and glutathione peroxidase levels decreased 3-5 fold in the electromagnetism-exposed animals. CONCLUSION: Our results indicate that the adverse effect of the generated electromagnetic frequency had a negative impact on testicular architecture and enzymatic activity. This finding also indicated the possible role of vitamins C and E in mitigating the oxidative stress imposed on the testes and restoring normality to the testes.

Al-Dousary SH. Mobile phone induced sensorineural hearing loss. Saudi Med J. 28(8):1283-1286, 2007.

The increased use of mobile phones worldwide has focused interest on the biological effects and possible health outcomes of exposure to radiofrequency fields from mobile phones, and their base stations. Various reports suggest that mobile phone use can cause health problems like fatigue, headache, dizziness, tension, and sleep disturbances; however, only limited research data is available in medical literature regarding interaction between electromagnetic fields emitted by mobile phones and auditory function; and the possible impact on hearing. We report a case of sensorineural hearing loss due to Global System for Mobile Communications mobile phone use, in a 42-year-old male.

Alhekail ZO. Electromagnetic radiation from microwave ovens. J Radiol Prot 21(3):251-258, 2001.

Electromagnetic radiation from microwave ovens in Saudi Arabia was investigated by means of a field measurement survey. The survey was carried out for 106 ovens used in households and restaurants in Riyadh city. Ovens were between 1 month and 14 years old with operating power ranging from 0.5 to 4.4 kW. One oven was found to leak more than the 5 mW cm(-2) limit specified in the standard. Fifteen other ovens were found to leak 1 mW cm(-2) or more, with the remaining ovens leaking less than that. Based on the survey result, previous studies and the fast decay of radiated power density with distance from the oven, the conclusion was that user exposure to RF radiation from microwave ovens is much less than the general public exposure limit set by most international standards at 2450 MHz, i.e. 1 mW cm(-2), and that a detrimental effect on health is an unlikely result of exposure to radiation from microwave ovens.

Alhusseiny A, Al-Nimer M, Majeed A. Electromagnetic energy radiated from mobile phone alters electrocardiographic records of patients with ischemic heart disease. Ann Med Health Sci Res. 2(2):146-151, 2012.

BACKGROUND: Electromagnetic energy radiated from mobile phones did not show significant effect on the blood pressure, heart rate, and electrocardiographic (ECG) parameters in animals and humans. **AIM:** This study aimed to investigate the effect of radiofrequency of mobile phone on the electrocardiographic parameters in patients with history of ischemic heart disease, taking into consideration the gender factor. **SUBJECTS**

AND METHODS: A total number of 356 participants (129 males and 227 females) were admitted in this study. They were grouped into: subjects without cardiac diseases (Group I), patients with ischemic heart disease (Group II), and patients with history of cardiac diseases not related to myocardial ischemia (Group III). Electrocardiogram was obtained from each patient when the mobile phone was placed at the belt level and over precordium in turn-off mode (baseline) and turn-on mode for 40 sec ringing. The records of ECG were electronically analyzed. **RESULTS:** Prolongation of QTc interval was significantly observed in male gender of Groups I and III (P < 0.001). Male patients of Group II showed significant QTc interval prolongation (P = 0.01) and changes in the voltage criteria (P = 0.001). These changes were not observed in female patients with ischemic heart disease. The position of mobile at the belt level or over the precordium showed effects on the heart. **CONCLUSIONS:** The radiofrequency of cell phone prolongs the QT interval in human beings and it interferes with voltage criteria of ECG records in male patients with myocardial ischemia.

Al-Khlaiwi T, Meo SA. Association of mobile phone radiation with fatigue, headache, dizziness, tension and sleep disturbance in Saudi population. Saudi Med J. 25(6):732-736, 2004.

OBJECTIVE: The widespread use of mobile phones has been increased over the past decade; they are now an essential part of business, commerce and society. The use of mobile phones can cause health problems. Therefore, the aim of the present study is to investigate the association of using mobile phones with fatigue, headache, dizziness, tension and sleep disturbance in the Saudi population and provide health and social awareness in using these devices. METHODS: This study was conducted in the Department of Physiology, College of Medicine, King Saud University, Riyadh, Kingdom of Saudi Arabia during the year 2002 to 2003. In the present study, a total of 437 subjects (55.1% male and 39.9% female) were invited, they have and had been using mobile phones. A questionnaire was distributed regarding detailed history and association of mobile phones with health hazards. RESULTS: The results of the present study showed an association between the use of mobile phones and health hazards. The overall mean percentage for these clinical findings in all groups were headache (21.6%), sleep disturbance (4.%), tension (3.9%), fatigue (3%) and dizziness (2.4%). CONCLUSION: Based on the results of the present study, we conclude that the use of mobile phones is a risk factor for health hazards and suggest that long term or excessive use of mobile phones should be avoided by health promotion activities such as group discussions, public presentations and through electronic and print media sources.

Alon L, Cho GY, Yang X, Sodickson DK, Deniz CM. A method for safety testing of radiofrequency/microwave-emitting devices using MRI. Magn Reson Med. 2014 Nov 25. doi: 10.1002/mrm.25521. [Epub ahead of print]

PURPOSE: Strict regulations are imposed on the amount of radiofrequency (RF) energy that devices can emit to prevent excessive deposition of RF energy into the body. In this study, we investigated the application of MR temperature mapping and 10-g average specific absorption rate (SAR) computation for safety evaluation of RF-emitting devices. METHODS: Quantification of the RF power deposition was shown for an MRI-compatible dipole antenna and a non-MRI-compatible mobile phone via phantom temperature change measurements. Validation of the MR temperature mapping method was demonstrated by comparison with physical temperature measurements and electromagnetic field simulations. MR temperature measurements alongside physical property measurements were used to reconstruct 10-g average SAR. RESULTS: The maximum temperature change for a dipole antenna and the maximum 10-g average SAR were 1.83°C and 12.4 W/kg, respectively, for simulations and 1.73°C and 11.9 W/kg, respectively, for experiments. The difference between MR and probe thermometry was <0.15°C. The maximum temperature change and the maximum 10-g average SAR for a cell phone radiating at maximum output for 15 min was 1.7°C and 0.54 W/kg, respectively. CONCLUSION: Information acquired using MR temperature mapping and thermal property measurements can assess RF/microwave safety with high resolution and fidelity.

Al-Qahtani K. Mobile Phone Use and the Risk of Parotid Gland Tumors: A Retrospective Case-Control Study. Gulf J Oncolog. 2016 Jan;1(20):71-8.

BACKGROUND: Mobile phones are integral part of the modern lifestyle. As they emit radio frequency electromagnetic field, their role in carcinogenesis needs to be ascertained. The goal of this study was to investigate the association between the use of cellular phones and the risk for parotid gland tumors. MATERIALS AND METHODS: A total of 26 patients diagnosed with parotid gland tumors and 61 healthy controls were enrolled through a hospital-based retrospective case-control study. The patients were referred and admitted to a tertiary hospital from January 1996 to March 2013. RESULTS: The odds of exposure were 3.47 times higher among patients compared to their controls. 95% CI suggested that the true Odds Ratio (OR) at the population level could be somewhere between 1.3 and 9.23 and so the observed OR was statistically significant at 5% level of significance. CONCLUSIONS: Overall, an association between the exposure of cellular phone use for more than 1 hour daily and parotid tumor was observed. This association should be interpreted with caution because of the relatively small sample size.

Alsanosi AA, Al-Momani MO, Hagr AA, Almomani FM, Shami IM, Al-Habeeb SF. The acute auditory effects of exposure for 60 minutes to mobile`s electromagnetic field. Saudi Med J. 34(2):142-146, 2013.

OBJECTIVE: To assess the immediate consequences of 60 minutes exposure to mobile phones on hearing function by determining changes in distortion product otoacoustic emission (DPOAE) and hearing threshold levels (HTLs). **METHODS:** This prospective control clinical trial study was carried out at the Ear, Nose and Throat Department, King Abdulaziz University Hospital, Riyadh, Kingdom of Saudi Arabia from July 2009 to July 2011. The data collected included age, symptoms experienced after exposure, and HTLs and DPOAE were recorded before, and immediately after 60 minutes of exposure to the same model of mobile phone. **RESULTS:** Heat/pain was the most commonly reported symptom. In the test-ears, significant shift ($p<0.05$) was noticed in HTLs at 1000 and 2000 Hz but not at other frequencies, while non test-ears did not reveal significant shift in HTLs. Additionally, test-ears revealed significant differences ($p<0.05$) in DPOAE at 1000

Hz, 1400 Hz, 2000 Hz, and at the average of all frequencies, while non test-ears did not show significant differences. **CONCLUSION:** Sixty minutes of close exposure to electromagnetic fields emitted by a mobile phone had an immediate effect on HTL assessed by pure-tone audiogram and inner ear (assessed by DPOAE) in young human subjects. It also caused a number of other otologic symptoms.

Al-Serori H, Kundi M, Ferk F, Mišík M, Nersesyan A, Murbach M, Lah TT, Knasmüller S. Evaluation of the potential of mobile phone specific electromagnetic fields (UMTS) to produce micronuclei in human glioblastoma cell lines. Toxicol In Vitro. 40:264-271, 2017.

Some epidemiological studies indicate that mobile phones cause glioblastomas in humans. Since it is known that genomic instability plays a key role in the etiology of cancer, we investigated the effects of the universal mobile telecommunications system radiofrequency (UMTS-RF) signal, which is used in "smart" phones, on micronucleus (MN) formation and other anomalies such as nuclear buds (NBUDs) and nucleoplasmatic bridges (NPBs). MN are formed by structural and numerical aberrations, NBs reflect gene amplification and NPBs are formed from dicentric chromosomes. The experiments were conducted with human glioblastoma cell lines, which differ in regard to their p53 status, namely U87 (wild-type) and U251 (mutated). The cells were cultivated for 16h in presence and absence of fetal calf serum and exposed to different SAR doses (0.25, 0.50 and 1.00W/kg), which reflect the exposure of humans, in presence and absence of mitomycin C as former studies indicate that RF may cause synergistic effects in combination with this drug. We found no evidence for induction of MN and other anomalies. However, with the highest dose, induction of apoptosis was observed in U251 cells on the basis of the morphological features of the cells. Our findings indicate that the UMTS-RF signal does not cause chromosomal damage in glioblastoma cells; the mechanisms which lead to induction of programmed cell death will be investigated in further studies.

Altamura G, Toscano S, Gentilucci G, Ammirati F, Castro A, Pandozi C, Santini M, Influence of digital and analogue cellular telephones on implanted pacemakers. Eur Heart J 18(10):1632-4161, 1997.

The aim of this study was to find out whether digital and analogue cellular 'phones affect patients with pacemakers. The study comprised continuous ECG monitoring of 200 pacemaker patients. During the monitoring certain conditions caused by interference created by the telephone were looked for: temporary or prolonged pacemaker inhibition; a shift to asynchronous mode caused by electromagnetic interference; an increase in ventricular pacing in dual chamber pacemakers, up to the programmed upper rate. The Global System for Mobile Communications system interfered with pacing 97 times in 43 patients (21.5%). During tests on Total Access of Communication System telephones, there were 60 cases of pacing interference in 35 patients (17.5%). There were 131 interference episodes during ringing vs 26 during the on/off phase; ($P < 0.0001$); 106 at maximum sensitivity level vs 51 at the 'base' value; $P <0.0001$). Prolonged pacing inhibition (> 4 s) was seen at the pacemaker 'base' sensing value in six patients using the Global system but in only one patient using Total Access. CONCLUSION: Cellular 'phones may be dangerous for pacemaker patients. However, they can be used safely if patients do not carry the 'phone close to the pacemaker, which is the only place where high risk interference has been observed.

Altuntas G, Sadoglu D, Ardic S, Yilmaz H, Imamoglu M, Turedi S.Acute effects of the electromagnetic waves emitted by mobile phones on attention in emergency physicians. Am J Emerg Med. 2017 Nov 13. pii: S0735-6757(17)30940-3. doi: 10.1016/j.ajem.2017.11.031.

STUDY OBJECTIVE: The purpose of this study was to investigate the acute effects of the electromagnetic waves (EMW) emitted by mobile phones on attention in emergency physicians. METHODS: This single-center, prospective, randomized, double-blinded clinical study was performed among emergency physicians in a tertiary hospital. Thirty emergency physicians were enrolled in the study. Initial d2 test was applied in the evaluation of attention and concentration of all the physicians, who were randomly assigned into one of two groups. The control group members hold mobile phones in 'off' mode to their left ears for 15min. The members of the intervention group hold mobile phones in 'on' mode to their left ears for 15min, thus exposing them to 900-1800MHz EMW. The d2 test was re-applied to both groups after this procedure. Differences in attention and concentration levels between the groups were compared. RESULTS: Difference between initial and final d2 test in total performance (TN-E, p=0.319), in total number of figures marked (TN, p=0.177), in test performance percentile (PR, p=0.619) and in attention fluctuation (FR, p=0.083) were similar between the groups. However, difference in the number of figures missed (E1 selective attention, p=0.025), difference between numbers of incorrectly marked figures (E2, p=0,018) and difference in focus levels (E, p=0.016) were significantly in favor of the intervention group. CONCLUSION: According to our study findings, the EMW emitted by mobile phones has no deleterious effect on the attention and concentration levels of emergency physicians, and even has a positive impact on selective attention levels.

Aly AA, Cheema MI, Tambawala M, Laterza R, Zhou E, Rathnabharathi K, Barnes FS. Effects of 900-MHz Radio Frequencies on the Chemotaxis of Human Neutrophils in Vitro. IEEE Transactions on Biomedical Engineering, 55(2): 795-797, 2008.

Summary: The effects of radio frequency (RF) fields on the ability of human neutrophils to follow concentration gradients of Cyclic Adenosine 3', 5'-Monophosphate (C-AMP) are reported. Blood from healthy adult donors was exposed in vitro to different temperatures and 900-MHz RF field at approximately 0.4 V/m. It was observed that the neutrophils' speed increased with increasing temperatures from 35 ^{o}C to 40 ^{o}C where it peaked and then decreased above 40 ^{o}C without RF exposure. When 900-MHz RF field was applied, the speed increased above the value observed at the same temperature, and the maximum speed exceeded that measured value at any temperature by approximately 50%. The calculated temperature change resulting from the RF exposure was less than one microdegree. The direction of motion changed from along the concentration gradient and the electrical field lines to motion at right angles to the concentration gradient and the electric field. The average time for the neutrophils to respond to the effect of RF radiation was about 2.5 min.

Ammari M, Brillaud E, Gamez C, Lecomte A, Sakly M, Abdelmelek H, de Seze R. Effect of a chronic GSM 900MHz exposure on glia in the rat brain. Biomed Pharmacother. 62(4):273-281, 2008.

Extension of the mobile phone technology raises concern about the health effects of 900MHz microwaves on the central nervous system (CNS). In this study we measured GFAP expression using immunocytochemistry method, to evaluate glial evolution 10 days after a chronic exposure (5 days a week for 24 weeks) to GSM signal for 45min/day at a brain-averaged specific absorption rate (SAR)=1.5W/kg and for 15min/day at a SAR=6W/kg in the following rat brain areas: prefrontal cortex (PfCx), caudate putamen (Cpu), lateral globus pallidus of striatum (LGP), dentate gyrus of hippocampus (DG) and cerebellum cortex (CCx). In comparison to sham or cage control animals, rats exposed to chronic GSM signal at 6W/kg have increased GFAP stained surface areas in the brain ($p<0.05$). But the chronic exposure to GSM at 1.5W/kg did not increase GFAP expression. Our results indicated that chronic exposure to GSM 900MHz microwaves (SAR=6W/kg) may induce persistent astroglia activation in the rat brain (sign of a potential gliosis).

Ammari M, Lecomte A, Sakly M, Abdelmelek H, de-Seze R. Exposure to GSM 900 MHz electromagnetic fields affects cerebral cytochrome c oxidase activity. Toxicology. 250(1):70-74, 2008.

The world-wide and rapidly growing use of mobile phones has raised serious concerns about the biological and health-related effects of radio frequency (RF) radiation, particularly concerns about the effects of RFs upon the nervous system. The goal of this study was conducted to measure cytochrome oxidase (CO) levels using histochemical methods in order to evaluate regional brain metabolic activity in rat brain after exposure to a GSM 900 MHz signal for 45 min/day at a brain-averaged specific absorption rate (SAR) of 1.5 W/Kg or for 15 min/day at a SAR of 6 W/Kg over seven days. Compared to the sham and control cage groups, rats exposed to a GSM signal at 6 W/Kg showed decreased CO activity in some areas of the prefrontal and frontal cortex (infralimbic cortex, prelimbic cortex, primary motor cortex, secondary motor cortex, anterior cingulate cortex areas 1 and 2 (Cg1 and Cg2)), the septum (dorsal and ventral parts of the lateral septal nucleus), the hippocampus (dorsal field CA1, CA2 and CA3 of the hippocampus and dental gyrus) and the posterior cortex (retrosplenial agranular cortex, primary and secondary visual cortex, perirhinal cortex and lateral entorhinal cortex). However, the exposure to GSM at 1.5 W/Kg did not affect brain activity. Our results indicate that 6 W/Kg GSM 900 MHz microwaves may affect brain metabolism and neuronal activity in rats.

Ammari M, Jacquet A, Lecomte A, Sakly M, Abdelmelek H, de Seze R. Effect of head-only sub-chronic and chronic exposure to 900-MHz GSM electromagnetic fields on spatial memory in rats. Brain Inj. 22(13-14):1021-1029, 2008.

PRIMARY OBJECTIVE: This study was carried out to investigate the behavioural effects of sub-chronic and chronic head-only exposure to 900 MHz GSM (Global System for Mobile communications) in male rats. **METHODS:** Rats were exposed for 45 minutes per day, at a brain-averaged specific absorption rate (SAR) = 1.5 W Kg(-1) or 15 minutes per day at a SAR = 6 W Kg(-1), during 8 or 24 weeks. Then, their spatial memory was tested using the radial-arm maze. In the first phase (10 days), rats were trained to visit the eight arms of the maze without returning to an arm already visited. In the second phase (8 days), a 45-minute intra-trial delay was introduced after four visited arms. **RESULTS:** Performance of exposed rats (1.5 or 6 W Kg(-1)) was compared with that of sham, negative control and positive control rats. Scopolamine treatment in the positive control rats induced deficit in spatial memory task in the second phase of the test. However, spatial memory task was unaffected in exposed rats. **CONCLUSION:** Sub-chronic and chronic head-only exposure of rats to GSM 900 MHz signal (45-minutes, SAR = 1.5 or 15-minutes, SAR = 6 W Kg(-1)) did not induce spatial memory deficit in the radial-arm maze.

Ammari M, Gamez C, Lecomte A, Sakly M, Abdelmelek H, De Seze R. GFAP expression in the rat brain following sub-chronic exposure to a 900 MHz electromagnetic field signal. Int J Radiat Biol. 86(5):367-375, 2010.

PURPOSE: The rapid development and expansion of mobile communications contributes to the general debate on the effects of electromagnetic fields emitted by mobile phones on the nervous system. This study aims at measuring the glial fibrillary acidic protein (GFAP) expression in 48 rat brains to evaluate reactive astrocytosis, three and 10 days after long-term head-only sub-chronic exposure to a 900 MHz electromagnetic field (EMF) signal, in male rats. METHODS: Sprague-Dawley rats were exposed for 45 min/day at a brain-averaged specific absorption rate (SAR) = 1.5 W/kg or 15 min/day at a SAR = 6 W/kg for five days per week during an eight-week period. GFAP expression was measured by the immunocytochemistry method in the following rat brain areas: Prefrontal cortex, cerebellar cortex, dentate gyrus of the hippocampus, lateral globus pallidus of the striatum, and the caudate putamen. RESULTS: Compared to the sham-treated rats, those exposed to the sub-chronic GSM (Global System for mobile communications) signal at 1.5 or 6 W/kg showed an increase in GFAP levels in the different brain areas, three and ten days after treatment. CONCLUSION: Our results show that sub-chronic exposures to a 900 MHz EMF signal for two months could adversely affect rat brain (sign of a potential gliosis).

Amoako JK, Fletcher JJ, Darko EO. Measurement and analysis of radiofrequency radiations from some mobile phone base stations in Ghana. Radiat prot dosimetry. 135(4):256-260, 2009.

A survey of the radiofrequency electromagnetic radiation at public access points in the vicinity of 50 cellular phone base stations has been carried out. The primary objective was to measure and analyse the electromagnetic field strength levels emitted by antennae installed and operated by the Ghana Telecommunications Company. On all the sites measurements were made using a hand-held spectrum analyser to determine the electric field level with the 900 and 1800 MHz frequency bands. The results indicated that power densities at public access points varied from as low as 0.01 microW m(-2) to as high as 10 microW m(-2) for the frequency of 900 MHz. At a transmission frequency of 1800 MHz, the variation of power densities is from 0.01 to 100 microW m(-2). The results were found to be in compliant with the International Commission on Non-ionizing Radiological

Protection guidance level but were 20 times higher than the results generally obtained for such a practice elsewhere. There is therefore a need to re-assess the situation to ensure reduction in the present level as an increase in mobile phone usage is envisaged within the next few years.

Anane R, Geffard M, Taxile M, Bodet D, Billaudel B, Dulou PE, Veyret B. Effects of GSM-900 microwaves on the experimental allergic encephalomyelitis (EAE) rat model of multiple sclerosis. Bioelectromagnetics 24(3):211-213, 2003.

The effects of acute exposure to GSM-900 microwaves (900 MHz, 217 Hz pulse modulation) on the clinical parameters of the acute experimental allergic encephalomyelitis (EAE) model in rats were investigated in two independent experiments: rats were either habituated or nonhabituated to the exposure restrainers. EAE was induced with a mixture of myelin basic protein and Mycobacterium tuberculosis. Female Lewis rats were divided into cage control, sham exposed, and two groups exposed either at 1.5 or 6.0 W/kg local specific absorption rate (SAR averaged over the brain) using a loop antenna placed over their heads. There was no effect of a 21-day exposure (2 h/day) on the onset, duration, and termination of the EAE crisis.

Anane R, Dulou P-E, Taxile M, Geffard M, Crespeau F, Veyret B. Effects of GSM-900 microwaves on DMBA-induced mammary gland tumors in female Sprague-Dawley rats. Radiat Res 160:492–497, 2003.

The aim of this investigation was to test the hypothesis that sub-chronic whole-body exposure to GSM-900 microwaves had an effect on tumor promotion and progression. Mammary tumors were induced by ingestion of a single 10-mg dose of 7,12-dimethylbenz(a)anthracene (DMBA) in female Sprague-Dawley rats (Ico:OFA-SD; IOPS Caw). In two independent experiments, DMBA-treated animals were divided into four groups: sham-exposed (16) and exposed (three groups of 16 animals). The specific absorption rates (SARs), averaged over the whole body, were 3.5, 2.2 and 1.4 W/kg in the first experiment (May–July) and 1.4, 0.7 and 0.1 W/kg in the second experiment (September–November). Exposure started 10 days after DMBA treatment and lasted 2 h/day, 5 days/week for 9 weeks. Animals were exposed to plane waves with the electric field parallel to the long axis of the animals. Body weight and the number, location and size of the tumors were recorded at regular intervals. Rats were killed humanely 3 weeks after the end of exposure. The results are negative in terms of latency, multiplicity and tumor volume. With regard to tumor incidence, in the first experiment there was an increase in the rate of incidence at 1.4 W/kg but less at 2.2 W/kg and none at 3.5 W/kg. Overall, these results, which are rather inconsistent, do not bring new evidence of a co-promoting effect of exposure to GSM-900 signals using the DMBA rat model.

Anderson LE, Sheen DM, Wilson BW, Grumbein SL, Creim JA, Sasser LB. Two-year chronic bioassay study of rats exposed to a 1.6 GHz radiofrequency signal. Radiat Res. 162(2):201-210, 2004.

The purpose of this study was to determine whether long-term exposure to a 1.6 GHz radiofrequency (RF) field would affect the incidence of cancer in Fischer 344 rats. Thirty-six timed-pregnant rats were randomly assigned to each of three treatment groups: two groups exposed to a far-field RF Iridium signal and a third group that was sham exposed. Exposures were chosen such that the brain SAR in the fetuses was 0.16 W/kg. Whole-body far-field exposures were initiated at 19 days of gestation and continued at 2 h/day, 7 days/week for dams and pups after parturition until weaning (approximately 23 days old). The offspring (700) of these dams were selected, 90 males and 90 females for each near-field treatment group, with SAR levels in the brain calculated to be as follows: (1) 1.6 W/kg, (2) 0.16 W/kg and (3) near-field sham controls, with an additional 80 males and 80 females as shelf controls. Confining, head-first, near-field exposures of 2 h/day, 5 days/week were initiated when the offspring were 36 +/- 1 days old and continued until the rats were 2 years old. No statistically significant differences were observed among treatment groups for number of live pups/litter, survival index, and weaning weights, nor were there differences in clinical signs or neoplastic lesions among the treatment groups. The percentages of animals surviving at the end of the near-field exposure were not different among the male groups. In females a significant decrease in survival time was observed for the cage control group.

Anderson V, Joyner KH, Specific absorption rate levels measured in a phantom head exposed to radio frequency transmissions from analog hand-held mobile phones. Bioelectromagnetics 16(1):60-69,1995.

Electric fields (E-fields) induced within a phantom head from exposure to three different advanced mobile phone system (AMPS) hand-held telephones were measured using an implantable E-field probe. Measurements were taken in the eye nearest the phone and along a lateral scan through the brain from its centre to the side nearest the phone. During measurement, the phones were positioned alongside the phantom head as in typical use and were configured to transmit at maximum power (600 mW nominal). The specific absorption rate (SAR) was calculated from the in situ E-field measurements, which varied significantly between phone models and antenna configuration. The SARs induced in the eye ranged from 0.007 to 0.21 W/kg. Metal-framed spectacles enhanced SAR levels in the eye by 9-29%. In the brain, maximum levels were recorded at the measurement point closest to the phone and ranged from 0.12 to 0.83 W/kg. These SARs are below peak spatial limits recommended in the U.S. and Australian national standards [IEEE Standards Coordinating Committee 28 (1991): C95.1-1991 and Standards Australia (1990): AS2772.1-1990] and the IRPA guidelines for safe exposure to radio frequency (RF) electromagnetic fields [IRPA (1988): Health Phys 54:115-123]. Furthermore, a detailed thermal analysis of the eye indicated only a 0.022 degrees C maximum steady-state temperature rise in the eye from a uniform SAR loading of 0.21 W/kg. A more approximate thermal analysis in the brain also indicated only a small maximum temperature rise of 0.034 degrees C for a local SAR loading of 0.83 W/kg.

Anderson V. Comparisons of peak SAR levels in concentric sphere head models of children and adults for irradiation by a dipole at 900 MHz. Phys Med Biol. 48(20):3263-3275, 2003.

The aim of this study is to examine the scale and significance of differences in peak specific energy absorption rate (SAR) in the brains of children and adults exposed to radiofrequency emissions from mobile phones. Estimates were obtained by method of multipole analysis of a three layered (scalp/cranium/brain) spherical head exposed to a nearby 0.4 lambda dipole at 900 MHz. A literature review of head parameters that influence SAR induction revealed strong indirect evidence based on total body water content that there are no substantive age-related changes in tissue conductivity after the first year of life. However, it was also found that the thickness of the ear, scalp and cranium do decrease on average with decreasing age, though individual variability within any age group is very high. The model analyses revealed that compared to an average adult, the peak brain 10 g averaged SAR in mean 4, 8, 12 and 16 year olds (yo) is increased by a factor of 1.31, 1.23, 1.15 and 1.07, respectively. However, contrary to the expectations of a recent prominent expert review, the UK Stewart Report, the relatively small scale of these increases does not warrant any special precautionary measures for child mobile phone users since: (a) SAR testing protocols as contained in the CENELEC (2001) standard provide an additional safety margin which ensures that allowable localized SAR limits are not exceeded in the brain; (b) the maximum worst case brain temperature rise (approximately 0.13 to 0.14 degrees C for an average 4 yo) in child users of mobile phones is well within safe levels and normal physiological parameters; and (c) the range of age average increases in children is less than the expected range of variation seen within the adult population.

Andersson B, Berg M, Arnetz BB, Melin L, Langlet I, Lidén S. A cognitive-behavioral treatment of patients suffering from "electric hypersensitivity". Subjective effects and reactions in a double-blind provocation study. J Occup Environ Med. 38(8):752-758, 1996.

This study tested psychological treatment of patients with "electric hypersensitivity." Seventeen patients were randomly assigned to a treatment group or a waiting-list control group in a pretest-posttest control group design. The patients were also taking part in double-blind provocation tests before and after the treatment. Subjective ratings of symptoms were registered and blood samples were taken and analyzed for "stress-related" variables, such as prolactin, cortisol, dehydroepiandrosterone, and cholesterol levels. The patients in the experimental group reduced their evaluations of the disability more than the control group did. This indicates that psychological treatment may be of value in this disease. However, none of the psychophysiological measures or the subjective reactions to the provocation test showed any significant between-group difference. The conclusion from the provocation test is that this group of alleged hypersensitive patients did not react to the electromagnetic fields.

Andrzejak R, Poreba R, Poreba M, Derkacz A, Skalik R, Gac P, Beck B, Steinmetz-Beck A, Pilecki W. The influence of the call with a mobile phone on heart rate variability parameters in healthy volunteers. Ind Health. 46(4):409-417, 2008.

It is possible that electromagnetic field (EMF) generated by mobile phones (MP) may have an influence on the autonomic nervous system (ANS) and modulates the function of circulatory system. The aim of the study was to estimate the influence of the call with a mobile phone on heart rate variability (HRV) in young healthy people. The time and frequency domain HRV analyses were performed to assess the changes in sympathovagal balance in a group of 32 healthy students with normal electrocardiogram (ECG) and echocardiogram at rest. The frequency domain variables were computed:

ultra low frequency (ULF) power, very low frequency (VLF) power, low frequency (LF) power, high frequency (HF) power and LF/HF ratio was determined. ECG Holter monitoring was recorded in standardized conditions: from 08:00 to 09:00 in the morning in a sitting position, within 20 min periods: before the telephone call (period I), during the call with use of mobile phone (period II), and after the telephone call (period III). During 20 min call with a mobile phone time domain parameters such as standard deviation of all normal sinus RR intervals (SDNN [ms]--period I: 73.94+/-25.02, period II: 91.63+/-35.99, period III: 75.06+/-27.62; I-II: p<0.05, II-III: p<0.05) and standard deviation of the averaged normal sinus RR intervals for all 5-mm segments (SDANN [ms]--period I: 47.78+/-22.69, period II: 60.72+/-27.55, period III: 47.12+/-23.21; I-II: p<0.05, II-III: p<0.05) were significantly increased. As well as very low frequency (VLF [ms2]--period I: 456.62+/-214.13, period II: 566.84+/-216.99, period III: 477.43+/-203.94; I-II: p<0.05), low frequency (LF [ms(2)]--period I: 607.97+/-201.33, period II: 758.28+/-307.90, period III: 627.09+/-220.33; I-II: p<0.01, II-III: p<0.05) and high frequency (HF [ms(2)]--period I: 538.44+/-290.63, period II: 730.31+/-445.78, period III: 590.94+/-301.64; I-II: p<0.05) components were the highest and the LF/HF ratio (period I: 1.48+/-0.38, period II: 1.16+/-0.35, period III: 1.46+/-0.40; I-II: p<0.05, II-III: p<0.05) was the lowest during a call with a mobile phone. The tone of the parasympathetic system measured indirectly by analysis of heart rate variability was increased while sympathetic tone was lowered during the call with use of a mobile phone. It was shown that the call with a mobile phone may change the autonomic balance in healthy subjects. Changes in heart rate variability during the call with a mobile phone could be affected by electromagnetic field but the influence of speaking cannot be excluded.

Angelone LM, Bit-Babik G, Chou CK. Computational Electromagnetic analysis in a human head model with EEG electrodes and leads exposed to RF-field sources at 915 MHz and 1748 MHz. Radiat Res. 174(1):91-100. 2010.

Abstract An electromagnetic analysis of a human head with EEG electrodes and leads exposed to RF-field sources was performed by means of Finite-Difference Time-Domain simulations on a 1-mm(3) MRI-based human head model. RF-field source models included a half-wave dipole, a patch antenna, and a realistic CAD-based mobile phone at 915 MHz and 1748 MHz. EEG electrodes/leads models included two configurations of EEG leads, both a standard 10-20 montage with 19 electrodes and a 32-electrode cap, and metallic and high resistive leads. Whole-head and peak 10-g average SAR showed less than 20% changes with and without leads. Peak 1-g and 10-g average SARs were below the ICNIRP and IEEE guideline limits. Conversely, a comprehensive volumetric assessment of changes in the RF field with and without metallic EEG leads showed an increase of two orders of magnitude in single-voxel power absorption in the epidermis and a 40-fold increase in the brain during exposure to the 915 MHz mobile phone. Results varied with the geometry and conductivity of EEG electrodes/leads. This enhancement confirms the validity of the question whether any observed effects in studies involving EEG recordings during RF-field exposure are directly related to the RF fields generated by the source or indirectly to the RF-field-induced currents due to the presence of conductive EEG leads.

Anghileri LJ, Mayayo E, Domingo JL, Thouvenot P. Radiofrequency-induced

carcinogenesis: cellular calcium homeostasis changes as a triggering factor. InterJ RadBiol. 81(3):205-209, 2005.

The aim was to study the effects of radiofrequency (Rf) in a mice strain characterized by age-determined carcinogenesis of lymphatic tissues. Mice were treated with a 1 h/week Rf exposure for 4 months. A group submitted to sham exposure was used as control animals. The evolution of carcinogenesis was followed up to 18 months. The maximal life span of control mice was about 24 months. All dead animals were clinically and histologically examined to give an age-determined comparative quantification of the evolving carcinogenesis. A radiocalcium tracer method permitted the evaluation of Rf effects on transmembrane transport of extracellular calcium at 1 and 24 h after exposure. The determination of induced lipid peroxidation completed this second study. The findings show that Rf provoked an earlier general lymphocyte cell infiltration, formation of lymphoblastic ascites and extranodal tumours of different histological types, as well as an increased early mortality. The results suggest that in Rf-exposed mice, carcinogenesis may be induced earlier and with different pathological forms than in control animals. The modifications in cellular calcium homeostasis and the age-determined thymus involution appear to be important factors involved in this carcinogenesis process.

Anghileri LJ, Mayayo E, Domingo JL. Iron-radiofrequency synergism in lymphomagenesis. Immunopharmacol Immunotoxicol. 28(1):175-183, 2006.

The parenteral **iron** administration effects on the acceleration of lymphomagenesis by radiofrequency exposure were investigated using an animal model that develops spontaneous lymphomas with ageing. Complementary studies of the in vivo uptake of 59Fe-labeled ferric gluconate and ferric-ATP complex showed differences ob absorption and excretion between both **iron** compounds. In vitro assays of their effects on calcium cellular uptake using a cell model and tissues homogenates showed a molecular structure-dependence. The current results (mortality, clinical and histopathological examinations) demonstrated a synergism between radiofrequency and ferric gluconate, and the increased risk of radiofrequency exposure when it is simultaneous to parenteral iron administration.

Anghileri LJ, Mayayo E, Domingo JL. Aluminum, calcium ion and radiofrequency synergism in acceleration of lymphomagenesis. Immunopharmacol Immunotoxicol. 31(3):358-362. 2009

This study that was done on lymphomagene-bearing mice indicates a synergism aluminum-radiofrequency which induces an early increase in mortality that is in concomitance with lymphoid elements proliferation and infiltration of spleen and liver. These two last phenomena were assesed by determination of the hypertrophic index (Growth Index) which is the organ weight to to the body weight ratio, as well as by the histopathological examination of the organ tissue. The importance of this synergism appears to be determined by the ionization at the physiological pH of the used aluminum complexes: much higher with lactate complex than with the citrate one. On the other hand, this dissociation appears to induce a remarkable acceleration of the mortality and the lymphoid elements-related hypertrophy of the spleen and liver at early age. Aluminum complexes are known as modifiers of the intracellular calcium homeostasis, and to verify if such process could be implicated in this synergism, the effects of calcium chloride were assayed, in this case the calcium-overload had no effects in the presence of a workable cellular control of intracellular calcium homeostasis. This finding support the hypothesis that ionized aluminum provided by lactate may be implicated in the inhibition of the buffering and extruding extracellular calcium system.

Anghileri LJ, Mayayo E, Domingo JL, Thouvenot P. Evaluation of health risks caused by radio frequency accelerated carcinogenesis: the importance of processes driven by the calcium ion signal. Eur J Cancer Prev. 15(3):191-195, 2006.

The acceleration of carcinogenesis, which was induced either by radio frequency radiation from a cellular telephone or by the ferric-ATP complex, was similar in a mouse strain characterized by age-determined carcinogenesis of lymphoid tissues. Organ hypertrophy, the presence of lymphoid blood and ascites, the development of solid tumours, and mortality were very different to those found in control animals. These results emphasize the role of calcium ion signal influx in the activation of oncogenes and the failure of thymus-determined immune defences.

Anglesio L, Benedetto A, Bonino A, Colla D, Martire F, Saudino Fusette S, d'Amore G. Population exposure to electromagnetic fields generated by radio base stations: evaluation of the urban background by using provisional model and instrumental measurements. Radiat Prot Dosimetry 97(4):355-358, 2001.

Electromagnetic radiation, which is used by broadcasting and mobile telephone systems to transmit information, permeates the city environment. In order to properly evaluate population exposure to electromagnetic fields, knowledge of their intensity and spectral components is necessary. In this study the results of radiofrequency field monitoring carried out in Torino, a large town located in the north-west of Italy are shown: the variation of the electromagnetic field strength is evaluated as a function of the height from the ground, the location in the urban area and the frequency. separating the contributions of the different sources (broadcasting antennas and radio base stations for mobile phones). Furthermore, the contribution of the radio base stations is theoretically evaluated, adding the emissions off all installations situated in Torino and examining the field strength maps calculated, considering the orography, for different heights. The theoretical values are also compared with those measured in the frequency range of mobile telephony emissions.

Aniolczyk H, Electromagnetic field pattern in the environment of GSM base stations. Int J Occup Med Environ Health 12(1):47-58, 1999.

Three mobile phone systems are used in Poland: analog, operated at the 450 MHz frequency range, and two digital systems operated at 900 MHz and 1800 MHz. The GSM--Global System for Mobile Communication meets all relevant requirements, and it is most widely used throughout the world. According to the mobile phone concept, the whole communication area is divided into sub-areas (cells) where base stations are located. The base stations are provided with the transmitter units mounted on free-standing masts, high chimneys and building roofs, including those of the residential buildings. The transmitter antennas of the base stations constitute a source of 935-960 EMF radiation. This work analyses the essential characteristics of the base station antennas from the point of view of radiation intensity. The analysis is based on the results of EMF measurements performed by experts of two relevant research institutes. For inaccessible antennas, the measurements were performed at the accredited laboratory.

Antonopoulos A, Eisenbrandt H, Obe G, Effects of high-frequency electromagnetic fields on human lymphocytes in vitro. Mutat Res 395(2-3): 209-214, 1997.

Human peripheral lymphocytes were incubated in the presence of high-frequency electromagnetic fields of 380, 900 and 1800 MHz. The measured endpoints were cell cycle progression and the frequencies of sister-chromatid exchanges. No differences between treated and control cultures could be found.

Anttila K. Mycotoxins, fungus and 'electrohypersensitivity'. Med Hypotheses. 55(3):208-214, 2000.

'Electrohypersensitivity' is often explained as a psychological syndrome. Our modern environment contains a lot of different substances and some of them are toxic. Mycotoxins are types of toxins that are biologically very active and that affect living organisms. Mycotoxins and fungi capable of producing toxins have been detected in ventilation systems, water damage and in foodstuff. Many of those displaying symptoms caused by electromagnetic fields have fungus infections or have been living in fungus-contaminated environments for long periods. In animal studies mycotoxins have shown the same effects as those seen in the 'electrohypersensitivity' syndrome. Phototoxic reactions are well known in veterinary medicine and in medical science, so the question is whether the 'electrohypersensitivity' syndrome is caused by 'phototoxic' reactions?

Apollonio F, D'Inzeo G, Tarricone L. Energy evaluation of mw effects on Ach receptor channels with parallel computing Electromag. Biol. Med. 19:69-79, 2000.

We present an evaluation of the effects of microwave fields on the acetylcholine (ACh) receptor channel, based on energy issues. The channel is considered a stochastic automaton, flipping randomly from one state to another, and the incident field modifies transitions among the states. The observation of some appropriate biochemical parameters demonstrates that microwave fields cause conformational changes in the receptor site. An energetic mapping of ACh conformational changes is also achieved, clearing the ground for future development of this research in the field of molecular simulations.

Arai N, Enomoto H, Okabe S, Yuasa K, Kamimura Y, Ugawa Y. Thirty minutes mobile phone use has no short-term adverse effects on central auditory pathways. Clin Neurophysiol. 114(8):1390-1394, 2003.

OBJECTIVE: To investigate whether pulsed high-frequency electromagnetic field (pulsed EM field) emitted by a mobile phone for 30 min has short-term adverse effects on the human central auditory system.METHODS: We studied the auditory brainstem response (ABR), the ABR recovery function and middle latency response (MLR) before and after using a mobile phone for 30 min in 15 normal hearing volunteers.RESULTS: None of the 3 measures were affected by exposure to pulsed EM field emitted by a mobile phone for

30 min.CONCLUSIONS: Based on the ABR and MLR methods utilized in the study, we conclude that 30 min mobile phone use has no short-term adverse effects on the human auditory system.

Aran JM, Carrere N, Chalan Y, Dulou PE, Larrieu S, Letenneur L, Veyret B, Dulon D. Effects of exposure of the ear to GSM microwaves: in vivo and in vitro experimental studies. Int J Audiol. 43(9):545-554, 2004.

The effects of mobile phone (GSM) microwaves on the ears of guinea pigs were investigated in two in vivo experiments and one in vitro experiment. In the first experiment, three groups of eight guinea pigs had their left ear exposed for 1 h/day, 5 days/week, for 2 months, to GSM microwaves (900 MHz. GSM modulated) at specific absorption rates (SARs) of 1, 2 and 4 W/kg respectively, and a fourth group was sham-exposed. Distortion-product otoacoustic emissions (DPOAEs) were measured for each ear before exposure, at the end of the 2-month exposure period, and 2 months later. In the second experiment, the same protocol was applied to eight sham-exposed and 16 exposed guinea pigs at 4W/kg, but the auditory brainstem response (ABR) thresholds were monitored. Repeated-measures ANOVA showed no difference in DPOAE amplitudes or in ABR thresholds between the exposed and non-exposed ears and between the sham-exposed and exposed groups In the course of the second experiment, acute effects were also investigated by measuring once, in all animals, ABR thresholds just before and just after the 1-h exposure: no statistically significant difference was observed. In vitro, the two organs of Corti (OCs) of newborn rats (n=15) were isolated and placed in culture. For each animal, one OC was exposed for 24-48 h to 1 W/kg GSM microwaves, and the other was sham-exposed. After 2-3 days of culture, all OCs were observed under light microscopy. They all appeared normal to naive observers at this stage of development. These results provided no evidence that microwave radiation, at the levels produced by mobile phones, caused damage to the inner ear or the auditory pathways in our experimental animals.

Arbabi-Kalati F, Salimi S, Vaziry-Rabiee A, Noraeei M. Effect of mobile phone usage time on total antioxidant capacity of saliva and salivary immunoglobulin a. Iran J Public Health. 43(4):480-484, 2014.

BACKGROUND: Nowadays mobile phone is very popular, causing concern about the effect it has on people's health. Parotid salivary glands are in close contact to cell phone while talking with the phone and the possibility of being affected by them. Limited studies have evaluated the effect of cell phone use on the secretions of these glands; so this study was designed to investigate the effects of duration of mobile phone use on the total antioxidant capacity of saliva. METHODS: Unstimulated saliva from 105 volunteers without oral lesions collected. The volunteers based on daily usage of mobile phones were divided into three groups then total antioxidant capacity of saliva was measured by Ferric Reducing Ability of Plasma (FRAP) method. Data were analyzed by SPSS software version 19. ANOVA was used to compare 3 groups and post-hoc Tukey test to compare between two groups. RESULTS: Average total antioxidant capacities of saliva in 3 groups were 657.91 µmol/lit, 726.77 µm/lit and 560.17 µmol/lit, respectively. The two groups had statistically significant different (P = 0.039). CONCLUSION: Over an hour talking with a cell phone decreases total antioxidant capacity of saliva in comparison with talking less than twenty minutes.

Ardoino L, Barbieri E, Vecchia P. Determinants of exposure to electromagnetic fields from mobile phones. Radiat Prot Dosimetry. 111(4):403-406, 2004.

In actual conditions of use, the power radiated from cellular phones changes during conversation depending on several factors. Upon request from the radio base station (RBS), the phone in fact, reduces, its power to a level that is deemed optimum for the quality of conversation. In this study, special phones, which had been modified to allow the continuous logging of power emitted during the calls have been used. Off-line processing of recorded data allowed the analysis of the behaviour of mobile phones under real-use conditions. Further data recorded by operators at selected base stations were used for the purposes of comparison and checking of the effectiveness of the experimental method. The results indicate a high proportion of use of the highest power levels, under any circumstance. Such behaviour is mainly due to frequent handovers requested by the control software to optimise the communication traffic.

Arendash GW, Sanchez-Ramos J, Mori T, Mamcarz M, Lin X, Runfeldt M, Wang L, Zhang G, Sava V, Tan J, Cao C. Electromagnetic field treatment protects against and reverses cognitive impairment in Alzheimer's disease mice. J Alzheimers Dis. 19(1):191-210, 2010.

Despite numerous studies, there is no definitive evidence that high-frequency electromagnetic field (EMF) exposure is a risk to human health. To the contrary, this report presents the first evidence that long-term EMF exposure directly associated with cell phone use (918 MHz; 0.25 w/kg) provides cognitive benefits. Both cognitive-protective and cognitive-enhancing effects of EMF exposure were discovered for both normal mice and transgenic mice destined to develop Alzheimer's-like cognitive impairment. The cognitive interference task utilized in this study was designed from, and measure-for-measure analogous to, a human cognitive interference task. In Alzheimer's disease mice, long-term EMF exposure reduced brain amyloid-beta (Abeta) deposition through Abeta anti-aggregation actions and increased brain temperature during exposure periods. Several inter-related mechanisms of EMF action are proposed, including increased Abeta clearance from the brains of Alzheimer's disease mice, increased neuronal activity, and increased cerebral blood flow. Although caution should be taken in extrapolating these mouse studies to humans, we conclude that EMF exposure may represent a non-invasive, non-pharmacologic therapeutic against Alzheimer's disease and an effective memory-enhancing approach in general.

Arendash GW, Mori T, Dorsey M, Gonzalez R, Tajiri N, Borlongan C. Electromagnetic Treatment to Old Alzheimer's Mice Reverses β-Amyloid Deposition, Modifies Cerebral Blood Flow, and Provides Selected Cognitive Benefit. PLoS One. 7(4):e35751, 2012.

Few studies have investigated physiologic and cognitive effects of "long-term" electromagnetic field (EMF) exposure in humans or animals. Our recent studies have provided initial insight into the long-term impact of adulthood EMF exposure (GSM, pulsed/modulated, 918 MHz, 0.25-1.05 W/kg) by showing 6+ months of daily EMF treatment protects against or reverses cognitive impairment in Alzheimer's transgenic (Tg) mice, while even having cognitive benefit to normal mice. Mechanistically, EMF-induced cognitive benefits involve suppression of brain β-amyloid (Aβ) aggregation/deposition in Tg mice and brain mitochondrial enhancement in both Tg and normal mice. The present study extends this work by showing that daily EMF treatment given to very old (21-27 month) Tg mice over a 2-month period reverses their very advanced brain Aβ aggregation/deposition. These very old Tg mice and their normal littermates together showed an increase in general memory function in the Y-maze task, although not in more complex tasks. Measurement of both body and brain temperature at intervals during the 2-month EMF treatment, as well as in a separate group of Tg mice during a 12-day treatment period, revealed no appreciable increases in brain temperature (and no/slight increases in body temperature) during EMF "ON" periods. Thus, the neuropathologic/cognitive benefits of EMF treatment occur without brain hyperthermia. Finally, regional cerebral blood flow in cerebral cortex was determined to be reduced in both Tg and normal mice after 2 months of EMF treatment, most probably through cerebrovascular constriction induced by freed/disaggregated Aβ (Tg mice) and slight body hyperthermia during "ON" periods. These results demonstrate that long-term EMF treatment can provide general cognitive benefit to very old Alzheimer's Tg mice and normal mice, as well as reversal of advanced Aβ neuropathology in Tg mice without brain heating. Results further underscore the potential for EMF treatment against AD.

Arns M, Van Luijtelaar G, Sumich A, Hamilton R, Gordon E. Electroencephalographic, personality, and executive function measures associated with frequent mobile phone use. Int J Neurosci. 117(9):1341-1360, 2007.

The present study employs standardized data acquired from the Brain Resource International Database to study the relationship between mobile phone usage, personality, and brain function (n = 300). Based on the frequency and duration of mobile phone usage, three groups were formed. The findings suggest a subtle slowing of brain activity related to mobile phone use that is not explained by differences in personality. These changes are still within normal physiological ranges. Better executive function in mobile phone users may reflect more focused attention, possibly associated with a cognitive training effect (i.e., frequently making phone calls in distracting places), rather than a direct effect of mobile phone use on cognition.

Aslan A, İkinci A, Baş O, Sönmez OF, Kaya H, Odacı E. Long-term exposure to a continuous 900 MHz electromagnetic field disrupts cerebellar morphology in young adult male rats. Biotech Histochem. 92(5):324-330, 2017.

The pathological effects of exposure to an electromagnetic field (EMF) during childhood and adolescence may be greater than those from exposure during adulthood. We investigated possible pathological changes in the cerebellum of adolescent rats exposed to 900 MHz EMF daily for 25 days. We used three groups of six 21-day-old male rats as follows: unexposed control group (Non-EG), sham-exposed group (Sham-EG) and an EMF-exposed group (EMF-EG). EMF-EG rats were exposed to EMF in an EMF cage for 1 h daily from postnatal days 21 through 46. Sham-EG rats were placed in the EMF cage for 1 h daily, but were not subjected to EMF. No procedures were performed on the Non-EG rats. The cerebellums of all animals were removed on postnatal day 47, sectioned and stained with cresyl violet for histopathological and stereological analyses. We found significantly fewer Purkinje cells in the EMF-EG group than in the Non-EG and Sham-EG groups. Histopathological evaluation revealed alteration of normal Purkinje cell arrangement and pathological changes including intense staining of neuron cytoplasm in the EMF-EG group. We found that exposure to continuous 900 MHz EMF for 1 h/day during adolescence can disrupt cerebellar morphology and reduce the number of Purkinje cells in adolescent rats.

Astrain I, Bernaus J, Claverol J, Escobar A, Godoy P. [Prevalence of mobile phone use while driving vehicles] Gac Sanit 17(1):66-69, 2003. [Article in Spanish]

Objective: To estimate the prevalence of mobile telephone use while driving vehicles in the city of Lleida (Spain).Methods: A random sample of 1536 cars passing through six intersections regulated by traffic lights in Lleida were selected (three with urban traffic and three with interurban traffic). Cyclists, motorcyclists and driving school cars were excluded. The variables studied were mobile telephone use, age, (18-40; 41-60; >61), sex, the presence of passengers, type of intersection (urban traffic/interurban traffic), day of the week (working day/weekend or holiday) and hour of the day (rush hour/non-rush hour). The prevalence of mobile telephone use was calculated in percentages with a 95% CI. The relationship among the dependent variable (mobile telephone use) and the other independent variables was studied using odds radios (OR) and 95% CI.Results: A total of 1536 direct observations were made and mobile telephone use was detected in 50 drivers. The prevalence was 3.3 (95% CI, 2.4-4.3). The prevalence was higher in men (OR = 2.2; 95% CI, 1.0-5.7), in drivers aged more than 60 years old (OR = 2.2; 95% CI, 0.5-8,4) and in those aged 18-40 years old (OR =1.5; 95% CI, 0.8-3.0), in unaccompanied drivers (OR = 3.0; 95% CI, 1.5-6.3), in urban intersections (OR = 2.7; 95% CI, 1.2-5.9), on workdays (OR = 2.0; 95% CI, 0.9-4.4) and at the rush hour (OR =1.4; 95% CI, 0.8-2.4).Conclusions: The prevalence of mobile telephone use while driving vehicles can be considered high, because of the increase in car accidents. The profile of drivers using mobile telephones corresponds to men aged 18-40 years or more than 61 years, in urban intersections, without passengers, during workdays and at the rush hour. We recommend the implementation of measures to decrease the use of mobile telephones while driving.

Asbridge M, Brubacher JR, Chan H.Cell phone use and traffic crash risk: a culpability analysis.Int J Epidemiol. 2012 Nov 18. [Epub ahead of print]

BACKGROUND: The use of a cell phone or communication device while driving is illegal in many jurisdictions, yet evidence evaluating the crash risk associated with cell phone use in naturalistic settings is limited. This article aims to determine whether cell phone use while driving increases motor vehicle crash culpability. METHOD: Drivers involved in crashes where police reported cell phone use (n = 312) and propensity matched drivers (age, sex, suspect alcohol/drug impairment, crash type, date, time of day, geographical location) without cell phone use (n = 936) were drawn from Insurance Corporation of British Columbia Traffic Accident System data. A standardized scoring tool, modified to account for Canadian driving conditions, was used to determine crash culpability from police reports on all drivers from the crashes. The association between crash culpability and cell phone use was determined, with additional subgroup analyses based on crash severity, driver characteristics and type of licence. RESULTS: A comparison of crashes with vs without cell phones revealed an odds ratio of 1.70 (95% confidence interval 1.22-2.36; P = 0.002). This association was consistent after adjustment for matching variables and other covariates. Subgroup analyses demonstrated an association for male drivers, unimpaired drivers, injured and non-injured drivers, and for drivers aged between 26 and 65 years. CONCLUSIONS: Crash culpability was found to be significantly associated with cell phone use by drivers, increasing the odds of a culpable crash by 70% compared with drivers who did not use a cell phone. This increased risk was particularly high for middle-aged drivers.

Aslan A, Kırdemır V, Kocak A, Atay T, Baydar ML, Ozerdemoglu RA, Aydogan NH. Effect of 1800 MHz Electromagnetic Radiation Emitted from Cellular Phones on Fracture Healing. Arch Med Res. 2014 Feb 4. pii: S0188-4409(14)00007-1. doi: 10.1016/j.arcmed.2014.01.006. [Epub ahead of print]

BACKGROUND AND AIMS: In this study, we aimed to investigate whether 1800 MHz frequency electromagnetic radiation (EMRs) have an effect on bone healing. METHODS: A total of 30 Wistar albino rats were divided into two equal groups. Fractures were created in the right tibias of all rats; next, intramedullary fixations with K-wire were performed. A control group (Group I) was kept under the same experimental conditions except without EMF exposure. Rats in Group II were exposed to an 1800 MHz frequency EMF for 30 min a day for 5 days a week. Next, radiological, mechanical, and histological examinations were performed to evaluate tibial fracture healing. RESULTS: Radiological, histological and mechanical scores were not significantly different between groups (respectively, p = 0.114, p = 0.184 and p = 0.083), and all of these scores were lower than those of the controls. CONCLUSIONS: EMR at 1800 MHz frequency emitted from cellular phones has no effect on bone fracture healing.

Atasoy HI, Gunal MY, Atasoy P, Elgun S, Bugdayci G. Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices. J Pediatr Urol. 9(2):223-229, 2013.

OBJECTIVE: To investigate effects on rat testes of radiofrequency radiation emitted from indoor Wi-Fi Internet access devices using 802.11.g wireless standards. METHODS: Ten Wistar albino male rats were divided into experimental and control groups, with five rats per group. Standard wireless gateways communicating at 2.437 GHz were used as radiofrequency wave sources. The experimental group was exposed to radiofrequency energy for 24 h a day for 20 weeks. The rats were sacrificed at the end of the study. Intracardiac blood was sampled for serum 8-hydroxy-2'-deoxyguanosine levels. Testes were removed and examined histologically and immunohistochemically. Testis tissues were analyzed for malondialdehyde levels and prooxidant-antioxidant enzyme activities. RESULTS: We observed significant increases in serum 8-hydroxy-2'-deoxyguanosine levels and 8-hydroxyguanosine staining in the testes of the experimental group indicating DNA damage due to exposure ($p < 0.05$). We also found decreased levels of catalase and glutathione peroxidase activity in the experimental group, which may have been due to radiofrequency effects on enzyme activity ($p < 0.05$). CONCLUSIONS: These findings raise questions about the safety of radiofrequency exposure from Wi-Fi Internet access devices for growing organisms of reproductive age, with a potential effect on both fertility and the integrity of germ cells.

Atay T, Aksoy BA, Aydogan NH, Baydar ML, Yildiz M, Ozdemir R. Effect of electromagnetic field induced by radio frequency waves at 900 to 1800 MHz on bone mineral density of iliac bone wings. J Craniofac Surg. 20(5):1556-1560, 2009.

OBJECTIVE: Telecommunication has gained a different meaning in daily life with the introduction of the mobile phone system. However, electromagnetic pollution has increased in parallel to this improvement. In this study, we aimed to investigate the effects of electromagnetic waves emitted from cellular phones operating at a frequency of 900 to 1800 MHz on the bone mineral density of the human iliac bone wings, which are the most common carriage sites for mobile phones. MATERIALS AND METHODS: A total of 150 male volunteer participants were included in this study. The mean age was 31.85 years, and the age range was between 21 and 57 years. The participants were separated into 2 groups based on as follows: iliac side exposed to electromagnetic wave (group 1) and unexposed side (group 2). Of the total number of participants, 122 were carrying their phones on their right iliac wings, whereas 28 were carrying their phones on their left iliac wings. The mean daily carriage duration was 14.7 hours (between 12 and 20 h), and the mean duration for cellular phone use was 6.2 years (between 4 and 9 yr). Mineral bone density was measured using dual-energy x-ray absorptiometry in the right and the left iliac wings of all the participants. The SPSS 15 software (SPSS Inc, Chicago, IL) was used for statistical analysis. In the comparison of the 2 sides, Student t test was performed and $P < 0.05$ was considered significant. RESULTS: The mean dual-energy x-ray absorptiometry values measured from group 1 were slightly lower than those from group 2, but there was no statistically significant difference between the groups ($P > 0.05$). In addition, the mean values of group 1 were not as low as those measured in osteopeny or osteoporosis cases. CONCLUSIONS: Current data may suggest that taking into consideration cellular phone use when iliac bone graft is necessary in clinical practice would constitute an important factor for more favorable outcomes.

Atchley P, Dressel J. Conversation limits the functional field of view. Hum Factors. 46(4):664-673, 2004.

The purpose of these two experiments is to investigate one possible mechanism that might account for an increase in crash risk with in-car phone use: a reduction in the functional field of view. In two between-subjects experiments, college undergraduates performed a task designed to measure the functional field of view in isolation and while performing a hands-free conversational task. In both experiments, the addition of the conversational task led to large reductions in the functional field of view. Because similar reductions have been shown to increase crash risk, reductions in the functional field of view by conversation may be an important mechanism involved in increased risk for crashes with in-car phone use. Actual or potential applications of this research include improving driver performance.

Atlı Şekeroğlu Z, Akar A, Sekeroğlu V. Evaluation of the cytogenotoxic damage in immature and mature rats exposed to 900 MHz radio frequency electromagnetic fields. Int J Radiat Biol. 2013 May 29. [Epub ahead of print]

Abstract Purpose: One of the most important issues regarding radio frequency electromagnetic fields (RF-EMF) is their effect on genetic material. Therefore, we investigated the cytogenotoxic effects of 900 MHz radio frequency electromagnetic fields (RF-EMF) and the effect of a recovery period after exposure to RF-EMF on bone marrow cells of immature and mature rats. Materials and methods: The immature and mature rats in treatment groups were exposed to RF-EMF for 2 h/day for 45 days. Average electrical field values for immature and mature rats were 28.1±4.8 V/m and 20.0±3.2 V/m, respectively. Whole-body specific absorption rate (SAR) values for immature and mature rats were in the range of 0.38-0.78 W/kg, and 0.31-0.52 W/kg during the 45 days, respectively. Two recovery groups were kept for 15 days after RF-EMF exposure. Results: Significant differences were observed in chromosome aberrations (CA), micronucleus (MN) frequency, mitotic index (MI) and ratio of polychromatic erythrocytes (PCE) in all treatment and recovery groups. The cytogenotoxic damage in immature rats was statistically higher than the mature rats. The recovery period did not reduce the damage to the same extent as the corresponding control groups. Conclusions: The exposure of RF-EMF leads to cytotoxic and genotoxic damage in immature and mature rats. More sensitive studies are required to elucidate the possible carcinogenic risk of EMF exposure in humans, especially children.

Augner C, Florian M, Pauser G, Oberfeld G, Hacker GW. GSM base stations: Short-term effects on well-being. Bioelectromagnetics. 30:73-80, 2009.

The purpose of this study was to examine the effects of short-term GSM (Global System for Mobile Communications) cellular phone base station RF-EMF (radiofrequency electromagnetic fields) exposure on psychological symptoms (good mood, alertness, calmness) as measured by a standardized well-being questionnaire. Fifty-seven participants were selected and randomly assigned to one of three different exposure scenarios. Each of those scenarios subjected participants to five 50-min exposure sessions, with only the first four relevant for the study of psychological symptoms. Three exposure levels were created by shielding devices in a field laboratory, which could be installed or removed during the breaks between sessions such that double-blinded conditions prevailed. The overall median power flux densities were 5.2 microW/m(2) during "low," 153.6 microW/m(2) during "medium," and 2126.8 microW/m(2) during "high" exposure sessions. For scenario HM and MH, the first and third sessions were "low" exposure. The second session was "high" and the fourth was "medium" in scenario HM; and vice versa for scenario MH. Scenario LL had four successive "low" exposure sessions constituting the reference condition. Participants in scenarios HM and MH (high and medium exposure) were significantly calmer during those sessions than participants in scenario LL (low exposure throughout) (P = 0.042). However, no significant differences between exposure scenarios in the "good mood" or "alertness" factors were obtained. We conclude that short-term exposure to GSM base station signals may have an impact on well-being by reducing psychological arousal.

Augner C, Hacker GW. Are people living next to mobile phone base stations more strained? Relationship of health concerns, self-estimated distance to base station, and psychological parameters. Indian J Occup Environ Med. 13(3):141-145, 2009.

BACKGROUND AND AIMS: Coeval with the expansion of mobile phone technology and the associated obvious presence of mobile phone base stations, some people living close to these masts reported symptoms they attributed to electromagnetic fields (EMF). Public and scientific discussions arose with regard to whether these symptoms were due to EMF or were nocebo effects. The aim of this study was to find out if people who believe that they live close to base stations show psychological or psychobiological differences that would indicate more strain or stress. Furthermore, we wanted to detect the relevant connections linking self-estimated distance between home and the next mobile phone base station (DBS), daily use of mobile phone (MPU), EMF-health concerns, electromagnetic hypersensitivity, and psychological strain parameters. DESIGN, MATERIALS AND METHODS: Fifty-seven participants completed standardized and non-standardized questionnaires that focused on the relevant parameters. In addition, saliva samples were used as an indication to determine the psychobiological strain by concentration of alpha-amylase, cortisol, immunoglobulin A (IgA), and substance P. RESULTS: Self-declared base station neighbors (DBS </= 100 meters) had significantly higher concentrations of alpha-amylase in their saliva, higher rates in symptom checklist subscales (SCL) somatization, obsessive-compulsive, anxiety, phobic anxiety, and global strain index PST (Positive Symptom Total). There were no differences in EMF-related health concern scales. CONCLUSIONS: We conclude that self-declared base station neighbors are more strained than others. EMF-related health concerns cannot explain these findings. Further research should identify if actual EMF exposure or other factors are responsible for these results.

Augner C, Hacker GW, Oberfeld G, Florian M, Hitzl W, Hutter J, Pauser G. Effects of Exposure to GSM mobile phone base station signals on salivary cortisol, alpha-amylase, and Immunoglobulin A. Biomed Environ Sci. 23(3):199-207, 2010.

OBJECTIVE: The present study aimed to test whether exposure to radiofrequency electromagnetic fields (RF-EMF) emitted by mobile phone base stations may have effects on salivary alpha-amylase, immunoglobulin A (IgA), and cortisol levels.

METHODS: Fifty seven participants were randomly allocated to one of three different experimental scenarios (22 participants to scenario 1, 26 to scenario 2, and 9 to scenario 3). Each participant went through five 50-minute exposure sessions. The main RF-EMF source was a GSM-900-MHz antenna located at the outer wall of the building. In scenarios 1 and 2, the first, third, and fifth sessions were "low" (median power flux density 5.2 muW/m(2)) exposure. The second session was "high" (2126.8 muW/m(2)), and the fourth session was "medium" (153.6 muW/m(2)) in scenario 1, and vice versa in scenario 2. Scenario 3 had four "low" exposure conditions, followed by a "high" exposure condition. Biomedical parameters were collected by saliva samples three times a session. Exposure levels were created by shielding curtains. RESULTS: In scenario 3 from session 4 to session 5 (from "low" to "high" exposure), an increase of cortisol was detected, while in scenarios 1 and 2, a higher concentration of alpha-amylase related to the baseline was identified as compared to that in scenario 3. IgA concentration was not significantly related to the exposure.CONCLUSIONS: RF-EMF in considerably lower field densities than ICNIRP-guidelines may influence certain psychobiological stress markers.

Augner C, Gnambs T, Winker R, Barth A. Acute effects of electromagnetic fields emitted by GSM mobile phones on subjective well-being and physiological reactions: a meta-analysis.Sci Total Environ. 424:11-15, 2012.

The potential effects of radiofrequency electromagnetic fields (RF-EMF) emitted by GSM mobile phones on subjective symptoms, well-being and physiological parameters have been investigated in many studies. However, the results have been ambiguous. The current meta-analysis aims to clarify whether RF-EMF have an influence on well-being in self-reported sensitive persons, as well as in non-sensitive people. A literature search revealed 17 studies including 1174 participants. The single effects for various subjective and objective outcomes were meta-analytically combined to yield a single population parameter. Dependant variables were subjective (e.g. headaches) and objective parameters (e.g. heart rate variability) of well-being. The results show no significant impact of short-term RF-EMF exposure on any parameter. Future research should focus on the possible effects of long-term exposure.

Auvinen A, Hietanen M, Luukkonen R, Koskela R-S, Brain tumors and salivary gland cancers among cellular telephone users Epidemiology 13:356-359, 2002.

Background. Possible risk of cancer associated with use of cellular telephones has lately been a subject of public debate. Methods. We conducted a register-based, case-control study on cellular phone use and cancer. The study subjects were all cases of brain tumor (N = 398) and salivary gland cancer (N = 34) diagnosed in Finland in 1996, with five controls per case. Results. Cellular phone use was not associated with brain tumors or salivary gland cancers overall, but there was a weak association between gliomas and analog cellular phones. Conclusions. A register-based approach has limited value in risk assessment of cellular phone use owing to lack of information on exposure.

Avci B, Akar A, Bilgici B, Tunçel ÖK. Oxidative stress induced by 1.8 GHz radio frequency electromagnetic radiation and effects of garlic extract in rats. Int J Radiat Biol. 88(11):799-805, 2012.

PURPOSE: We aimed to study the oxidative damage induced by radiofrequency electromagnetic radiation (RF-EMR) emitted by mobile telephones and the protective effect of garlic extract used as an anti-oxidant against this damage. **MATERIALS AND METHODS:** A total of 66 albino Wistar rats were divided into three groups. The first group of rats was given 1.8 GHz, 0.4 W/kg specific absorption rate (SAR) for 1 h a day for three weeks. The second group was given 500 mg/kg garlic extract in addition to RF-EMR. The third group of rats was used as the control group. At the end of the study, blood and brain tissue samples were collected from the rats. **RESULTS:** After the RF-EMR exposed, the advanced oxidation protein product (AOPP) levels of brain tissue increased compared with the control group ($p < 0.001$). Garlic administration accompanying the RF-EMR, on the other hand, significantly reduced AOPP levels in brain tissue ($p < 0.001$). The serum nitric oxide (NO) levels significantly increased both in the first and second group ($p < 0.001$). However, in the group for which garlic administration accompanied that of RF-EMR, there was no difference in serum NO levels compared with the RF-EMR exposed group ($p > 0.05$). There was no significant difference among the groups with respect to malondialdehyde (MDA) levels in brain tissue and blood samples ($p > 0.05$). Similarly, no difference was detected among the groups regarding serum paroxonase (PON) levels ($p > 0.05$). We did not detect any PON levels in the brain tissue. **CONCLUSIONS:** The exposure of RF-EMR similar to 1.8 GHz Global system for mobile communication (GSM) leads to protein oxidation in brain tissue and an increase in serum NO. We observed that garlic administration reduced protein oxidation in brain tissue and that it did not have any effects on serum NO levels.

Avdikos A, Karkabounas S, Metsios A, Kostoula O, Havelas K, Binolis J, Verginadis I, Hatziaivazis G, Simos I, Evangelou A. Anticancer effects on leiomyosarcoma-bearing Wistar rats after electromagnetic radiation of resonant radiofrequencies. Hell J Nucl Med. 10(2):95-101, 2007.

In the present study, the effects of a resonant low intensity static electromagnetic field (EMF), causing no thermal effects, on Wistar rats have been investigated. Sarcoma cell lines were isolated from leiomyosarcoma tumors induced in Wistar rats by the subcutaneous (s.c) injection of 3,4-benzopyrene. Furthermore, smooth muscle cells (SMC) were isolated from the aorta of Wistar rats and cultivated. Either leiomyosarcoma cells (LSC) or SMC were used to record a number of characteristic resonant radiofrequencies, in order to determine the specific electromagnetic fingerprint spectrum for each cell line. These spectra were used to compose an appropriate algorithm, which transforms the recorded radiofrequencies to emitted ones. The isolated LSC were cultured and then exposed to a resonant low intensity radiofrequency EMF (RF-EMF), at frequencies between 10 kHz to 120 kHz of the radiowave spectrum. The exposure lasted 45 consecutive minutes daily, for two consecutive days. Three months old female Wistar rats were inoculated with exposed and non-exposed to EMF LSC (4 x 10(6) LCS for animal). Inoculated with non-exposed to EMF cells animals were then randomly separated into three Groups. The first Group was sham exposed to the resonant EMF (control Group-CG), the second Group after the inoculation of LSC and appearance of a palpable tumor mass, was exposed to a non-resonant EMF radiation pattern, for 5 h per day till death of all animals (experimental control Group-ECG). The third Group of animals after inoculation of LSC and the appearance of a palpable tumor mass, was exposed to the resonant EMF radiation for 5 h per day, for a maximum of 60 days (experimental Group-I, EG-I). A fourth Group of animals was inoculated with LSC exposed to EMF irradiation and were not further exposed to irradiation (experimental Group-II, EG-II). Tumor induction was 100% in all Groups studied and all tumors were histologically identified as leiomyosarcomas. In the case of the EG-I, a number of tumors were completely regretted (final tumor induction: 66%). Both Groups of animals inoculated with exposed or non-exposed to the EMF LSC, (EG-I and EG-II, respectively) demonstrated a significant prolongation of the survival time and a lower tumor growth rate, in comparison to the control Group (CG) and the experimental control Group (ECG). However, the survival time of EG-I animals was found to be significantly longer and tumor growth rate significantly lower compared to EG-II animals. In conclusion, our results indicate a specific anticancer effect of resonant EMF irradiation. These results may possibly be attributed to (a) the duration of exposure of LSC and (b) the exposure of the entire animal to this irradiation.

Avendaño C, Mata A, Sanchez Sarmiento CA, Doncel GF. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation.Fertil Steril. 97(1):39-45, 2012.

OBJECTIVE: To evaluate the effects of laptop computers connected to local area networks wirelessly (Wi-Fi) on human spermatozoa.**DESIGN:** Prospective in vitro study.**SETTING:** Center for reproductive medicine.**PATIENT(S):** Semen samples from 29 healthy donors.**INTERVENTION(S):** Motile sperm were selected by swim up. Each sperm suspension was divided into two aliquots. One sperm aliquot (experimental) from each patient was exposed to an internet-connected laptop by Wi-Fi for 4 hours, whereas the second aliquot (unexposed) was used as control, incubated under identical conditions without being exposed to the laptop.**MAIN OUTCOME MEASURE(S):** Evaluation of sperm motility, viability, and DNA fragmentation.**RESULT(S):** Donor sperm samples, mostly normozoospermic, exposed ex vivo during 4 hours to a wireless internet-connected laptop showed a significant decrease in progressive sperm motility and an increase in sperm DNA fragmentation. Levels of dead sperm showed no significant differences between the two groups.**CONCLUSION(S):** To our knowledge, this is the first study to evaluate the direct impact of laptop use on human spermatozoa. Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility. Further in vitro and in vivo studies are needed to prove this contention.

Aweda MA, Gbenebitse S, Meidinyo RO. Effects of 2.45 GHz microwave exposures on the peroxidation status in Wistar rats. Niger Postgrad Med J. 10(4):243-246, 2003.

One of the consequences of exposures to microwave (MW) radiations is the enhanced production of free O2, free radicals, peroxides and superoxides. The effects on the lipid peroxidation status (LPS) of whole body irradiation of 120 Wistar rats with 2.45 GHz MW at a power density of 6mWcm(-2) have been studied using the MW generator model ER6660E from Toshiba UK Ltd. The LPS in the rats was monitored for a period of 8 weeks post irradiation using thiobarbituric acid (TRA) method. The MW exposures caused an increase in the LPS from the mean control value of 4.18 x 10(-6)g 1(-1)to a maximum of 6.50 x 10(-6) g 1(-1) within the first 24 hrs, and then gradually reduced to control value after about a week. 1mg kg(-1) of ascorbic acid administered before irradiation caused a decrease in the LPS from the control value to a minimum of 2.86 x 10(-6)g 1(-1) within the first week. The value then gradually rose to a maximum of 3.96 x 10(-6)g 1(-1) within the monitoring period. 1 mg kg(-1) of a-tocopherol also administered before irradiation also caused a decrease in the LPS from the control value to a minimum of 2.10 x 10(-6) g 1(-1) within the first week. The value then gradually rose to a maximum of 3.94 x 10(-6) g 1(-1) within the monitoring period. The results obtained from this study demonstrate that MW exposures cause significant increase in the LPS and there are protective effects of the anti-oxidants ascorbic acid and alpha-tocopherol.

Aweda MA, Ajekigbe AT, Ibitoye AZ, Evwhierhurhoma BO, Eletu OB. Potential health risks due to telecommunications radiofrequency radiation exposures in Lagos State Nigeria. Nig Q J Hosp Med. 19(1):6-14, 2009.

BACKGROUND: The global system mobile telecommunications system (GSM) which was recently introduced in Nigeria is now being used by over 40 million people in Nigeria. The use of GSM is accompanied with exposure of the users to radiofrequency radiation (RFR), which if significant, may produce health hazards. This is the reason why many relevant national and international organizations recommended exposure limits to RFR and why it is made compulsory for GSM handsets to indicate the maximum power output as a guide to potential consumers. OBJECTIVE: This study was conducted to measure the RFR output power densities (S) from the most commonly used GSM handsets used in Lagos State and compare with the limit recommended for safety assessment. METHODS: Over 1100 most commonly used handsets of different makes and models as well as wireless phones were sampled and studied in all over the local government areas of the State. An RFR meter, Electrosmog from LESSEMF USA was used for the measurements. The handsets were assessed for health risks using the reference value of 9 Wm(-2) as recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). RESULTS: The range of the S-values obtained varied from a minimum of 1.294 0.101 Wm(-2) with Siemens model R228 to a maximum of 16.813 +/- 0.094 Wm(-2) with Samsung model C140*. The results from wireless telephones showed very low S-values ranging from a minimum of 0.024 +/- 0.001 Wm(-2) with HUAWEI and ST CDMA 1 to a maximum of 0.093 +/- 0.002 Wm(-2) with HISENSE. CONCLUSION: The results showed that the population in Lagos State may be at risk due to significant RFR exposures resulting principally from the use of GSM. Quite a number of handsets emit power above the ICNIRP recommended value. Measured RFR power close to Radio and Television masts and transmitters are within tolerable limits in most cases, only that the public should not reside or work close to RFR installations. Phone calls with GSM should be restricted to essential ones while youths and children that are more susceptible to RFR hazards should be supervised in their use of GSM. Wireless phones are quite safe.

Ayata A, Mollaoglu H, Yilmaz HR, Akturk O, Ozguner F, Altuntas I. Oxidative stress-mediated skin damage in an experimental mobile phone model can be prevented by melatonin. J Dermatol. 31(11):878-883, 2004.

Most mobile phones emit 900 MHz of radiation that is mainly absorbed by the external organs. The effects of 900 MHz of radiation on fibrosis, lipid peroxidation, and anti-oxidant enzymes and the ameliorating effects of melatonin (Mel) were evaluated in rat skin. Thirty Wistar-Albino rats were used in the study. The experimental groups were the control group, the irradiated group (IR), and the irradiated+Mel treated group (IR+Mel). A dose of 900 MHz, 2 W radiation was applied to the IR group every day for 10 days (30 min/day). The IR+Mel group received 10 mg/kg/day melatonin in tap water for 10 days before the irradiation. At the end of the 10th day, a skin specimen was excised from the thoracoabdominal area. The levels of malondialdehyde (MDA) and hydroxypyroline and the activities of superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and catalase (CAT) were studied in the skin samples. MDA and hydroxyproline levels and activities of CAT and GSH-Px were increased significantly in the IR group compared to the control group ($p<0.05$) and decreased significantly in the IR+Mel group ($p<0.05$). SOD activity was decreased significantly in the IR group and this decrease was not prevented by the Mel treatment. These results suggest that rats irradiated with 900 MHz suffer from increased fibrosis and lipid peroxidation (LPO). Mel treatment can reduce the fibrosis and LPO caused by radiation.

Aydin B, Akar A. Effects of a 900-MHz electromagnetic field on oxidative stress parameters in rat lymphoid organs, polymorphonuclear leukocytes and plasma. Arch Med Res. 42(4):261-267, 2011.

BACKGROUND AND AIMS: The present study investigated the effects of a 900-MHz electromagnetic field (EMF) for 2 h/day for 45 days on lymphoid organs (spleen, thymus, bone marrow), polymorphonuclear leukocytes (PMNs) and plasma of rats, focusing on changes in the enzymatic and nonenzymatic antioxidant system. We determined whether there is any difference between immature and mature rats in terms of oxidative damage caused by EMF and tested recovery groups to determine whether EMF-induced damage is reversible in immature and mature rats. METHODS: Twenty four immature and 24 mature rats were divided randomly and equally into six groups as follows: two control groups, immature (2 weeks old) and mature (10 weeks old); two groups were exposed to 900 MHz (28.2 ± 2.1 V/m) EMF for 2 h/day for 45 days. Two recovery groups were kept for 15 days after EMF exposure. RESULTS: Substantial, deleterious biochemical changes were observed in oxidative stress metabolism after EMF exposure. Antioxidant enzyme activity, glutathione levels in lymphoid organs and the antioxidant capacity of the plasma decreased, but lipid peroxidation and nitric oxide levels in PMNs and plasma and also myeloperoxidase activity in PMNs increased. Oxidative damage was tissue specific and improvements seen after the recovery period were limited, especially in immature rats. CONCLUSIONS: In the present study, much higher levels of irreversible oxidative damage were observed in the major lymphoid organs of immature rats than in mature rats.

Aydin D, Feychting M, Schüz J, Andersen TV, Poulsen AH, Prochazka M, Klæboe L, Kuehni CE, Tynes T, Röösli M. Predictors and overestimation of recalled mobile phone use among children and adolescents. Prog Biophys Mol Biol. 107(3):356-361, 2011.

A growing body of literature addresses possible health effects of mobile phone use in children and adolescents by relying on the study participants' retrospective reconstruction of mobile phone use. In this study, we used data from the international case-control study CEFALO to compare self-reported with objectively operator-recorded mobile phone use. The aim of the study was to assess predictors of level of mobile phone use as well as factors that are associated with overestimating own mobile phone use. For cumulative number and duration of calls as well as for time since first subscription we calculated the ratio of self-reported to operator-recorded mobile phone use. We used multiple linear regression models to assess possible predictors of the average number and duration of calls per day and logistic regression models to assess possible predictors of overestimation. The cumulative number and duration of calls as well as the time since first subscription of mobile phones were overestimated on average by the study participants. Likelihood to overestimate number and duration of calls was not significantly different for controls compared to cases (OR=1.1, 95%-CI: 0.5 to 2.5 and OR=1.9, 95%-CI: 0.85 to 4.3, respectively). However, likelihood to overestimate was associated with other health related factors such as age and sex. As a consequence, such factors act as confounders in studies relying solely on self-reported mobile phone use and have to be considered in the analysis.

Aydin D, Feychting M, Schüz J, Tynes T, Andersen TV, Schmidt LS, Poulsen AH, Johansen C, Prochazka M, Lannering B, Klæboe L, Eggen T, Jenni D, Grotzer M, Von der Weid N, Kuehni CE, Röösli M. Mobile phone use and brain tumors in children and adolescents: a multicenter case-control study. J Natl Cancer Inst. 103(16):1264-1276, 2011.

BACKGROUND: It has been hypothesized that children and adolescents might be more vulnerable to possible health effects from mobile phone exposure than adults. We investigated whether mobile phone use is associated with brain tumor risk among children and adolescents.METHODS: CEFALO is a multicenter case-control study conducted in Denmark, Sweden, Norway, and Switzerland that includes all children and adolescents aged 7-19 years who were diagnosed with a brain tumor between 2004 and 2008. We conducted interviews, in person, with 352 case patients (participation rate: 83%) and 646 control subjects (participation rate: 71%) and their parents. Control subjects were randomly selected from population registries and matched by age, sex, and geographical region. We asked about mobile phone use and included mobile phone operator records when available. Odds ratios (ORs) for brain tumor risk and 95% confidence intervals (CIs) were calculated using conditional logistic regression models.RESULTS: Regular users of mobile phones were not statistically significantly more likely to have been diagnosed with brain tumors compared with nonusers (OR =

1.36; 95% CI = 0.92 to 2.02). Children who started to use mobile phones at least 5 years ago were not at increased risk compared with those who had never regularly used mobile phones (OR = 1.26, 95% CI = 0.70 to 2.28). In a subset of study participants for whom operator recorded data were available, brain tumor risk was related to the time elapsed since the mobile phone subscription was started but not to amount of use. No increased risk of brain tumors was observed for brain areas receiving the highest amount of exposure.CONCLUSION: The absence of an exposure-response relationship either in terms of the amount of mobile phone use or by localization of the brain tumor argues against a causal association.

Aydin D, Feychting M, Schüz J, Andersen TV, Poulsen AH, Prochazka M, Klaeboe L, Kuehni CE, Tynes T, Röösli M. Impact of random and systematic recall errors and selection bias in case--control studies on mobile phone use and brain tumors in adolescents (CEFALO study). Bioelectromagnetics. 32(5):396-407, 2011.

Whether the use of mobile phones is a risk factor for brain tumors in adolescents is currently being studied. Case--control studies investigating this possible relationship are prone to recall error and selection bias. We assessed the potential impact of random and systematic recall error and selection bias on odds ratios (ORs) by performing simulations based on real data from an ongoing case--control study of mobile phones and brain tumor risk in children and adolescents (CEFALO study). Simulations were conducted for two mobile phone exposure categories: regular and heavy use. Our choice of levels of recall error was guided by a validation study that compared objective network operator data with the self-reported amount of mobile phone use in CEFALO. In our validation study, cases overestimated their number of calls by 9% on average and controls by 34%. Cases also overestimated their duration of calls by 52% on average and controls by 163%. The participation rates in CEFALO were 83% for cases and 71% for controls. In a variety of scenarios, the combined impact of recall error and selection bias on the estimated ORs was complex. These simulations are useful for the interpretation of previous case-control studies on brain tumor and mobile phone use in adults as well as for the interpretation of future studies on adolescents.

Aydogan F, Unlu I, Aydin E, Yumusak N, Devrim E, Samim EE, Ozgur E, Unsal V, Tomruk A, Ozturk GG, Seyhan N. The effect of 2100 MHz radiofrequency radiation of a 3G mobile phone on the parotid gland of rats. Am J Otolaryngol. 2014 Oct 5. pii: S0196-0709(14)00207-5. doi: 10.1016/j.amjoto.2014.10.001. [Epub ahead of print]

PURPOSE: We aimed to evaluate the effect of 2100 MHz radiofrequency radiation on the parotid gland of rats in short and relatively long terms. MATERIAL AND METHODS: Thirty Wistar albino rats were divided into four groups. Groups A and B served as the control groups (for 10 days and 40 days, respectively), and each group included six rats. Groups C and D were composed of nine rats each, and they were the exposure groups. The rats were exposed to 2100 MHz radiofrequency radiation emitted by a generator, simulating a third generation mobile phone for 6 hours/day, 5 days/week, for 10 or 40 days. Following exposure, the rats were sacrificed and parotid glands were removed.

Histopathological and biochemical examinations were performed. RESULTS: Although there were no histopathological changes in the control groups except for two animals in group A and three animals in group B, the exposure groups C (10 days) and D (40 days) showed numerous histopathological changes regarding salivary gland damage including acinar epithelial cells, interstitial space, ductal system, vascular system, nucleus, amount of cytoplasm and variations in cell size. The histopathological changes were more prominent in group D compared to group C. There was statistically significant different parameter regarding variation in cell size between the groups B and D (p=0.036). CONCLUSION: The parotid gland of rats showed numerous histopathological changes after exposure to 2100 MHz radiofrequency radiation, both in the short and relatively long terms. Increased exposure duration led to an increase in the histopathological changes.

Aydoğan F, Aydın E, Koca G, Özgür E, Atilla P, Tüzüner A, Demirci Ş, Tomruk A, Öztürk GG, Seyhan N, Korkmaz M, Müftüoğlu S, Samim EE. The effects of 2100-MHz radiofrequency radiation on nasal mucosa and mucociliary clearance in rats. Int Forum Allergy Rhinol. 5(7):626-632, 2015.

BACKGROUND: Nasal mucociliary clearance has an important role in voiding the airways from inhaled foreign substances. This activity could be disturbed by environmental factors such as radiofrequency radiation. The aim of the present study was to investigate short-term and relatively long-term effects of 2100-MHz radiofrequency radiation emitted by a generator, simulating a 3G-mobile phone, on the nasal septal mucosa and mucociliary clearance in rats. METHODS: Thirty Wistar albino rats were divided into 4 groups. There were 6 rats in Group A and Group B, which served as the control groups (10-day and 40-day groups, respectively). Groups C (10-day exposure) and D (40-day exposure) were both composed of 9 rats; they comprised the radiofrequency radiation exposure groups. The rats in groups C and D were exposed to 2100-MHz radiofrequency radiation emitted by a generator, simulating a 3G-mobile phone, 6 hours/day, for 10 or 40 days, respectively. After exposure, nasal mucociliary clearance was measured by rhinoscintigraphy. After euthanization, the nasal septa of the animals were removed, and tissue samples of the nasal mucosa were examined using a transmission electron microscope. RESULTS: The differences in mucociliary clearances between groups A and C, groups B and D, and groups C and D were found to be statistically significant ($p = 0.005$, $p < 0.001$, $p < 0.001$, respectively). Although there were no histopathological abnormalities in the control groups, the exposure groups showed a number of degenerated and apoptotic cells, ciliary disorganization and ciliary loss in the epithelial cells, epithelial metaplasia, alteration of normal chromatin distribution and karyolysis in nuclei, changes in the basal cells, and lymphocytic infiltration. The histopathological changes were more severe in group D. CONCLUSION: Radiofrequency radiation at 2100 MHz damaged the nasal septal mucosa, and disturbed the mucociliary clearance. Ciliary disorganization and ciliary loss in the epithelial cells resulted in deterioration of nasal mucociliary clearance.

Ayinmode BO, Farai IP. STUDY OF VARIATIONS OF RADIOFREQUENCY POWER DENSITY FROM MOBILE PHONE BASE STATIONS WITH DISTANCE. Radiat Prot Dosimetry. 2013 Apr 25. [Epub ahead of print]

The variations of radiofrequency (RF) radiation power density with distance around some mobile phone base stations (BTSs), in ten randomly selected locations in Ibadan, western Nigeria, were studied. Measurements were made with a calibrated hand-held spectrum analyser. The maximum Global System of Mobile (GSM) communication 1800 signal power density was 323.91 µW m^{-2} at 250 m radius of a BTS and that of GSM 900 was 1119.00 µW m^{-2} at 200 m radius of another BTS. The estimated total maximum power density was 2972.00 µW m^{-2} at 50 m radius of a different BTS. This study shows that the maximum carrier signal power density and the total maximum power density from a BTS may be observed averagely at 200 and 50 m of its radius, respectively. The result of this study demonstrates that exposure of people to RF radiation from phone BTSs in Ibadan city is far less than the recommended limits by International scientific bodies.

Aynali G, Nazıroğlu M, Celik O, Doğan M, Yarıktaş M, Yasan H. Modulation of wireless (2.45 GHz)-induced oxidative toxicity in laryngotracheal mucosa of rat by melatonin. Eur Arch Otorhinolaryngol. 270(5):1695-1700, 2013.

It is well known that oxidative stress induces larynx cancer, although antioxidants induce modulator role on etiology of the cancer. It is well known that electromagnetic radiation (EMR) induces oxidative stress in different cell systems. The aim of this study was to investigate the possible protective role of melatonin on oxidative stress induced by Wi-Fi (2.45 GHz) EMR in laryngotracheal mucosa of rat. For this purpose, 32 male rats were equally categorized into four groups, namely controls, sham controls, EMR-exposed rats, EMR-exposed rats treated with melatonin at a dose of 10 mg/kg/day. Except for the controls and sham controls, the animals were exposed to 2.45 GHz radiation during 60 min/day for 28 days. The lipid peroxidation levels were significantly ($p < 0.05$) higher in the radiation-exposed groups than in the control and sham control groups. The lipid peroxidation level in the irradiated animals treated with melatonin was significantly ($p < 0.01$) lower than in those that were only exposed to Wi-Fi radiation. The activity of glutathione peroxidase was lower in the irradiated-only group relative to control and sham control groups but its activity was significantly ($p < 0.05$) increased in the groups treated with melatonin. The reduced glutathione levels in the mucosa of rat did not change in the four groups. There is an apparent protective effect of melatonin on the Wi-Fi-induced oxidative stress in the laryngotracheal mucosa of rats by inhibition of free radical formation and support of the glutathione peroxidase antioxidant system.

Azadi Oskouyi E, Rajaei F, Safari Variani A, Sarokhani MR, Javadi A. Effects of microwaves (950 MHZ mobile phone) on morphometric and apoptotic changes of rabbit epididymis. Andrologia. 2014 Jul 25. doi: 10.1111/and.12321. [Epub ahead of print]

The effect of mobile phone radiation on human reproduction system is still a matter of debate. In this study, 18 male rabbits were randomly divided into two experimental groups and one control group. Experimental groups received simulated microwaves with the frequency of 950 MHz and the output power of 3 and 6 watts for 2 weeks, 2 h a day. After a week of rest, the microscopic slides from the quada of the excised epididymis were prepared. Then, the diameter of epididymis, the height of epithelium and the number of apoptotic cells in epithelium in study groups were determined. The data were compared using spss software and one-way anova test. The epithelial height and diameter of the epididymis in 3 watt and 6 watt groups had a significant decrease compared to the control group ($P < 0.001$), while the testosterone level only in 6 watt group was significantly decreased compared to control group. The rate of apoptosis in the epithelial cells of the epididymis had a significant increase only in 6 watt group compared to the control group ($P < 0.001$). This study showed that the microwaves with the frequency of 950 MHz can have negative impacts on morphometric and apoptotic changes of rabbit epididymis.

Azah CK, Amoako JK, Fletcher JJ. Levels of electric field strength within the immediate vicinity of FM radio stations in Accra, Ghana. Radiat Prot Dosimetry. 156(4):395-400, 2013.

Heightened awareness of the ever-expanding use of radiofrequency (RF) techniques and technology has led to mounting concerns from the general public and the scientific community regarding the possible health effects that may arise as a consequence of exposure to RF radiations and has drawn the attention of many researchers the world over. A survey of the RF electromagnetic radiation at public access points in the vicinity of 20 frequency-modulated (FM) radio stations has been made in Accra, Ghana. The fundamental object was to determine the levels of RF fields from FM broadcast antennae within 10-200 m radius about the foot of the FM base station and at a height of 1.5 m above the ground at selected locations. A spectrum analyser and a bi-conical antenna element sensitive and effective within the frequency band of 30-300 MHz were used. Results obtained indicated that the levels of electric field strength ranged from 5.4E-04 V m(-1) at FM station 'O' to 7.4E-08 V m(-1) at FM station 'D'. At a transmission frequency range of 88-108 MHz, the variation of power densities is from 2.5E-10 to 1.5E-17 Wm(-2). These values are very low and are far below the reference level set by the International Commission on Non-Ionizing Radiation Protection and therefore do not pose any known hazard to the inhabitants of Accra, Ghana. The electric field levels presented in this work are comparable with those reported from epidemiological studies conducted elsewhere.

Babincova M, Leszczynska D, Sourivong P, Babinec P, Selective treatment of neoplastic cells using ferritin-mediated electromagnetic hyperthermia. Med Hypotheses 54(2):177-179, 2000.

A new method of cancer treatment is proposed, based on the unique magnetic properties of ferritin iron core which, in alternating magnetic field of frequency approximately 100 kHz, is easily heated to temperatures sufficiently high to destroy neoplastic cells containing an excess of this protein, without damaging the normal cells.

Bachmann M, Kalda J, Lass J, Tuulik V, Säkki M, Hinrikus H. Non-linear analysis of the electroencephalogram for detecting effects of low-level electromagnetic fields. Med Biol Eng Comput. 43(1):142-149, 2005.

The study compared traditional spectral analysis and a new scale-invariant method, the analysis of the length distribution of low-variability periods (LDLVPs), to distinguish between electro-encephalogram (EEG) signals with and without a weak stressor, a low-level modulated microwave field. During the experiment, 23 healthy volunteers were exposed to a microwave (450 MHz) of 7 Hz frequency on-off modulation. The field power density at the scalp was 0.16 mW cm(-2). The experimental protocol consisted of ten cycles of repetitive microwave exposure. Signals from frontal EEG channels FP1 and FP2 were analysed. Smooth power spectrum and length distribution curves of low-variability periods, as well as probability distribution close to normal, confirmed that stationarity of the EEG signal during recordings was achieved. The quantitative measure of LDLVPs provided a significant detection of the effect of the stressor for the six subjects exposed to the microwave field but for none of the sham recordings. The spectral analysis revealed a significant result for one subject only. A significant effect of the exposure to the EEG signal was detected in 25% of subjects, with microwave exposure increasing EEG variability. The effect was not detectable by power spectral measures.

Bachmann M, Rubljova J, Lass J, Tomson R, Tuulik V, Hinrikus H. Adaptation of human brain bioelectrical activity to low-level microwave. Conf Proc IEEE Eng Med Biol Soc. 2007:4747-4750, 2007.

The experiments of adaptation of the human brain bioelectrical activity were carried out on a group of 14 healthy volunteers exposed to 450 MHz microwave radiation modulated at 40 Hz frequencies. The field power density at the scalp was 0.16 mW/cm(2). Results of the study indicate that adaptation effect of human brain to low-level microwave exposure is evident. The initial increase of EEG power was compensated and even overcompensated. The adaptation phenomena were obvious in EEG alpha and beta rhythms.

Bachmann M, Lass J, Kalda J, Säkki M, Tomson R, Tuulik V, Hinrikus H. Integration of differences in EEG analysis reveals changes in human EEG caused by microwave. Conf Proc IEEE Eng Med Biol Soc. 1:1597-1600, 2006.

Three different methods in combination with integration of differences in signals were applied for EEG analysis to distinguish changes in EEG caused by microwave: S-parameter, power spectral density and length distribution of low variability periods. The experiments on the effect of modulated low-level microwaves on human EEG were carried out on four different groups of healthy volunteers exposed to 450 MHz microwave radiation modulated with 7 Hz, 14 Hz, 21 Hz, 40 Hz, 70 Hz, 217 or 1000 Hz frequencies. The field power density at the scalp was 0.16 mW/cm2. The EEG analysis performed for individuals with three different methods showed that statistically significant changes occur in the EEG rhythms energy and dynamics between 12% and 30% of subjects.

Bahreyni Toossi MH, Sadeghnia HR, Mohammad Mahdizadeh Feyzabadi M, Hosseini M, Hedayati M, Mosallanejad R, Beheshti F, Alizadeh Rahvar Z. Exposure

to mobile phone **(900-1800 MHz) during pregnancy: tissue oxidative stress after childbirth. J Matern Fetal Neonatal Med. 2017 Apr 23:1-6. doi: 10.1080/14767058.2017.1315657. [Epub ahead of print]**

BACKGROUND: The present study has investigated the effects of **mobile phone** (900-1800 MHz)-induced electromagnetic radiation on redox status in the heart, liver, kidney, cerebellum, and hippocampus of dams and the offspring mice.MATERIALS AND METHODS: Pregnant Balb/C were divided into two groups including the control and the experimental group. The experimental group was exposed to **mobile phone** (900-1800 MHz), during pregnancy (2 h/d for 20 d). The dams and the offspring of both groups were sacrificed and tissues of interest were harvested immediately after delivery. Malondialdehyde (MDA) concentration, total thiol groups (TTG) content, superoxide dismutase (SOD), and catalase (CAT) activities were determined in the tissues.RESULTS: In the experimental groups, MDA levels were significantly increased, while TTG, SOD, and CAT were significantly decreased in the total tissues of dams and their offspring.CONCLUSION: Exposure to **mobile phone** (900-1800 MHz) during pregnancy induced oxidative stress in tissues of dams and their offspring.

Bak M, Dudarewicz A, Zmyślony M, Sliwinska-Kowalska M. Effects of GSM signals during exposure to event related potentials (ERPs). Int J Occup Med Environ Health. 23(2):191-199, 2010.

Objectives: The primary aim of this work was to assess the effect of electromagnetic field (EMF) from the GSM mobile phone system on human brain function. The assessment was based on the assay of event related potentials (ERPs). Material and Methods: The study group consisted of 15 volunteers, including 7 men and 8 women. The test protocol comprised determination of P300 wave in each volunteer during exposure to the EMF. To eliminate possible effects of the applied test procedure on the final result, the test was repeated without EMF exposure. P300 latency, amplitude, and latency of the N1, N2, P2 waves were analysed. Results: The statistical analysis revealed an effect of EMF on P300 amplitude. In the experiment with EMF exposure, lower P300 amplitudes were observed only at the time in which the volunteers were exposed to EMF; when the exposure was discontinued, the values of the amplitude were the same as those observed before EMF application. No such change was observed when the experiment was repeated with sham exposure, which may be considered as an indirect proof that lower P300 amplitude values were due to EMF exposure. No statistically significant changes were noted in the latencies of the N1, N2, P2 waves that precede the P300 wave, nor in the latency of the P300 itself. Conclusions: The results suggest that exposure to GSM EMF exerts some effects on CNS, including effects on long latency ERPs.

Bakacak M, Bostancı MS, Attar R, Yıldırım ÖK, Yıldırım G, Bakacak Z, Sayar H, Han A. The effects of electromagnetic fields on the number of ovarian primordial follicles: An experimental study. Kaohsiung J Med Sci. 31(6):287-292, 2015.

The aim of this study was to evaluate the effect of an electromagnetic field (EMF), generated close to the ovaries, on primordial follicles. A total of 16 rats were used in this study. The study group consisted of rats exposed to an EMF in the abdominal region for 15 min/d for 15 days. Both the study and control group were composed of eight rats. After the treatment period of 15 days, the ovaries of the rats were extracted, and sections of ovarian tissue were taken for histological evaluation. The independent samples t test was used to compare the two groups. In the study group, the means of the right and left ovarian follicle numbers were 34.00 ± 10.20 and 36.00 ± 10.53, respectively. The average total ovarian follicle number was 70.00 ± 19.03. In the control group, the means of the right and left ovarian follicle numbers were 78.50 ± 25.98 and 71.75 ± 29.66, respectively, and the average total ovarian follicle number was 150.25 ± 49.53. The comparisons of the means of the right and left ovarian follicle numbers and the means of the total ovarian follicle numbers between the study and control groups indicated that the study group had significantly fewer follicles ($p < 0.001$, $p = 0.011$, and $p = 0.002$, respectively). This study found a significant decrease in the number of ovarian follicles in rats exposed to an EMF. Further clinical studies are needed to reveal the effects of EMFs on ovarian reserve and infertility.

Bakos J, Kubinyi G, Sinay H, Thuroczy G. GSM modulated radiofrequency radiation does not affect 6-sulfatoxymelatonin excretion of rats. Bioelectromagnetics 24(8):531-534, 2003.

In this study, the effect of exposure to 900 and 1800 MHz GSM-like radiofrequency radiation upon the urinary 6-sulfatoxymelatonin (6SM) excretion of adult male Wistar rats was studied. Seventy-two rats were used in six independent experiments, three of which were done with 900 MHz and the other three with 1800 MHz. The exposures were performed in a gigahertz transverse electromagnetic mode (GTEM) cell. The power densities of radiation were 100 and 20 microW/cm(2) at 900 and 1800 MHz frequency, respectively. The carrier frequency was modulated with 218 Hz, as in the GSM signal. The animals were exposed for 2 h between 8:00 AM and noon daily during the 14 day exposure period. The urine of rats was collected from 12:00 AM to 8:00 AM, collecting from exposed and control animal groups on alternate days. The urinary 6SM concentration was measured by (125)I radioimmunoassay and was referred to creatinine. The combined results of three experiments done with the same frequency were statistically analyzed. Statistically significant changes in the 6SM excretion of exposed rats ($n = 18$) compared to control group ($n = 18$) were not found either at 900 or 1800 MHz.

Balakrishnan K, Murali V, Rathika C, Manikandan T, Malini RP, Kumar RA, Krishnan M. Hsp70 is an independent stress marker among frequent users of mobile phones. J Environ Pathol Toxicol Oncol. 33(4):339-347, 2014.

The aim of this study was to measure the serum concentrations of heat shock protein (HSP) 70 and C-reactive protein (CRP) and the expression levels of the hsp70 gene among frequent users of mobile phones (FUMPs). We enrolled 120 employees of information technology (IT)/IT enabled service companies (FUMPs; IT professionals) and 102 infrequent users of mobile phones (IFUMPs; people from non-IT professions) as controls. The serum concentrations of HSP70 and CRP were measured by enzyme-linked immunosorbant assay and hsp70 gene expression by reverse transcription polymerase chain reaction. Significantly higher concentrations of serum HSP70 ($P < 0.00012$) and CRP ($P < 0.04$) were observed among FUMPs than IFUMPs. A higher level of hsp70 gene expression (fold induction) was observed among FUMPs than IFUMPs ($P < 7.06 \times 10\text{-}13$). In contrast to the duration of exposure-dependent increase of serum concentration of CRP, the serum HSP70 concentration was found to be independent of the duration of exposure to mobile phones. Thus, the study convincingly demonstrated the role of serum HSP and CRP as systemic inflammatory biomarkers for mobile phone-induced radiation.

Balcer-Kubiczek EK, Harrison GH. Neoplastic transformation of C3H/10T1/2 cells following exposure to 120-Hz modulated 2.45-GHz microwaves and phorbol ester tumor promoter. Radiat Res 126(1):65-72, 1991.

Some recent epidemiological studies have shown a positive association between cancer incidence and exposure to electromagnetic (EM) fields. Evidence from in vitro studies indicates that this effect could be due to synergistic interaction between EM fields and tumor promoters. However, no dose-response data related directly to carcinogenesis have been published. In this study, actively growing cultures of C3H/10T1/2 cells were exposed for 24 h to 2.45-GHz microwaves pulse-modulated at 120 Hz. Conditions of EM-field exposure were designed to simulate low-field exposures (specific absorption rate 0.1, 1, or 4.4 W/kg; the corresponding peak amplitudes were electric field 18, 56, or 120 V/m, magnetic field 0.09, 0.27, or 0.56 muT, respectively). In separate experiments, a 24-h EM-field exposure at 4.4 W/kg was preceded or followed by X irradiation at 0.5, 1, or 1.5 Gy. Cells were assayed for cell survival and neoplastic transformation with or without post-treatment administration of 0.1 micrograms/ml of 12-O-tetradecanoylphorbol-13-acetate (TPA) for the duration of the assay. The EM fields alone had no effect on cell survival or induction of neoplastic transformation. However, enhancement of transformation due to EM fields plus TPA was highly significant and ranged up to a level equivalent to that produced by 1.5 Gy of X rays. The frequency of neoplastic transformation was dependent on the level of EM exposure and was additive with doses of X rays given as a cocarcinogen.

Balci M, Devrim E, Durak I. Effects of mobile phones on oxidant/antioxidant balance in cornea and lens of rats. Curr Eye Res. 32(1):21-25, 2007.

Purpose: To investigate the effects of mobile-phone-emitted radiation on the oxidant/antioxidant balance in corneal and lens tissues and to observe any protective effects of vitamin C in this setting. Methods: Forty female albino Wistar rats were assigned to one of four groups containing 10 rats each. One group received a standardized daily dose of mobile phone radiation for 4 weeks. The second group received this same treatment along with a daily oral dose of vitamin C (250 mg/kg). The third group received this dose of vitamin C alone, while the fourth group received standard laboratory care and served as a control. In corneal and lens tissues, malondialdehyde (MDA) levels and activities of superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and catalase (CAT) were measured with spectrophotometric methods. Results: In corneal tissue, MDA level and CAT activity significantly increased in the mobile phone group compared with the mobile phone plus vitamin C group and the control group ($p < 0.05$), whereas SOD activity was significantly decreased ($p < 0.05$). In the lens tissues, only the MDA level significantly increased in the mobile phone group relative to mobile phone plus vitamin C group and the control groups ($p < 0.05$). In lens tissue, significant differences were not found between the groups in terms of SOD, GSH-Px, or CAT ($p > 0.05$). Conclusions: The results of this study suggest that mobile telephone radiation leads to oxidative stress in corneal and lens tissues and that antioxidants such as vitamin C can help to prevent these effects

Balci M, Namuslu M, Devrim E, Durak I. Effects of computer monitor-emitted radiation on oxidant/antioxidant balance in cornea and lens from rats. Mol Vis. 15:2521-2525, 2009.

PURPOSE: This study aims to investigate the possible effects of computer monitor-emitted radiation on the oxidant/antioxidant balance in corneal and lens tissues and to observe any protective effects of vitamin C (vit C). METHODS: Four groups (PC monitor, PC monitor plus vitamin C, vitamin C, and control) each consisting of ten Wistar rats were studied. The study lasted for three weeks. Vitamin C was administered in oral doses of 250 mg/kg/day. The computer and computer plus vitamin C groups were exposed to computer monitors while the other groups were not. Malondialdehyde (MDA) levels and superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and catalase (CAT) activities were measured in corneal and lens tissues of the rats. RESULTS: In corneal tissue, MDA levels and CAT activity were found to increase in the computer group compared with the control group. In the computer plus vitamin C group, MDA level, SOD, and GSH-Px activities were higher and CAT activity lower than those in the computer and control groups. Regarding lens tissue, in the computer group, MDA levels and GSH-Px activity were found to increase, as compared to the control and computer plus vitamin C groups, and SOD activity was higher than that of the control group. In the computer plus vitamin C group, SOD activity was found to be higher and CAT activity to be lower than those in the control group. CONCLUSION: The results of this study suggest that computer-monitor radiation leads to oxidative stress in the corneal and lens tissues, and that vitamin C may prevent oxidative effects in the lens.

Baliatsas C, van Kamp I, Kelfkens G, Schipper M, Bolte J, Yzermans J, Lebret E. Non-specific physical symptoms in relation to actual and perceived proximity to mobile phone base stations and powerlines. BMC Public Health. 11:421, 2011.

BACKGROUND: Evidence about a possible causal relationship between non-specific physical symptoms (NSPS) and exposure to electromagnetic fields (EMF) emitted by sources such as mobile phone base stations (BS) and powerlines is insufficient. So far little epidemiological research has been published on the contribution of psychological components to the occurrence of EMF-related NSPS. The prior objective of the current study is to explore the relative importance of actual and perceived proximity to base stations and psychological components as determinants of NSPS, adjusting for demographic, residency and area characteristics. METHODS: Analysis was performed on data obtained in a cross-sectional study on environment and health in 2006 in the

Netherlands. In the current study, 3611 adult respondents (response rate: 37%) in twenty-two Dutch residential areas completed a questionnaire. Self-reported instruments included a symptom checklist and assessment of environmental and psychological characteristics. The computation of the distance between household addresses and location of base stations and powerlines was based on geo-coding. Multilevel regression models were used to test the hypotheses regarding the determinants related to the occurrence of NSPS. RESULTS: After adjustment for demographic and residential characteristics, analyses yielded a number of statistically significant associations: Increased report of NSPS was predominantly predicted by higher levels of self-reported environmental sensitivity; perceived proximity to base stations and powerlines, lower perceived control and increased avoidance (coping) behavior were also associated with NSPS. A trend towards a moderator effect of perceived environmental sensitivity on the relation between perceived proximity to BS and NSPS was verified (p = 0.055). There was no significant association between symptom occurrence and actual distance to BS or powerlines. CONCLUSIONS: Perceived proximity to BS, psychological components and socio-demographic characteristics are associated with the report of symptomatology. Actual distance to the EMF source did not show up as determinant of NSPS.

Baliatsas C, Van Kamp I, Lebret E, Rubin GJ. Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF): A systematic review of identifying criteria. BMC Public Health. 2012 Aug 11;12:643. doi: 10.1186/1471-2458-12-643.

BACKGROUND: Idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF) remains a complex and unclear phenomenon, often characterized by the report of various, non-specific physical symptoms (NSPS) when an EMF source is present or perceived by the individual. The lack of validated criteria for defining and assessing IEI-EMF affects the quality of the relevant research, hindering not only the comparison or integration of study findings, but also the identification and management of patients by health care providers. The objective of this review was to evaluate and summarize the criteria that previous studies employed to identify IEI-EMF participants. METHODS: An extensive literature search was performed for studies published up to June 2011. We searched EMBASE, Medline, Psychinfo, Scopus and Web of Science. Additionally, citation analyses were performed for key papers, reference sections of relevant papers were searched, conference proceedings were examined and a literature database held by the Mobile Phones Research Unit of King's College London was reviewed. RESULTS: Sixty-three studies were included. "Hypersensitivity to EMF" was the most frequently used descriptive term. Despite heterogeneity, the criteria predominantly used to identify IEI-EMF individuals were: 1. Self-report of being (hyper)sensitive to EMF. 2. Attribution of NSPS to at least one EMF source. 3. Absence of medical or psychiatric/psychological disorder capable of accounting for these symptoms 4. Symptoms should occur soon (up to 24 hours) after the individual perceives an exposure source or exposed area. (Hyper)sensitivity to EMF was either generalized (attribution to various EMF sources) or source-specific. Experimental studies used a larger number of criteria than those of observational design and performed more frequently a medical examination or interview as prerequisite for inclusion. CONCLUSIONS: Considerable heterogeneity exists in the criteria used by the researchers to identify IEI-EMF, due to explicit differences in their conceptual frameworks. Further work is required to produce consensus criteria not only for research purposes but also for use in clinical practice. This could be achieved by the development of an international protocol enabling a clearly defined case definition for IEI-EMF and a validated screening tool, with active involvement of medical practitioners.

Balik HH, Turgut-Balik D, Balikci K, Ozcan IC. Some ocular symptoms and sensations experienced by long term users of mobile phones. Pathol Biol (Paris). 53(2):88-91, 2005.

In this study, a survey was conducted to investigate the possible effects of long term usage of mobile phone (MP) on eyes. The studied symptoms are blurring of vision, redness on the eyes, vision disturbance, secretion of the eyes, inflammation in the eyes and lacrimation of the eyes. There is no effect on redness on the eyes and vision disturbance, but some statistical evidences are found that MP may cause blurring of vision, secretion of the eyes, inflammation in the eyes and lacrimation of the eyes. These results suggest an awareness of the symptoms and sensations.

Balikci K, Cem Ozcan I, Turgut-Balik D, Balik HH. A survey study on some neurological symptoms and sensations experienced by long term users of mobile phones. Pathol Biol (Paris). 53(1):30-34, 2005.

A survey study was conducted to investigate the possible effects of mobile phone on headache, dizziness, extreme irritation, shaking in the hands, speaking falteringly, forgetfulness, neuro-psychological discomfort, increase in the carelessness, decrease of the reflex and clicking sound in the ears. There is no effect on dizziness, shaking in hands, speaking falteringly and neuro-psychological discomfort, but some statistical evidences are found that mobile phone may cause headache, extreme irritation, increase in the carelessness, forgetfulness, decrease of the reflex and clicking sound in the ears.

Balmori A. Mobile Phone Mast Effects on Common Frog (Rana temporaria) Tadpoles: The City Turned into a Laboratory. Electromagn Biol Med. 29(1-2):31-35, 2010.

An experiment has been made exposing eggs and tadpoles of the common frog (Rana temporaria) to electromagnetic radiation from several mobile (cell) phone antennae located at a distance of 140 meters. The experiment lasted two months, from the egg phase until an advanced phase of tadpole prior to metamorphosis. Measurements of electric field intensity (radiofrequencies and microwaves) in V/m obtained with three different devices were 1.8 to 3.5 V/m. In the exposed group (n = 70), low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) was observed. Regarding the control group (n = 70) under the same conditions but inside a Faraday cage, the coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained. These results indicate that radiation emitted by phone masts in a real situation may affect the development and may cause an increase in mortality of exposed tadpoles. This research may have huge implications for the natural world, which is now exposed to high microwave radiation levels from a multitude of phone masts.

Balode, Z, Assessment of radio-frequency electromagnetic radiation by the micronucleus test in bovine peripheral erythrocytes. Sci Total Environ 180(1):81-85, 1996.

Previous bioindicative studies in the Skrunda Radio Location Station area have focused on the somatic influence of electromagnetic radiation on plants, but it is also important to study genetic effects. We have chosen cows as test animals for cytogenetical evaluation because they live in the same general exposure area as humans, are confined to specific locations and are chronically exposed to radiation. Blood samples were obtained from female Latvian Brown cows from a farm close to and in front of the Skrunda Radar and from cows in a control area. A simplified alternative to the Schiff method of DNA staining for identification of micronuclei in peripheral erythrocytes was applied. Microscopically, micronuclei in peripheral blood erythrocytes were round in shape and exhibited a strong red colour. They are easily detectable as the only coloured bodies in the uncoloured erythrocytes. From each individual animal 2000 erythrocytes were examined at a magnification of x 1000 for the presence of micronuclei. The counting of micronuclei in peripheral erythrocytes gave low average incidences, 0.6 per 1000 in the exposed group and 0.1 per 1000 in the control, but statistically significant (P < 0.01) differences were found in the frequency distribution between the control and exposed groups.

Bamiou DE, Ceranic B, Cox R, Watt H, Chadwick P, Luxon LM. Mobile telephone use effects on peripheral audiovestibular function: A case-control study. Bioelectromagnetics.29(2):108-117,2008.

Low level radio-frequency (RF) signals may produce disorientation, headache and nausea. This double blind study tested nine case-subjects, who complained of various symptoms after prolonged mobile telephone use and 21 control subjects. Each subject underwent a series of trials, in which a dummy mobile telephone exposure system was held to each ear for 30 min in (a) pulsed, (b) continuous RF emission or, (c) no emission test modes. In the active pulsed and continuous modes the same mean power as the output of a typical handset was delivered at a carrier frequency of 882 MHz and at a maximum specific absorption rate (SAR) value of 1.3 W kg(-1) (+/- 30%). In Experiment I (auditory), transient evoked otoacoustic emissions (TEOAE), which assess the outer hair cells in the inner ear, were conducted. In Experiment II (vestibular) the vestibulo-ocular reflex was recorded by video-oculography (VOG), at baseline and immediately post exposure. There were no significant TEOAE changes from baseline to post-exposure recording for any of the exposures and no significant differences in the TEOAEs' change from baseline to post exposure between cases and controls. The VOG did not identify any effect of the exposure on the vestibular end organ in either cases or controls. In conclusion, 30 min exposure to mobile phone RF did not show any immediate effects on vestibulocochlear function as measured by TEOAE and the VOR.

Bamiou DE, Ceranic B, Vickers D, Zamyslowska-Szmytke E, Cox R, Chadwick P, Luxon LM. Mobile telephone use effects on perception of verticality. Bioelectromagnetics. 2014 Sep 26. doi: 10.1002/bem.21877. [Epub ahead of print]

Low-level radiofrequency (RF) signals may produce disorientation and nausea. In experiment I, we assessed mobile phone effects on graviception in nine symptomatic subjects after mobile telephone use and 21 controls. The mobile handset was strapped to each ear for 30 min in pulsed emission, continuous RF emission, or no emission test mode, respectively. The subjective visual vertical and horizontal (SVV/SVH) were tested from min 25 of exposure. There was no exposure effect; however, there was an ear effect, with the SVV/SVH being shifted to the opposite direction of the ear exposed. This could be due to thermal or RF effects or handset weight. In experiment II, we assessed the handset weight effect on 18 normal controls. After baseline SVV/SVH, the switched off handset was strapped to either ear; the SVV/SVH was repeated 25 min later. A significant ear effect was found. We compared the observed ear effect SVV/SVH change in the experiment II group to the continuous exposure ear effect change in the experiment I group, and the difference was not significant. The ear effect was attributed to a minor head tilt due to the handset weight, or proprioceptive stimulation of neck muscle affecting the perception of verticality.

Banaceur S, Banasr S, Sakly M, Abdelmelek H. Whole body exposure to 2.4 GHz WIFI signals: effects on cognitive impairment in adult triple transgenic mouse models of Alzheimer's disease (3xTg-AD). Behav Brain Res. 240:197-201, 2013.

The present investigation aimed at evaluating the effects of long-term exposure to WIFI type radiofrequency (RF) signals (2.40 GHz), two hours per day during one month at a Specific Absorption Rate (SAR) of 1.60 W/kg. The effects of RF exposure were studied on wildtype mice and triple transgenic mice (3xTg-AD) destined to develop Alzheimer's-like cognitive impairment. Mice were divided into four groups: two sham groups (WT, TG; n=7) and two exposed groups (WTS, TGS; n=7). The cognitive interference task used in this study was designed from an analogous human cognitive interference task including the Flex field activity system test, the two-compartment box test and the Barnes maze test. Our data demonstrate for the first time that RF improves cognitive behavior of 3xTg-AD mice. We conclude that RF exposure may represent an effective memory-enhancing approach in Alzheimer's disease.

Banerjee S, Singh NN, Sreedhar G, Mukherjee S. Analysis of the Genotoxic Effects of Mobile Phone Radiation using Buccal Micronucleus Assay: A Comparative Evaluation. J Clin Diagn Res. 2016 Mar;10(3):ZC82-5. doi: 10.7860/JCDR/2016/17592.7505. Epub 2016 Mar 1.

INTRODUCTION: Micronucleus (MN) is considered to be a reliable marker for genotoxic damage and it determines the presence and the extent of the chromosomal damage. The MN is formed due to DNA damage or chromosomal disarrangements. The MN has a close association with cancer incidences. In the new era, mobile phones are constantly gaining popularity specifically in the young generation, but this device uses radiofrequency radiation that may have a possible carcinogenic effect. The available reports related to the carcinogenic effect of mobile radiation on oral mucosa are contradictory. AIM: To explore the effects of mobile phone radiation on the MN frequency in oral mucosal cells. MATERIALS AND METHODS: The subjects were divided into two major groups: low mobile phone users and high mobile phone users. Subjects who used their mobile phone since less than five years and less than three hours a week comprised of the first group and those who used their mobile since more than five years and more than 10 hours a week comprised of the second group. Net surfing and text messaging was not considered in this study. Exfoliated buccal mucosal cells were collected from both the groups and the cells were stained with DNA-specific stain acridine orange. Thousand exfoliated buccal mucosal cells were screened and the cells which were positive for micronuclei were counted. The micronucleus frequency was represented as mean±SD, and unpaired Student t-test was used for intergroup comparisons. RESULTS: The number of micronucleated cells/ 1000 exfoliated buccal mucosal cells was found to be significantly increased in high mobile phone users group than the low mobile phone users group. The use of mobile phone with the associated complaint of warmth around the ear showed a maximum increase in the number of micronucleated cells /1000 exfoliated buccal mucosal cells. CONCLUSION: Mobile phone radiation even in the permissible range when used for longer duration causes significant genotoxicity. The genotoxicity can be avoided to some extent by the regular use of headphones.

Baohong Wang, Jiliang H, Lifen J, Deqiang L, Wei Z, Jianlin L, Hongping D. Studying the synergistic damage effects induced by 1.8GHz radiofrequency field radiation (RFR) with four chemical mutagens on human lymphocyte DNA using comet assay in vitro. Mutat Res. 578(1-2):149-157, 2005.

The aim of this investigation was to study the synergistic DNA damage effects in human lymphocytes induced by 1.8GHz radiofrequency field radiation (RFR, SAR of 3W/kg) with four chemical mutagens, i.e. mitomycin C (MMC, DNA crosslinker), bleomycin (BLM, radiomimetic agent), methyl methanesulfonate (MMS, alkylating agent), and 4-nitroquinoline-1-oxide (4NQO, UV-mimetic agent). The DNA damage of lymphocytes exposed to RFR and/or with chemical mutagens was detected at two incubation time (0 or 21h) after treatment with comet assay in vitro. Three combinative exposure ways were used. Cells were exposed to RFR and chemical mutagens for 2 and 3h, respectively. Tail length (TL) and tail moment (TM) were utilized as DNA damage indexes. The results showed no difference of DNA damage indexes between RFR group and control group at 0 and 21h incubation after exposure ($P>0.05$). There were significant difference of DNA damage indexes between MMC group and RFR+MMC co-exposure group at 0 and 21h incubation after treatment ($P<0.01$). Also the significant difference of DNA damage indexes between 4NQO group and RFR+4NQO co-exposure group at 0 and 21h incubation after treatment was observed ($P<0.05$ or $P<0.01$). The DNA damage in RFR+BLM co-exposure groups and RFR+MMS co-exposure groups was not significantly increased, as compared with corresponding BLM and MMS groups ($P>0.05$). The experimental results indicated 1.8GHz RFR (SAR, 3W/kg) for 2h did not induce the human lymphocyte DNA damage effects in vitro, but could enhance the human lymphocyte DNA damage effects induced by MMC and 4NQO. The synergistic DNA damage effects of 1.8GHz RFR with BLM or MMS were not obvious.

Baohong W, Lifen J, Lanjuan L, Jianlin L, Deqiang L, Wei Z, Jiliang H. Evaluating the combinative effects on human lymphocyte DNA damage induced by ultraviolet

ray C plus 1.8GHz microwaves using comet assay in vitro. Toxicology. 232(3):311-316, 2007.

The objective of this study was to observe whether 1.8GHz microwaves (MW) (SAR, 3 W/kg) exposure can influence human lymphocyte DNA damage induced by ultraviolet ray C (UVC). The lymphocytes, which were from three young healthy donors, were exposed to 254 nm UVC at the doses of 0.25, 0.5, 0.75, 1.0, 1.5 and 2.0 J m(-2), respectively. The lymphocytes were irradiated by 1.8GHz MW (SAR, 3 W/kg) for 0, 1.5 and 4 h. The combinative exposure of UVC plus MW was conducted. The treated cells were incubated for 0, 1.5 and 4 h. Finally, comet assay was used to measure DNA damage of above treated lymphocytes. The results indicated that the difference of DNA damage induced between MW group and control group was not significant (P>0.05). The MTLs induced by UVC were 1.71+/-0.09, 2.02+/-0.08, 2.27+/-0.17, 2.27+/-0.06, 2.25+/-0.12, 2.24+/-0.11 microm, respectively, which were significantly higher than that (0.96+/-0.05 microm) of control (P<0.01). MTLs of some sub-groups in combinative exposure groups at 1.5-h incubation were significantly lower that those of corresponding UVC sub-groups (P<0.01 or P<0.05). However, MTLs of some sub-groups in combinative exposure groups at 4-h incubation were significantly higher that those of corresponding UVC sub-groups (P<0.01 or P<0.05). In this experiment it was found that 1.8GHz (SAR, 3 W/kg) MW exposure for 1.5 and 4 h did not enhance significantly human lymphocyte DNA damage, but could reduce and increase DNA damage of human lymphocytes induced by UVC at 1.5-h and 4-h incubation, respectively.

Barbaro V, Bartolini P, Donato A, Militello C, Electromagnetic interference of analog cellular telephones with pacemakers. Pacing Clin Electrophysiol 19(10):1410-1418, 1996.

The aim of this study was to verify whether there is a public health risk from the interference of analog cellular telephones with pacemakers. We used a human trunk simulator to reproduce an actual implant, and two cellular telephones working with the TACS (Total Access Communication System) standard. Results showed that the electromagnetic field radiated from the analog cellular telephones interfered with a large number of the pacemakers tested (10/25). When the telephone antenna was in close proximity to the pacemaker head, pacemaker desensitizing and sensitizing and pulse inhibition was detected at the moment of an incoming call and throughout ringing. In the worst case of pulse inhibition, the pacemaker skipped three nonconsecutive beats and then resumed its normal pacing, while the desensitizing and sensitizing phenomena persisted as long as the interfering signal was on. Pulse inhibition was also observed when the connection did not succeed. Maximum sensing threshold variation was about 186% (increase) and 62% (decrease) for desensitizing and sensitizing phenomena, respectively. It was also demonstrated that the signal emitted by analog cellular telephones during the crossing of contiguous cells could induce pacemaker pulse inhibition, but under our experimental conditions this event did not seem to pose a risk for the pacemaker patient.

Barcal J, Cendelín J, Vozeh F, Zalud V. Effect of whole-body exposure to high-

frequency electromagnetic field on the brain electrogeny in neurodefective and healthy mice. Prague Med Rep. 106(1):91-100, 2005.

A direct registration of brain cortical and hippocampal activity during a high-frequency electromagnetic field (HF EMF) exposure was performed. All experimental procedures were done under urethane anaesthesia (20%, 2 g/kg i.p.) in Lurcher mutant mice, wild type (healthy littermates) were used as controls. Experimental animals were exposed to the HF EMF with frequency corresponding to cellular phones. Our method is based on the use of gel electrodes (silicon tubes or glass microcapillaries filled with agar) where the connection with classical electrodes is located out of HF EMF space. ECoG evaluation showed a distinct shift to lower frequency components but clear effect has been observed only in wild type (healthy) mice whereas in Lurcher mutant mice only gentle differences between frequency spectra were found. Measurement of hippocampal rhythmicity showed gentle changes with increase of higher frequencies (i.e. opposite effect than in cortex) and changes in theta oscillations registered from a dentate gyrus and CA1 area in both types of animals (healthy and mutant). These findings support the idea about possible influencing the central nervous system by HF EMF exposure and support also some recent results about possible health risks resulting from cellular phones use.

Barcal J, Vozeh F. Effect of whole-body exposure to high-frequency electromagnetic field on the brain cortical and hippocampal activity in mouse experimental model. NeuroQuantology 5:292-302, 2007.

Evaluation of the direct registration of brain cortical and hippocampal activity during a high-frequency electromagnetic field (HF-EMF) exposure was performed. Experimental procedures were done under general anesthesia (urethane, 20%, 2g/kg i.p.) in Lurcher mutant mice, wild type (healthy littermates) were used as controls. Animals were exposed to the HF-EMF with frequency corresponding to cellular phones (900 MHz). We used of gel electrodes (silicon tubes or glass microcapillary filled with agar) where the connection with classical electrodes was located out of HF-EMF space. ECoG evaluation showed a distinct shift to lower frequency components but clear effect has been observed only in wild type (healthy) mice whereas in Lurcher mutant mice only gentle differences between frequency spectra were found. Measurement of hippocampal rhythmicity showed gentle changes with increase of higher frequencies (i.e. opposite effect than in cortex) and changes in theta oscillations registered from a dentate gyrus and CA1 area in both types of animals (healthy and mutant). These findings support an idea about possible influencing the central nervous system by HF-EMF exposure and support also some recent results about possible health risks resulting from cellular phones use.

Barkana Y, Zadok D, Morad Y, Avni I. Visual field attention is reduced by concomitant hands-free conversation on a cellular telephone. Am J Ophthalmol. 138(3):347-353, 2004.

PURPOSE: To quantify the central attention-diverting effect of hands-free cellular phone conversation on visual field awareness. DESIGN: Experimental study. METHODS: Twenty male and 21 female healthy participants performed a pretest and baseline

Esterman visual field examinations with the Humphrey Systems Visual Field Analyzer II. During the consequent third examination, each participant engaged in a hands-free conversation using a cellular phone. The conversation was the same for all participants. Visual field performance parameters were compared between the second (baseline) examination, and the third (test) examination for each eye. RESULTS: During phone conversation, missed points increased from mean 1.0 +/- 1.5 to 2.6 +/- 3.4 (P <==.001) in the right eye and from 1.1 +/- 1.53 to 3.0 +/- 3.4 (P <.001) in the left eye. Fixation loss increased from mean 7.8% to 27.4% (P <.0001) and from 7.2% to 34.8% (P <.0001) for the right and left eyes, respectively. Test duration increased by a mean of 0.28 seconds (15%) per stimulus (P <.0001). Approximately half of missed points were inside the central 30 degrees. There was no significant difference in the performance of male and female participants. CONCLUSION: We describe a new model for the quantification of the attention-diverting effect of cellular-phone conversation on the visual field. In the current study, cellular hands-free conversation caused some subjects to miss significantly more points, react slower to each stimulus, and perform with reduced precision. Legislative restrictions on concomitant cellular-phone conversation and driving may need to be based on individual performance rather than a general ban on cellular phone usage.

Barker AT, Jackson PR, Parry H, Coulton LA, Cook GG, Wood SM. The effect of GSM and TETRA mobile handset signals on blood pressure, catechol levels and heart rate variability. Bioelectromagnetics.28(6):433-438, 2007.

An acute rise in blood pressure has been reported in normal volunteers during exposure to signals from a mobile phone handset. To investigate this finding further we carried out a double blind study in 120 healthy volunteers (43 men, 77 women) in whom we measured mean arterial pressure (MAP) during each of six exposure sessions. At each session subjects were exposed to one of six different radio frequency signals simulating both GSM and TETRA handsets in different transmission modes. Blood catechols before and after exposure, heart rate variability during exposure, and post exposure 24 h ambulatory blood pressure were also studied. Despite having the power to detect changes in MAP of less than 1 mmHg none of our measurements showed any effect which we could attribute to radio frequency exposure. We found a single statistically significant decrease of 0.7 mmHg (95% CI 0.3-1.2 mmHg, P = .04) with exposure to GSM handsets in sham mode. This may be due to a slight increase in operating temperature of the handsets when in this mode. Hence our results have not confirmed the original findings of an acute rise in blood pressure due to exposure to mobile phone handset signals. In light of this negative finding from a large study, coupled with two smaller GSM studies which have also proved negative, we are of the view that further studies of acute changes in blood pressure due to GSM and TETRA handsets are not required.

Barteri M, Pala A, Rotella S. Structural and kinetic effects of mobile phone microwaves on acetylcholinesterase activity. Biophys Chem. 113(3):245-253, 2005.

The present study provides evidence that "in vitro" simple exposure of an aqueous solution of electric eel acetylcholinesterase (EeAChE; EC 3.1.1.7.) to cellular phone emission alters its enzymatic activity. This paper demonstrates, by combining different experimental techniques, that radio frequency (RF) radiations irreversibly affect the structural and biochemical characteristics of an important CNS enzyme. These results were obtained by using a commercial cellular phone to reproduce the reality of the human exposition. This experimental procedure provided surprising effects collected practically without experimental errors because they were obtained comparing native and irradiated sample of the same enzyme solution. Although these results cannot be used to conclude whether exposure to RF during the use of cellular phone can lead to any hazardous health effect, they may be a significant first step towards further verification of these effects on other "ex vivo" or "in vivo" biological systems.

Barteri M, De Carolis R, Marinelli F, Tomassetti G, Montemiglio LC. Effects of microwaves (900 MHz) on peroxidase systems: a comparison between lactoperoxidase and horseradish peroxidase. Electromagn Biol Med. 2015 Jan 12:1-7. [Epub ahead of print]

This work shows the effects of exposure to an electromagnetic field at 900 MHz on the catalytic activity of the enzymes lactoperoxidase (LPO) and horseradish peroxidase (HRP). Experimental evidence that irradiation causes conformational changes of the active sites and influences the formation and stability of the intermediate free radicals is documented by measurements of enzyme kinetics, circular dichroism spectroscopy (CD) and cyclic voltammetry.

Barth A, Winker R, Ponocny-Seliger E, Mayrhofer W, Ponocny I, Sauter C, Vana N. A meta-analysis for neurobehavioral effects due to electromagnetic field exposure emitted by GSM mobile phones. Occup Environ Med.65(5):342-6, 2008.

BACKGROUND AND OBJECTIVE: Numerous studies have investigated the potential effects of electromagnetic fields (EMFs) emitted by GSM mobile phones (~900 MHz to ~1800 MHz) on cognitive functioning, but results have been equivocal. In order to try and clarify this issue, the current study carried out a meta-analysis on nineteen experimental studies. DESIGN: meta-analysis METHODS: Nineteen studies were taken into consideration. Ten of them were included in the meta-analysis as they fulfil several minimum requirements; for example, single-blind or double-blind experimental study design and documentation of means and standard deviation of the dependent variables. The meta-analysis aimed at comparing exposed with non-exposed subjects assuming that there is a common population effect so that one single effect size could be calculated. When homogeneity for single effect sizes was not given, an own population effect for each study and a distribution of population effects was assumed. RESULTS: Attention measured by the subtraction task seems to be affected in regard of decreased reaction time. Working memory measured by the N-back test seems to by affected too: Under condition 0-back target response time is lower under exposure, while under condition 2-back target response time increases. The number of errors under condition 2-back non-targets appears to be higher under exposure. CONCLUSION: Results of the meta-analysis suggest that EMFs may have a small impact on human attention and working memory.

Barthélémy A, Mouchard A, Bouji M, Blazy K, Puigsegur R, Villégier AS. Glial markers and emotional memory in rats following acute cerebral radiofrequency exposures. Environ Sci Pollut Res Int. 2016 Sep 30. [Epub ahead of print]

The widespread mobile phone use raises concerns on the possible cerebral effects of radiofrequency electromagnetic fields (RF EMF). Reactive astrogliosis was reported in neuroanatomical structures of adaptive behaviors after a single RF EMF exposure at high specific absorption rate (SAR, 6 W/kg). Here, we aimed to assess if neuronal injury and functional impairments were related to high SAR-induced astrogliosis. In addition, the level of beta amyloid 1-40 (Aβ 1-40) peptide was explored as a possible toxicity marker. Sprague Dawley male rats were exposed for 15 min at 0, 1.5, or 6 W/kg or for 45 min at 6 W/kg. Memory, emotionality, and locomotion were tested in the fear conditioning, the elevated plus maze, and the open field. Glial fibrillary acidic protein (GFAP, total and cytosolic fractions), myelin basic protein (MBP), and Aβ1-40 were quantified in six brain areas using enzyme-linked immunosorbent assay. According to our data, total GFAP was increased in the striatum (+114 %) at 1.5 W/kg. Long-term memory was reduced, and cytosolic GFAP was increased in the hippocampus (+119 %) and in the olfactory bulb (+46 %) at 6 W/kg (15 min). No MBP or Aβ1-40 expression modification was shown. Our data corroborates previous studies indicating RF EMF-induced astrogliosis. This study suggests that RF EMF-induced astrogliosis had functional consequences on memory but did not demonstrate that it was secondary to neuronal damage.

Bartsch H, Bartsch C, Seebald E, Deerberg F, Dietz K, Vollrath L, Mecke D. Chronic Exposure to a GSM-like Signal (Mobile Phone) Does Not Stimulate the Development of DMBA-Induced Mammary Tumors in Rats: Results of Three Consecutive Studies. Radiat Res 157(2):183-190, 2002.

Certain epidemiological and experimental studies raised concerns about the safety of radiofrequency (RF) electromagnetic fields because of a possible increased risk of leukemia and lymphoma. In this study, an RF field used in mobile telecommunication was tested using 7,12-dimethylbenz[a]anthracene (DMBA)-induced mammary tumors in female Sprague-Dawley rats as a model for human breast cancer. Three experiments were carried out under strictly standardized conditions and were started on the same day of three consecutive years. The field consisted of a GSM-like signal (900 MHz pulsed at 217 Hz, pulse width 577 [mu]s) of relatively low power flux density (100 [mu]W/cm(2) [plus minus] 3 dB) and was applied continuously throughout each experiment to freely moving animals. The specific absorption rates averaged over the whole body were 17.5--70 mW/kg. The highest values in young animals were at or around the exposure limit permissible for the general public (i.e. 80 mW/kg). The animals were palpated weekly for the presence of mammary tumors and were killed humanely when tumors reached a diameter of 1--2 cm to allow a reliable histopathological classification and a distinction between malignant and benign subtypes. The overall results of the three studies are that there was no statistically significant effect of RF-field exposure on tumor latency and that the cumulative tumor incidence at the end of the experiment was unaffected as well. The risk ratios were 1.08 (95% CI: 0.91--1.29) and 0.96 (95% CI: 0.85--1.07) for benign and malignant tumors, respectively. These observations are in agreement with other published findings. In the first experiment, however, the median latency for the development of the first malignant tumor in each animal was statistically significantly extended for RF-field-exposed animals compared to controls (278 days compared to 145 days, P = 0.009). No such differences were detected in the two subsequent experiments. These results show that low-level RF radiation does not appear to possess carcinogenic or cancer-promoting effects on DMBA-induced mammary tumors. To explain the mechanisms underlying the different results obtained in the three experiments, a hypothesis is presented which is based upon the neuroendocrine control mechanisms involved in the promotion of DMBA-induced mammary tumors. Despite the apparent absence of stimulatory effects of low-level RF-field exposure on the development and growth of solid tumors, it will be necessary to verify these results for leukemias and lymphomas, which may have completely different biological control mechanisms.

Bartsch H, Küpper H, Scheurlen U, Deerberg F, Seebald E, Dietz K, Mecke D, Probst H, Stehle T, Bartsch C. Effect of chronic exposure to a GSM-like signal (mobile phone) on survival of female Sprague-Dawley rats: Modulatory effects by month of birth and possibly stage of the solar cycle. Neuro Endocrinol Lett. 31(4):457-473, 2010.

During 1997-2008 two long-term (I and II) and two life-long (III and IV) experiments were performed analyzing the effect of chronic exposure to a low-intensity GSM-like signal (900 MHz pulsed with 217 Hz, 100 microW/cm(2) average power flux density, 38-80 mW/kg mean specific absorption rate for whole body) on health and survival of unrestrained female Sprague-Dawley rats kept under identical conditions. Radiofrequency (RF)-exposure was started at 52-70 days of age and continued for 24 (I), 17 (II) and up to 36 and 37 months, respectively (III/IV). In the first two experiments (1997-2000) 12 exposed and 12 sham-exposed animals each were observed until they were maximally 770 or 580 days old. In experiment I no adverse health effects of chronic RF-exposure were detectable, neither by macroscopic nor detailed microscopic pathological examinations. Also in experiment II no apparent macroscopic pathological changes due to treatment were apparent. Median survival time could not be estimated since in none of the groups more than 50% of the animals had died. In the course of two complete survival experiments (2002-2005; 2005-2008) 30 RF- and 30 sham-exposed animals each were followed up until their natural end or when they became moribund and had to be euthanized. A synoptical data analysis was performed. Survival data of all four groups could be fitted well by the Weibull distribution. According to this analysis median survival was significantly shortened under RF-exposure in both experiments by 9.06% (95% CI 2.7 to 15.0%) (p=0.0064); i.e by 72 days in experiment III and 77 days in experiment IV as compared to the corresponding sham-treated animals (III: 799 days; IV: 852 days). Both groups of animals of experiment III showed reduced median survival times by 6.25% (95% CI -0.3 to 12.4%) (p=0.0604) compared to the corresponding groups of experiment IV (53 days: sham-exposed animals, 48 days: RF-exposed animals) which may be due to the fact that animals of experiment III were born in October and animals of experiment IV in May indicating that the month of birth affects life span. From the results of the last two experiments it has to be concluded that chronic exposure to a low-intensity GSM-like signal may exert negative health effects and shorten survival if treatment is applied sufficiently long and the observational period covers the full life span of the animals concerned. The current data show that survival of rats kept under controlled laboratory conditions varies within certain limits depending on the month of birth. In view of our previous observations regarding an inhibitory or no effect of RF-exposure on DMBA-induced mammary cancer during the 1997-2000 period, an additional modulatory influence on a year-to-year basis should be considered which might be related to changing solar activity during the the 11-years' sunspot cycle. These potentially complex influences of the natural environment modulating the effects of anthropogenic RF-signals on health and survival require a systematic continuation of such experiments throughout solar cycle 24 which started in 2009.

Bas O, Odaci E, Kaplan S, Acer N, Ucok K, Colakoglu S. 900 MHz electromagnetic field exposure affects qualitative and quantitative features of hippocampal pyramidal cells in the adult female rat. Brain Res. 1265:178-185, 2009.

The effects of electromagnetic fields (EMFs) emitted by mobile phones on humans hold special interest due to their use in close proximity to the brain. The current study investigated the number of pyramidal cells in the cornu ammonis (CA) of the 16-week-old female rat hippocampus following postnatal exposure to a 900 megahertz (MHz) EMF. In this study were three groups of 6 rats: control (Cont), sham exposed (Sham), and EMF exposed (EMF). EMF group rats were exposed to 900 MHz EMF (1 h/day for 28 days) in an exposure tube. Sham group was placed in the exposure tube but not exposed to EMF (1 h/day for 28 days). Cont group was not placed into the exposure tube nor were they exposed to EMF during the study period. In EMF group rats, the specific energy absorption rate (SAR) varied between 0.016 (whole body) and 2 W/kg (locally in the head). All of the rats were sacrificed at the end of the experiment and the number of pyramidal cells in the CA was estimated using the optical fractionator technique. Histopathological evaluations were made on sections of the CA region of the hippocampus. Results showed that postnatal EMF exposure caused a significant decrease of the pyramidal cell number in the CA of the EMF group ($P<0.05$). Additionally, cell loss can be seen in the CA region of EMF group even at qualitative observation. These results may encourage researchers to evaluate the chronic effects of 900 MHz EMF on teenagers' brains.

Bassen HI, Moore HJ, Ruggera PS, Cellular phone interference testing of implantable cardiac defibrillators in vitro. Pacing Clin Electrophysiol 21(9):1709-1715, 1998.

An in vitro study was undertaken to investigate the potential for cellular telephones to nterfere with representative models of presently used ICDs. Digital cellular phones (DCPs) generate strong, amplitude modulated fields with pulse repetition rates near the physiological range sensed by the ICD as an arrhythmia. DCPs with Time Division Multiple Access (TDMA) pulsed amplitude modulation caused the most pronounced effect--high voltage firing or inhibition of pacing output of the ICDs. This electromagnetic interference (EMI) occurred only when the phones were within 2.3-5.8 cm of the ICD pulse generator that was submerged 0.5 cm in 0.18% saline. ICD performance always reverted to baseline when the cellular phones were removed from the immediate proximity of the ICD. Three models of ICDs were subjected to EMI susceptibility testing using two types of digital phones and one analog cellular phone, each operating at their respective maximum output power. EMI was observed in varying degrees from all DCPs. Inhibition of pacer output occurred in one ICD, and high voltage firing occurred in the two other ICDs, when a TDMA-11 Hz DCP was placed within 2.3 cm of the ICD. For the ICD that was most sensitive to delivering unintended therapy, inhibition followed by firing occurred at distances up to 5.8 cm. When a TDMA-50 Hz phone was placed at the minimum test distance of 2.3 cm, inhibition followed by firing was observed in one of the ICDs. EMI occurred most frequently when the lower portion of the monopole antenna of the cellular phone was placed over the ICD header.

Baste V, Riise T, Moen BE. Radiofrequency electromagnetic fields; male infertility and sex ratio of offspring. Eur J Epidemiol.23(5):369-377,2008.

Concern is growing about exposure to electromagnetic fields and male reproductive health. The authors performed a cross-sectional study among military men employed in the Royal Norwegian Navy, including information about work close to equipment emitting radiofrequency electromagnetic fields, one-year infertility, children and sex of the offspring. Among 10,497 respondents, 22% had worked close to high-frequency aerials to a "high" or "very high" degree. Infertility increased significantly along with increasing self-reported exposure to radiofrequency electromagnetic fields. In a logistic regression, odds ratio (OR) for infertility among those who had worked closer than 10 m from high-frequency aerials to a "very high" degree relative to those who reported no work near high-frequency aerials was 1.86 (95% confidence interval (CI): 1.46-2.37), adjusted for age, smoking habits, alcohol consumption and exposure to organic solvents, welding and lead. Similar adjusted OR for those exposed to a "high", "some" and "low" degree were 1.93 (95% CI: 1.55-2.40), 1.52 (95% CI: 1.25-1.84), and 1.39 (95% CI: 1.15-1.68), respectively. In all age groups there were significant linear trends with higher prevalence of involuntary childlessness with higher self-reported exposure to radiofrequency fields. However, the degree of exposure to radiofrequency radiation and the number of children were not associated. For self-reported exposure both to high-frequency aerials and communication equipment there were significant linear trends with lower ratio of boys to girls at birth when the father reported a higher degree of radiofrequency electromagnetic exposure.

Baste V, Mild KH, Moen BE. Radiofrequency exposure on fast patrol boats in the Royal Norwegian Navy--an approach to a dose assessment. Bioelectromagnetics. 31(5):350-360, 2010.

Epidemiological studies related to radiofrequency (RF) electromagnetic fields (EMF) have mainly used crude proxies for exposure, such as job titles, distance to, or use of different equipment emitting RF EMF. The Royal Norwegian Navy (RNoN) has measured RF field emitted from high-frequency antennas and radars on several spots where the crew would most likely be located aboard fast patrol boats (FPB). These boats are small, with short distance between the crew and the equipment emitting RF field. We have described the measured RF exposure aboard FPB and suggested different methods for calculations of total exposure and annual dose. Linear and spatial average in addition to percentage of ICNIRP and squared deviation of ICNIRP has been used. The methods will form the basis of a job exposure matrix where relative differences in exposure between groups of crew members can be used in further epidemiological studies of reproductive health.

Baste V, Moen BE, Oftedal G, Strand LA, Bjørge L, Mild KH. Pregnancy Outcomes After Paternal Radiofrequency Field Exposure Aboard Fast Patrol Boats. J Occup Environ Med. 54(4):431-438, 2012.

OBJECTIVES: To investigate adverse reproductive outcomes among male employees in the Royal Norwegian Navy exposed to radiofrequency electromagnetic fields aboard fast patrol boats. METHODS: Cohort study of Royal Norwegian Navy servicemen linked to the Medical Birth Registry of Norway, including singleton offspring born between 1967 and 2008 (n = 37,920). Exposure during the last 3 months before conception (acute) and exposure more than 3 months before conception (nonacute) were analyzed. RESULTS: Perinatal mortality and preeclampsia increased after service aboard fast patrol boats during an acute period and also after increased estimated radiofrequency exposure during an acute period, compared with service aboard other vessels. No associations were found between nonacute exposure and any of the reproductive outcomes. CONCLUSIONS: Paternal work aboard fast patrol boats during an acute period was associated with perinatal mortality and preeclampsia, but the cause is not clear.

Bastide M, Youbibier-Simoa BJ, Lebecq JC, Giaimis J. Toxicologic study of electromagnetic radiation emitted by television and video display screens and cellular telephones on chickens and mice. Indoor Built Environ 10:291-298, 2001.

The effects of continuous exposure of chick embryos and young chickens to the electromagnetic fields (EMFs) emitted by video display units (VDUs) and GSM cell phone radiation, either the whole spectrum emitted or attenuated by a copper gauze, were investigated. Permanent exposure to the EMFs radiated by a VDU was associated with significantly increased fetal loss (47-68%) and markedly depressed levels of circulating specific antibodies (IgG), corticosterone and melatonin. We have also shown that under chronic exposure conditions, GSM cell phone radiation was harmful to chick embryos, stressful for healthy mice and, in this species, synergistic with cancer insofar as it depleted stress hormones. The same pathological results were observed after substan tial reduction of the microwaves radiated from the cell phone by attenuating them with a copper gauze.

Batellier F, Couty I, Picard D, Brillard JP. Effects of exposing chicken eggs to a cell phone in "call" position over the entire incubation period. Theriogenology. 69(6):737-745,2008

The aim of the present study was to assess the effects of exposing fertile chicken eggs to a cell phone repeatedly calling a ten-digit number at 3-min intervals over the entire period of incubation. A pre-experiment was performed first to adjust incubation conditions in an experimental chamber devoid of metallic content and without automatic turning until the overall performance of hatchability was reproducible in the absence of the cell phone. The experimental period consisted of a series of 4 incubations referred to as "replicates". For each replicate, one batch of 60 eggs was exposed to the immediate environment (</=25cm) of a cell phone in the "call" position (exposed group), while another batch of 60 eggs, 1.5m away from the exposed group and also in the incubation chamber, was exposed to a similar cell phone in the "off" position (sham group). For each replicate, 2 other groups each of 60 eggs were also incubated, one in a standard mini-incubator ("Control I" group) and the second in a standard medium size incubator ("Control II" group). Temperature, relative humidity and electromagnetic fields in the experimental chamber were permanently monitored over the entire experiment. A significantly higher percentage of embryo mortality was observed in the "exposed" compared to the "sham" group in 2 of the 4 replicates (p<.05). In comparison with control groups, additional embryo mortality in the exposed group occurred mainly between Days 9 and 12 of incubation but a causal relationship between the intensity of the electric field and embryo mortality could not be established.

Bayat M, Hemati S, Soleimani-Estyar R, Shahin-Jafari A. Effect of long-term exposure of mice to 900 MHz GSM radiation on experimental cutaneous candidiasis. Saudi J Biol Sci. 24(4):907-914, 2017.

Mobile phones communicate with base stations using 900 MHz microwaves. The current study was aimed to survey the effects of long-term 900 MHz microwave exposure of mice on experimentally induced cutaneous candidiasis. Forty inbred, male, BALB/c mice were randomly divided into four groups. Cutaneous lesions with *Candida albicans* were experimentally induced on the lateral-back skin of the 20 mice. One group of the diseased mice were exposed (6 h per day and 7 d per week) to 900 MHz microwave radiation, while the other groups were not exposed. Two unexposed control groups were also included. The skin lesions were regularly monitored and the live candida cell density was enumerated using the colony-forming unit (CFU) assay. The process was repeated after a one week resting interval. One week later, all mice were challenged through intra tail veins using LD_{90} dose of *C. albicans*. Mortality of the mice was recorded and the candida load of the kidney homogenates from died animals was counted. 900 MHz microwave exposed mice had 1.5 day and 3.7 day delays on wound healing in stages two. Live Candida inoculated Wave exposed (LCW) mice also showed higher yeast loads in skin lesions at days 5, 7 and 9 post inoculation. Survival analysis of live candida challenged mice showed the radiation exposed group is prone to death induced by systemic infection and candida enumeration from the kidney homogenates showed radiation exposed animals have had significantly higher yeast load in the tissue. In collection, long-term 900 MHz radiation exposure of mice led to longevity of skin wounds and susceptibility of the animals to systemic challenge and higher incidences of microorganisms in internal tissues.

Beason RC, Semm P. Responses of neurons to an amplitude-modulated microwave stimulus. Neurosci Lett 333(3):175-178, 2002.

In this study we investigated the effects of a pulsed radio frequency signal similar to the signal produced by global system for mobile communication telephones (900 MHz carrier, modulated at 217 Hz) on neurons of the avian brain. We found that such stimulation resulted in changes in the amount of neural activity by more than half of the brain cells. Most (76%) of the responding cells increased their rates of firing by an average 3.5-fold. The other responding cells exhibited a decrease in their rates of spontaneous activity Such responses indicate potential effects on humans using hand-held cellular phones.

Bedir R, Tumkaya L, Şehitoğlu İ, Kalkan Y, Yilmaz A, Şahin OZ. The effect of exposure of rats during prenatal period to radiation spreading from mobile phones on renal development. Ren Fail. 37(2):305-309, 2015.

Background: The aim of this study was to investigate the effects of exposure to a 900-MHz electromagnetic field (EMF) produced by mobile phones on the renal development of prenatal rats. Histopathological changes and apoptosis in the kidneys, together with levels of urea, creatinine and electrolyte in serum were determined. METHODS: A total of 14 Sprague-Dawley rats were studied. Pregnant rats were divided into two equal groups: a control group and an EMF-exposed group. The study group was exposed to 900-MHz of EMF during the first 20 days of pregnancy, while the control group was unexposed to EMF. Sections obtained from paraffin blocks were stained for caspase-3 by immunohistochemistry, hematoxylin-eosin and Masson's trichrome. RESULTS: Mild congestion and tubular defects, and dilatation of Bowman's capsule were observed in the kidney tissues of rats in the exposed group. Apoptosis was evaluated using anti-caspase-3; stronger positive staining was observed in the renal tubular cells in the study group than those of the control group. Although there was a significant difference between the study and control groups in terms of K(+) level ($p < 0.05$), no significant difference was observed in the other parameters studied ($p > 0.05$). CONCLUSION: Our study shows that the electromagnetic waves propagated from mobile phones have harmful effects on the renal development of prenatal rats.

Beede KE, Kass SJ. Engrossed in conversation: The impact of cell phones on simulated driving performance. Accid Anal Prev38(2):415-21, 2006.

The current study examined the effects of cognitively distracting tasks on various measures of driving performance. Thirty-six college students with a median of 6 years of driving experience completed a driving history questionnaire and four simulated driving scenarios. The distraction tasks consisted of responding to a signal detection task and engaging in a simulated cell phone conversation. Driving performance was measured in terms of four categories of behavior: traffic violations (e.g., speeding, running stop signs), driving maintenance (e.g., standard deviation of lane position), attention lapses (e.g., stops at green lights, failure to visually scan for intersection traffic), and response time (e.g., time to step on brake in response to a pop-up event). Performance was significantly impacted in all four categories when drivers were concurrently talking on a hands-free phone. Performance on the signal detection task was poor and not significantly impacted by the phone task, suggesting that considerably less attention was paid to detecting these peripheral signals. However, the signal detection task did interact with the phone task on measures of average speed, speed variability, attention lapses, and reaction time. The findings lend further empirical support of the dangers of drivers being distracted by cell phone conversations.

Beekhuizen J, Vermeulen R, Kromhout H, Bürgi A, Huss A. Geospatial modelling of electromagnetic fields from mobile phone base stations. Sci Total Environ. 2013 Jan 16;445-446C:202-209. doi: 10.1016/j.scitotenv.2012.12.020. [Epub ahead of print]

There is concern that exposure to radio frequency electromagnetic fields (RF-EMF) from mobile phone base stations might lead to adverse health effects. In order to assess potential health risks, reliable exposure assessment is necessary. Geospatial exposure modelling is a promising approach to quantify ambient exposure to RF-EMF for epidemiological studies involving large populations. We modelled RF-EMF for Amsterdam, The Netherlands by using a 3D RF-EMF model (NISMap). We subsequently compared modelled results to RF-EMF measurements in five areas with differing built-up characteristics (e.g., low-rise residential, high-rise commercial). We performed, in each area, repeated continuous measurements along a predefined ~2km long path. This mobile monitoring approach captures the high spatial variability in electric field strengths. The modelled values were in good agreement with the measurements. We found a Spearman correlation of 0.86 for GSM900 and 0.85 for UMTS between modelled and measured values. The average measured GSM900 field strength was 0.21V/m, and UMTS 0.09V/m. The model underestimated the GSM900 field strengths by 0.07V/m, and slightly overestimated the UMTS field strengths by 0.01V/m. NISMap provides a reliable way of assessing environmental RF-EMF exposure for epidemiological studies of RF-EMF and health in urban areas.

Behari J, Kunjilwar KK, and Pyne S, Interaction of low level modulated RF radiation with Na^+–K^+-ATPase. Bioelectrochem Bioenerg 47:247-252, 1998.

The effect of low-level amplitude modulated radiofrequency radiation were studied on Na^+–K^+-ATPase activity in the brain of developing male Wistar rats of age 23 days (body weight 55–60 g). They were exposed to carrier wave (CW) frequency 147 MHz and its sub-harmonic frequencies 73.5 and 36.75 MHz amplitude modulated (AM) at 16 and 76 Hz for 30–35 days (3 h day^{-1}, Power density 1.47 mW cm^{-2},average specific absorption rate 9.65–6.11 W kg^{-1}). We observed a statistically significant increase in Na^+–K^+-ATPase activity in chronically exposed rats compared to the control ones. The increase in Na^+–K^+-ATPase activity was around 19–20% in the rats exposed to CW frequencies AM at 16 Hz compared to the controls, whereas the increase in Na^+–K^+-ATPase activity was around 15–16% in rats exposed to the same set of CW frequencies but AM at 76 Hz. Though there was a difference in Na^+–K^+-ATPase activities (3–4%) in the two groups but the difference was found to be statistically insignificant. Within the group of rats exposed to CW frequencies amplitude modulated at 16 and 76 Hz, respectively, the effect on Na^+–K^+-ATPase activity was found to be independent of the magnitude of CW frequencies. An additional single short duration (20–60 min) exposure of membranes in vitro from different exposed group to the above field did not show any significant alteration on Na^+–K^+-ATPase activity. It is concluded that a low level effect of amplitude modulated radiation produces statistically significant effect on Na^+–K^+-ATPase activity but is insensitive to the carrier wave frequencies under investigation.

Behari J, Nirala JP. Specific absorption rate variation in a brain phantom due to exposure by a 3G mobile phone: problems in dosimetry. Indian J Exp Biol. 51(12):1079-1085, 2013.

A specific absorption rate (SAR) measurements system has been developed for compliance testing of personal mobile phone in a brain phantom material contained in a Perspex box. The volume of the box has been chosen corresponding to the volume of a small rat and illuminated by a 3G mobile phone frequency (1718.5 MHz), and the emitted radiation directed toward brain phantom .The induced fields in the phantom material are measured. Set up to lift the plane carrying the mobile phone is run by a pulley whose motion is controlled by a stepper motor. The platform is made to move at a pre-determined rate of 2 degrees per min limited up to 20 degrees. The measured data for induced fields in various locations are used to compute corresponding SAR values and inter comparison obtained. These data are also compared with those when the mobile phone is placed horizontally with respect to the position of the animal. The SAR data is also experimentally obtained by measuring a rise in temperature due to this mobile exposures and data compared with those obtained in the previous set. To seek a comparison with the safety criteria same set of measurements are performed in 10 g phantom material contained in a cubical box. These results are higher than those obtained with the knowledge of induced field measurements. It is concluded that SAR values are sensitive to the angular position of the moving platform and are well below the safety criteria prescribed for human exposure. The data are suggestive of having a fresh look to understand the mode of electromagnetic field -bio interaction.

Behrens T, Lynge E, Cree I, Sabroe S, Lutz JM, Afonso N, Eriksson M, Guénel P, Merletti F, Morales-Suarez-Varela M, Stengrevics A, Févotte J, Llopis-González A, Gorini G, Sharkova G, Hardell L, Ahrens W. Occupational exposure to electromagnetic fields and sex-differential risk of uveal melanoma. Occup Environ Med.67(11):751-759, 2010

Objectives The association between occupational exposure to electromagnetic fields (EMF) and the risk of uveal melanoma was investigated in a case-control study in nine European countries. Methods Incident cases of uveal melanoma and population as well as hospital controls were included and frequency matched by country, 5-year birth cohort and sex. Subjects were asked whether they had worked close to high-voltage electrical transmission installations, computer screens and various electrical machines, or in complex electrical environments. Measurements of two Scandinavian job-exposure matrices were applied to estimate lifelong cumulative EMF exposure. Unconditional logistic regression analyses, stratified by sex and eye colour were calculated, adjusting for several potential confounders. Results 293 patients with uveal melanoma and 3198 control subjects were interviewed. Women exposed to electrical transmission installations showed elevated risks (OR 5.81, 95% CI 1.72 to 19.66). Positive associations with exposure to control rooms were seen among men and women, but most risk increases were restricted to subjects with dark iris colour. Application of published EMF measurements revealed stronger risk increases among women compared to men. Again, elevated risks were restricted to subjects with dark eye colour. Conclusion Although based on a low prevalence of exposure to potential occupational sources of EMF, our data indicate that exposed dark-eyed women may be at particular risk for uveal melanoma.

Bellieni CV, Pinto I, Bogi A, Zoppetti N, Andreuccetti D, Buonocore G. Exposure to electromagnetic fields from laptop use of "laptop" computers. Arch Environ Occup Health. 67(1):31-36, 2012.

Portable computers are often used at tight contact with the body and therefore are called "laptop." The authors measured electromagnetic fields (EMFs) laptop computers produce and estimated the induced currents in the body, to assess the safety of laptop computers. The authors evaluated 5 commonly used laptop of different brands. They measured EMF exposure produced and, using validated computerized models, the authors exploited the data of one of the laptop computers (LTCs) to estimate the magnetic flux exposure of the user and of the fetus in the womb, when the laptop is used at close contact with the woman's womb. In the LTCs analyzed, EMF values (range 1.8-6 μT) are within International Commission on Non-Ionizing Radiation (NIR) Protection (ICNIRP) guidelines, but are considerably higher than the values recommended by 2 recent guidelines for computer monitors magnetic field emissions, MPR II (Swedish Board for Technical Accreditation) and TCO (Swedish Confederation of Professional Employees), and those considered risky for tumor development. When close to the body, the laptop induces currents that are within 34.2% to 49.8% ICNIRP recommendations, but not negligible, to the adult's body and to the fetus (in pregnant women). On the contrary, the power supply induces strong intracorporal electric current densities in the fetus and in the adult subject, which are respectively 182-263% and 71-483% higher than ICNIRP 98 basic restriction recommended to prevent adverse health effects. Laptop is paradoxically an improper site for the use of a LTC, which consequently should be renamed to not induce customers towards an improper use.

Belokhvostov AS, Osipovich VK, Veselova OM, Kolodiazhnaia VA. [DNA analysis of retroposon-like genetic LINE elements in blood plasma of rats exposed to radio-diapason electromagnetic waves] Radiats Biol Radioecol 35(3):356-363, 1995.
[Article in Russian]

The elevation of LINE-elements' DNA level was revealed in blood plasma of rats exposed to electromagnetic waves. The amount of full-size 5'-containing LINE-elements copies was increased especially. Connection of this effect with retrotransposon activation and genetic instability condition of organism development is supposed.

Belousova TE, Kargina-Terent'eva RA, [Adrenergic nerve plexuses of heart and adrenal and myocardial catecholamines of spontaneously hypertensive rats under the influence of electromagnetic irradiation in the millimeter range]. Morfologiia 115(1):16-18, 1999. [Article in Russian]

Condition of adrenergic cardiac and adrenal nervous plexuses of Kyoto-Wistar Rats (WKY) and spontaneously hypertensive rats (SHR) was examined by quantitative neurohistochemical methods before and after extremely high frequency field (EHF field) influence of "Bayur" microwave therapy apparatus in mode 1 (42,194 MHz frequency, 7.1 mm wavelength) and in mode 3 (53,534 MHz frequency, 5.6 mm wavelength). Reduction of myocardial nervous plexus density and catecholamine luminescence intensity were detected in SHR, as well as decrease of adrenal glands relative weight and catecholamine luminescence intensity in adrenal medulla of SHR, that is indicative of suppression of sympatho-adrenal system of hypertensive animals by EHF field influence in medical operating modes.

Belyaev IYa, Alipov YD, Shcheglov VS, Lystsov VN, Resonance effect of microwaves on the genome conformational state of E. coli cells. Z Naturforsch [C] 47(7-8):621-827, 1992.

The effect of low intensity microwaves on the conformational state of the genome of X-irradiated E. coli cells was studied by the method of viscosity anomalous time dependencies. It has been established that within the ranges of 51.62-51.84 GHz and 41.25-41.50 GHz the frequency dependence of the observed effect has a resonance nature with a resonance half-width of the order of 100 MHz. The power dependence of the microwave effect within the range of 0.1-200 microW/cm2 has shown that a power density of 1 microW/cm2 is sufficient to suppress radiation-induced repair of the genome conformational state. The effect of microwave suppression of repair is well reproduced and does not depend on the sequence of cell exposure to X-rays and microwave radiation in the millimeter band. The results obtained indicate the role of the cell genome in the resonant interaction of cells with low intensity millimeter waves.

Belyaev IY, Shcheglov VS, Alipov YD, Polunin VA, Resonance effect of millimeter waves in the power range from 10(-19) to 3 x 10(-3) W/cm2 on Escherichia coli cells at different concentrations. Bioelectromagnetics 17(4):312-321, 1996.

The effect of millimeter waves (MMWs) on the genome conformational state (GCS) of E. coli AB1157 cells was studied by the method of anomalous viscosity time dependencies (AVTD) in the frequency range of 51.64-51.85 GHz. The 51.755 GHz resonance frequency of the cell reaction to MMWs did not depend on power density (PD) in the range from 10(-19) to 3 x 10(-3) W/cm2. The half-width of the resonant reaction of cells showed a sigmoid dependence on PD, changing from 3 MHz to 100 MHz. The PD dependence of the half-width had the same shape for different concentrations of exposed cells (4 x 10(7) and 4 x 10(8) cells/ml), whereas the magnitude of the 51.755 GHz resonance effect differed significantly and depended on the PD of MMW exposure. Sharp narrowing of the 51.755 GHz resonance in the PD range from 10(-4) to 10(-7) W/cm2 was followed by an emergence of new resonance frequencies. The PD dependence of the MMW effect at one of these resonance frequencies (51.674 GHz) differed markedly from the corresponding dependence at the 51.755 GHz resonance, the power window occurring in the range from 10(-16) to 10(-8) W/cm2. The results obtained were explained in the framework of a model of electron-conformational interactions. The frequency-time parameters of this model appeared to be in good agreement with experimental data.

Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M. 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics. 26(3):173-184, 2005.

We used exposure to microwaves from a global system for mobile communication (GSM) mobile phone (915 MHz, specific absorption rate (SAR) 37 mW/kg) and power frequency magnetic field (50 Hz, 15 muT peak value) to investigate the response of lymphocytes from healthy subjects and from persons reporting hypersensitivity to electromagnetic field (EMF). The hypersensitive and healthy donors were matched by gender and age and the data were analyzed blind to treatment condition. The changes in chromatin conformation were measured with the method of anomalous viscosity time dependencies (AVTD). 53BP1 protein, which has been shown to colocalize in foci with DNA double strand breaks (DSBs), was analyzed by immunostaining in situ. Exposure at room temperature to either 915 MHz or 50 Hz resulted in significant condensation of chromatin, shown as AVTD changes, which was similar to the effect of heat shock at 41 degrees C. No significant differences in responses between normal and hypersensitive subjects were detected. Neither 915 MHz nor 50 Hz exposure induced 53BP1 foci. On the contrary, a distinct decrease in background level of 53BP1 signaling was observed upon these exposures as well as after heat shock treatments. This decrease correlated with the AVTD data and may indicate decrease in accessibility of 53BP1 to antibodies because of stress-induced chromatin condensation. Apoptosis was determined by morphological changes and by apoptotic fragmentation of DNA as analyzed by pulsed-field gel electrophoresis (PFGE). No apoptosis was induced by exposure to 50 Hz and 915 MHz microwaves. In conclusion, 50 Hz magnetic field and 915 MHz microwaves under specified conditions of exposure induced comparable responses in lymphocytes from healthy and hypersensitive donors that were similar but not identical to stress response induced by heat shock.

Belyaev IY, Koch CB, Terenius O, Roxstrom-Lindquist K, Malmgren LO, H Sommer W, Salford LG, Persson BR. Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene expression but not double stranded DNA breaks or effects on chromatin conformation. Bioelectromagnetics.27(4):295-306,2006.

We investigated whether exposure of rat brain to microwaves (MWs) of global system for mobile communication (GSM) induces DNA breaks, changes in chromatin conformation and in gene expression. An exposure installation was used based on a test mobile phone employing a GSM signal at 915 MHz, all standard modulations included, output power level in pulses 2 W, specific absorption rate (SAR) 0.4 mW/g. Rats were exposed or sham exposed to MWs during 2 h. After exposure, cell suspensions were prepared from brain samples, as well as from spleen and thymus. For analysis of gene expression patterns, total RNA was extracted from cerebellum. Changes in chromatin conformation, which are indicative of stress response and genotoxic effects, were measured by the method of anomalous viscosity time dependencies (AVTD). DNA double strand breaks (DSBs) were analyzed by pulsed-field gel electrophoresis (PFGE). Effects of MW exposure were observed on neither conformation of chromatin nor DNA DSBs. Gene expression profiles were obtained by Affymetrix U34 GeneChips representing 8800 rat genes and analyzed with the Affymetrix Microarray Suite (MAS) 5.0 software. In cerebellum from all exposed animals, 11 genes were upregulated in a range of 1.34-2.74 fold and one gene was downregulated 0.48-fold ($P < .0025$). The induced genes encode proteins with diverse functions including neurotransmitter regulation, blood-brain barrier (BBB), and melatonin production. The data shows that GSM MWs at 915 MHz did not induce PFGE-detectable DNA double stranded breaks or changes in chromatin conformation, but affected expression of genes in rat brain cells

Belyaev IY, Markovà E, Hillert L, Malmgren LO, Persson BR. Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes. Bioelectromagnetics.30(2):129-141, 2009

We have recently described frequency-dependent effects of mobile phone microwaves (MWs) of global system for mobile communication (GSM) on human lymphocytes from persons reporting hypersensitivity to electromagnetic fields and healthy persons. Contrary to GSM, universal global telecommunications system (UMTS) mobile phones emit wide-band MW signals. Hypothetically, UMTS MWs may result in higher biological effects compared to GSM signal because of eventual "effective" frequencies within the wideband. Here, we report for the first time that UMTS MWs affect chromatin and inhibit formation of DNA double-strand breaks co-localizing 53BP1/gamma-H2AX DNA repair foci in human lymphocytes from hypersensitive and healthy persons and confirm that effects of GSM MWs depend on carrier frequency. Remarkably, the effects of MWs on 53BP1/gamma-H2AX foci persisted up to 72 h following exposure of cells, even longer than the stress response following heat shock. The data are in line with the hypothesis that the type of signal, UMTS MWs, may have higher biological efficiency and possibly larger health risk effects compared to GSM radiation emissions. No significant differences in effects between groups of healthy and hypersensitive subjects were observed, except for the effects of UMTS MWs and GSM-915 MHz MWs on the formation of the DNA repair foci, which were different for hypersensitive ($P < 0.02$[53BP1]//0.01[gamma-H2AX]) but not for control subjects ($P > 0.05$). The non-parametric statistics used here did not indicate specificity of the differences revealed between the effects of GSM and UMTS MWs on cells from hypersensitive subjects and more data are needed to study the nature of these differences.

Benson VS, Pirie K, Schüz J, Reeves GK, Beral V, Green J; for the Million Women Study Collaborators. Mobile phone use and risk of brain neoplasms and other cancers: prospective study. Int J Epidemiol. 2013 May 8. [Epub ahead of print]

BACKGROUND: Results from some retrospective studies suggest a possible increased risk of glioma and acoustic neuroma in users of mobile phones. METHODS: The relation between mobile phone use and incidence of intracranial central nervous system (CNS) tumours and other cancers was examined in 791 710 middle-aged women in a UK prospective cohort, the Million Women Study. Cox regression models were used to estimate adjusted relative risks (RRs) and 95% confidence intervals (CIs). Women reported mobile phone use in 1999 to 2005 and again in 2009. RESULTS: During 7 years' follow-up, 51 680 incident invasive cancers and 1 261 incident intracranial CNS tumours occurred. Risk among ever vs never users of mobile phones was not increased for all intracranial CNS tumours (RR = 1.01, 95% CI = 0.90-1.14, P = 0.82), for specified CNS tumour types nor for cancer at 18 other specified sites. For long-term users compared with never users, there was no appreciable association for glioma (10+ years: RR = 0.78, 95% CI = 0.55-1.10, P = 0.16) or meningioma (10+ years: RR = 1.10, 95% CI = 0.66-1.84, P = 0.71). For acoustic neuroma, there was an increase in risk with long term use vs never use (10+ years: RR = 2.46, 95% CI = 1.07-5.64, P = 0.03), the risk increasing with duration of use (trend among users, P = 0.03). CONCLUSIONS: In this large prospective study, mobile phone use was not associated with increased incidence of glioma, meningioma or non-CNS cancers.

Berg G, Schuz J, Samkange-Zeeb F, Blettner M. Assessment of radiofrequency exposure from cellular telephone daily use in an epidemiological study: German Validation study of the international case-control study of cancers of the brain-INTERPHONE-Study. J Expo Anal Environ Epidemiol. 15(3):217-224, 2004.

OBJECTIVE: The objective of the study is to validate self-reported cellular phone use information by comparing it with the cumulative emitted power and duration of calls measured by software-modified cellular phones (SMP). The information was obtained using a questionnaire developed for the international case-control study on the risk of the use of mobile phones in tumours of the brain or salivary gland (INTERPHONE-study). Method: The study was conducted in Bielefeld, Germany. Volunteers were asked to use SMPs instead of their own cellular phones for a period of 1 month. The SMP recorded the power emitted by the mobile phone handset during each base station contact. Information on cellular phone use for the same time period from traffic records of the network providers and from face-to-face interviews with the participants 3 months after the SMP use was assessed. Pearson's correlation coefficients and linear regression models were used to analyse the association between information from the interview and from the SMP. Results: In total, 1757 personal mobile phone calls were recorded for 45 persons by SMP and traffic records. The correlation between the self-reported information about the number and the duration of calls with the cumulative power of calls was 0.50 (P<0.01) and 0.48 (P<0.01), respectively. Almost 23% of the variance of the cumulative power was explained by either the number or the cumulative duration of calls. After inclusion of possible confounding factors in the regression model, the variance increased to 26%. Minor confounding factors were "network provider", "contract form", and "cellular phone model". Discussion: The number of calls alone is a sufficient parameter to estimate the cumulative power emitted by the handset of a cellular telephone. The cumulative power emitted by these phones is only associated with number of calls but not with possible confounding factors. Using the mobile phone while driving, mainly in cities, or mainly in rural areas is not associated with the recorded cumulative power in the SMP.

Berg G, Spallek J, Schuz J, Schlehofer B, Bohler E, Schlaefer K, Hettinger I, Kunna-Grass K, Wahrendorf J, Blettner M. Occupational exposure to radio frequency/microwave radiation and the risk of brain tumors: Interphone Study Group, Germany. Am J Epidemiol.164(6):538-548, 2006.

It is still under debate whether occupational exposure to radio frequency/microwave electromagnetic fields (RF/MW-EMF) contributes to the development of brain tumors. This analysis examined the role of occupational RF/MW-EMF exposure in the risk of glioma and meningioma. A population-based, case-control study including 381 meningioma cases, 366 glioma cases, and 1,494 controls aged 30-69 years was performed in three German regions in 2000-2003. An exposure matrix for occupational activity was constructed by using information on RF/MW-EMF exposure collected in a computer-assisted personal interview. "High" exposure was defined as an occupational exposure that may exceed the RF/MW-EMF exposure limits for the general public recommended by the International Commission on Non-Ionizing Radiation Protection. Multiple conditional logistic regressions were performed separately for glioma and meningioma. No significant association between occupational exposure to RF/MW-EMF and brain tumors was found. For glioma, the adjusted odds ratio for highly exposed persons compared with persons not highly exposed was 1.21 (95% confidence interval: 0.69, 2.13); for meningioma, it was 1.34 (95% confidence interval: 0.64, 2.81). However, the slight increase in risk observed with increasing duration of exposure merits further research with larger sample sizes.

Bergamaschi A, Magrini A, Ales G, Coppetta L, Somma G. Are thyroid dysfunctions related to stress or microwave exposure (900 MHz)? Int J Immunopathol Pharmacol. 17(2 Suppl):31-36, 2004.

In the last decade, numerous scientific evidence suggested possible adverse health effects from exposure to electromagnetic fields (EMF's) and the use of mobile phones. According to some studies EMF induced changes of trans-membrane Ca++ flux may lead to altered metabolism and/or secretion of neurohormones including TSH, ACTH, GH, prolactin and melatonin. The aim of this research was to analyse the effects of mobile phone use on thyroid function and to evaluate the possible role of occupational stress. 2598 employees (1355 men and 1243 women) with different duties (vendors, operators and network technicians) were included in the study. Exposure to EMF's, generated by mobile phones, was assessed both by submitting a questionnaire directly to the employees and acquiring data regarding conversation times. The workers were divided into three groups on the basis of their personal mobile phone use. Moreover, a group of 160 workers with TSH values below 0.4 UI/l was characterized. No statistically significant difference regarding TSH values below 0.4 UI/l was observed among workers with different duties but there was a greater prevalence of subjects with low TSH values among 192 employees with more than 33 hrs/month conversation time; this difference was statistically significant ($p < 0.05$). On the basis of our data, it is not possible to establish whether this result is determined by exposure to EMF's from mobile phones or by the stress of using these instruments.

Berg-Beckhoff G, Blettner M, Kowall B, Breckenkamp J, Schlehofer B, Schmiedel S, Bornkessel C, Reis U, Potthoff P, Schuz J Mobile phone base stations and adverse health effects: phase 2 of a cross-sectional study with measured radio frequency electromagnetic fields. Occup Environ Med 66:124-130, 2009.

ABSTRACT. Objective: The aim of the cross-sectional study was to test the hypothesis that exposure to continuous low-level radio frequency electromagnetic fields (RF-EMFs) emitted from mobile phone base stations was related to various health disturbances. Methods: For the investigation people living mainly in urban regions were selected from a nationwide study in 2006. In total, 3526 persons responded to a questionnaire (response rate 85%). For the exposure assessment a dosimeter measuring different RF-EMF frequencies was used. Participants answered a postal questionnaire on how mobile phone base stations affected their health and they gave information on sleep disturbances, headaches, health complaints and mental and physical health using standardised health questionnaires. Information on stress was also collected. Multiple linear regression models were used with health outcomes as dependent variables (n=1326). Results: For the five health scores used, no differences in their medians were observed for exposed versus nonexposed participants. People who attributed adverse health effects to mobile phone base stations reported significantly more sleep disturbances and health complaints, but they did not report more headaches or less mental and physical health. Individuals concerned about mobile phone base stations did not have different wellbeing scores compared with those who were not concerned. Conclusions: In this large population-based study, measured RF-EMFs emitted from mobile phone base stations were not associated with adverse health effects.

Bergdahl J, Tillberg A, Stenman E. Odontologic survey of referred patients with symptoms allegedly caused by electricity or visual display units. Acta Odontol Scand. 56(5):303-307, 1998.

Twenty-eight consecutive patients with symptoms allegedly caused by electricity or visual display units were odontologically investigated according to a specially designed registration form including an anamnestic interview and a clinical protocol. The most common oral and general symptoms reported were burning mouth, craniomandibular dysfunction symptoms, skin complaints, and fatigue. Oral symptoms such as craniomandibular dysfunction and general symptoms such as eye complaints and dizziness scored highest on a visual analog scale regarding mean symptom intensity. The patients reported various numbers of medical diagnoses, such as allergic rhinitis or asthma and hypothyroidism. Various dental diseases were found; the most common were temporomandibular joint and masticatory muscle dysfunctions, lesions in the oral mucosa, and periodontal diseases. Urinary-Hg (U-Hg) analysis showed a mean U-Hg concentration of 8.5 nmol Hg/L urine, and none of the patients exceeded the limit of 50 nmol Hg/L urine. The U-Hg concentration was positively correlated with the number of amalgam fillings ($P < 0.01$) and craniomandibular disorders ($P < 0.05$). No or low secretion of the minor mucous glands was found in 43% of the patients. One patient showed hypersensitivity to gold and cobalt. The present study showed that various odontologic factors might be involved in some of these patients' suffering. Thus, it is important that professionals from other disciplines collaborate with dentistry if these patients are to be properly investigated.

Bergqvist B, Arvidsson L, Pettersson E, Galt S, Saalman E, Hamnerius Y, Norden B, Effect of microwave radiation on permeability of liposomes. Evidence against non-thermal leakage. Biochim Biophys Acta 1201(1):51-54, 1994.

The effect of 2.45 GHz microwave radiation on the permeability of unilamellar phosphatidylcholine liposomes has been studied. Leakage of 5(6)-carboxyfluorescein from the liposomes was measured using spectrofluorimetry after exposure to either microwaves or thermal heating for 5-20 min intervals. The exposure temperature, 37.6 +/- 0.5 degrees C, was well above the phase transition temperature of the lipid membrane. The microwave exposure did not result in any non-thermal increase in permeability above that produced by thermal heating. This study refutes the results reported by Saalman et al. [Biochim Biophys Acta 1064(1):124-130, 1991] in which an increased liposome permeability due to microwave exposure was reported. The refined analysis in the present study shows that this increased liposome permeability was not a non-thermal microwave effect.

Berolo S, Steenstra I, Amick BC 3rd, Wells RP. A comparison of two methods to assess the usage of mobile hand-held communication devices. J Occup Environ Hyg. 2014 Dec 1:0. [Epub ahead of print]

Objective: The purposes of this study were to: 1) examine agreement between self-reported measures of mobile device use and direct measures of use, and 2) understand how respondents thought about their device use when they provided self-reports. Methods: Self-reports of six categories of device use were obtained using a previously developed questionnaire, and direct measures of use were collected using a custom logging application (n = 47). Bland-Altman analyses were used to examine agreement between the two measurement approaches. Interviews targeted participants' experiences completing the device use section of the questionnaire. Results: Self-reports of use on a typical day last week overestimated logged use; overestimates tended to be low at low average usage times, and became more variable as usage time increased. Self-reports of use yesterday also exceeded logged use, however the degree of overestimation was less than for a typical day last week. Six themes were identified from interviews, including the thought process used by participants to arrive at usage and the ease of reporting usage. Discussion: It is challenging for respondents of this questionnaire to provide accurate self-reports of use. The source of this challenge may be attributed to the intrinsic difficulty of estimating use, partly due to the multiple functions of the devices as well as the variability of use both within a day and a week. Conclusion: Research investigating the relationship between device use and health outcomes should include a logging application to examine exposure simultaneously with self-reports to better understand the sources of hazardous exposures.

Besset A, Espa F, Dauvilliers Y, Billiard M, de Seze R. No effect on cognitive function from daily mobile phone use. Bioelectromagnetics. 26(2):102-108, 2005.

The increasing use of mobiles phones (MP) has raised the problem of the effects of daily electromagnetic fields (EMF) exposure on human health. To date several studies have been published concerning the effects of acute MP exposure on psychomotor performances. This study investigated the effects of daily exposure to GSM 900 type MP on cognitive function. Fifty-five subjects (27 male and 28 female) were divided into two groups: a group with MP switched on and a group with MP switched off. The two groups were matched according to age, gender, and IQ. This double blind study lasted for 45 days and was divided in three periods: baseline (BLP, 2 days), exposure (EP, 27 days), and recovery (RP, 13 days). Subjects were exposed during EP and sham exposed during RP for 2 h/day, 5 days/week. The neuropsychological test battery composed of 22 tasks screened four neuropsychological categories: information processing, attention capacity, memory function, and executive function. This neuropsychological battery was performed four times on day 2 (BLP), day 15 (EP), day 29 (EP), and day 43 (RP). Our results indicate that daily MP use has no effect on cognitive function after a 13-h rest period.

Betts TR, Simpson IA, Inhibition of temporary pacing by a mobile phone. Heart 87:130, 2002.

A patient with no underlying rhythm was receiving transvenoustemporary pacing from an external pulse generator and bipolartemporary pacing wire on a coronary care unit. While examiningthe patient, the consultant cardiologist was telephoned on hismobile phone, carried in his jacket pocket. The electromagnetic interference generated by the ringing mobile phone caused inappropriatesensing by the pulse generator and inhibition of ventricularpacing. The image shows the resultant 2.5 second pause. Pacing recommenced when the mobile phone was moved away from the bedside.This case is a reminder that mobile phones may adversely affect electronic hospital equipment.

Bhatt CR, Redmayne M, Billah B, Abramson MJ, Benke G. Radiofrequency-electromagnetic field exposures in kindergarten children. J Expo Sci Environ Epidemiol. 2016 Oct 19. doi: 10.1038/jes.2016.55. [Epub ahead of print]

The aim of this study was to assess environmental and personal radiofrequency-electromagnetic field (RF-EMF) exposures in kindergarten children. Ten children and 20 kindergartens in Melbourne, Australia participated in personal and environmental exposure measurements, respectively. Order statistics of RF-EMF exposures were computed for 16 frequency bands between 88 MHz and 5.8 GHz. Of the 16 bands, the three highest sources of environmental RF-EMF exposures were: Global System for Mobile Communications (GSM) 900 MHz downlink (82 mV/m); Universal Mobile Telecommunications System (UMTS) 2100MHz downlink (51 mV/m); and GSM 900 MHz uplink (45 mV/m). Similarly, the three highest personal exposure sources were: GSM 900 MHz downlink (50 mV/m); UMTS 2100 MHz downlink, GSM 900 MHz uplink and GSM 1800 MHz downlink (20 mV/m); and Frequency Modulation radio, Wi-Fi 2.4 GHz and Digital Video Broadcasting-Terrestrial (10 mV/m). The median environmental exposures were: 179 mV/m (total all bands), 123 mV/m (total mobile phone base station downlinks), 46 mV/m (total mobile phone base station uplinks), and 16 mV/m (Wi-Fi 2.4 GHz). Similarly, the median personal exposures were: 81 mV/m (total all bands), 62 mV/m (total mobile phone base station downlinks), 21 mV/m (total mobile phone base station uplinks), and 9 mV/m (Wi-Fi 2.4 GHz). The measurements showed that environmental RF-EMF exposure levels exceeded the personal RF-EMF exposure levels at kindergartens.

Bhatt CR, Benke G, Smith CL, Redmayne M, Dimitriadis C, Dalecki A, Macleod S, Sim MR, Croft RJ, Wolfe R, Kaufman J, Abramson MJ. Use of mobile **and cordless** phones **and change in cognitive function: a prospective cohort analysis of Australian primary school children. Environ Health. 16(1):62, 2017.**

BACKGROUND: Some previous studies have suggested an association between children's use of mobile phones (MPs)/cordless phones (CPs) and development of cognitive function. We evaluated possible longitudinal associations between the use of MPs and CPs in a cohort of primary school children and effects on their cognitive function. METHODS: Data on children's socio-demographics, use of MPs and CPs, and cognitive function were collected at baseline (2010-2012) and follow-up (2012-2013). Cognitive outcomes were evaluated with the CogHealth™ test battery and Stroop Color-Word test. The change in the number of MP/CP voice calls weekly from baseline to follow-up was dichotomized: "an increase in calls" or a "decrease/no change in calls". Multiple linear regression analyses, adjusting for confounders and clustering by school, were performed to evaluate the associations between the change in cognitive outcomes and change in MP and CP exposures. RESULTS: Of 412 children, a larger proportion of them used a CP (76% at baseline and follow-up), compared to a MP (31% at baseline and 43% at follow-up). Of 26 comparisons of changes in cognitive outcomes, four demonstrated significant associations. The increase in MP usage was associated with larger reduction in response time for response inhibition, smaller reduction in the number of total errors for spatial problem solving and larger increase in response time for a Stroop interference task. Except for the smaller reduction in detection task accuracy, the increase in CP usage had no effect on the changes in cognitive outcomes. CONCLUSION: Our study shows that a larger proportion of children used CPs compared to MPs. We found limited evidence that change in the use of MPs or CPs in primary school children was associated with change in cognitive function.

Bianchi A, Phillips JG. Psychological predictors of problem mobile phone use. Cyberpsychol Behav. 8(1):39-51, 2005.

Mobile phone use is banned or illegal under certain circumstances and in some jurisdictions. Nevertheless, some people still use their mobile phones despite recognized safety concerns, legislation, and informal bans. Drawing potential predictors from the addiction literature, this study sought to predict usage and, specifically, problematic mobile phone use from extraversion, self-esteem, neuroticism, gender, and age. To measure problem use, the Mobile Phone Problem Use Scale was devised and validated as a reliable self-report instrument, against the Addiction Potential Scale and overall mobile phone usage levels. Problem use was a function of age, extraversion, and low self-esteem, but not neuroticism. As extraverts are more likely to take risks, and young drivers feature prominently in automobile accidents, this study supports community concerns about mobile phone use, and identifies groups that should be targeted in any intervention campaigns.

Bielski J, Sikorski M, [Disturbances of glucose tolerance in workers exposed to electromagnetic radiation]. Med Pr 47(3):227-231, 1996. [Article in Polish]

The study group was composed of 50 workers exposed to electromagnetic radiation (radiowaves). Out of them 31 persons (62%), employed mostly in the risk zone, showed irregular glycaemia after oral administration of 75 g of glucose. At normal blood sugar before breakfast, the glycaemia level was high following administration of glucose and it did not return to starting values after 2 hours. After 30 min from glucose administration the level accounted for 155 mg%, after 60 min-180 mg%, after 90 min-153 mg% and after 120 min-124 mg%, on average. In 10 persons (32%) with glucose tolerance disturbances, disorders in bioelectric activity of the brain (abnormal EEG record) were observed.

Bilgici B, Akar A, Avci B, Tuncel OK. Effect of 900 MHz radıofrequency radıatıon on oxıdatıve stress In rat braın and serum. Electromagn Biol Med. 32(1):20-29, 2013.

The increasing use of mobile telephones raises the question of possible adverse effects of the electromagnetic fields (EMF) that these phones produce. In this study, we examined the oxidative stress in the brain tissue and serum of rats that resulted from exposure to a 900-MHz EMF at a whole body average specific absorption rate (SAR) of 1.08 W/kg for 1 h/day for 3 weeks. We also examined the antioxidant effect of garlic powder (500 mg/kg/day) given orally to EMF-exposed rats. We found that malondialdehyde (MDA) ($p < 0.001$) and advanced oxidation protein product (AOPP) ($p < 0.05$) increased in rat brain tissue exposed to the EMF and that garlic reduced these effects ($p < 0.05$). There was no significant difference in the nitric oxide (NO) levels in the brain. Paraoxonase (PON) was not detected in the brain. There was a significant increase in the levels of NO ($p < 0.001$) detected in the serum after EMF exposure, and garlic intake did not affect this increase in NO. Our results suggest that there is a significant increase in brain lipid and protein oxidation after electromagnetic radiation (EMR) exposure and that garlic has a protective effect against this oxidative stress.

Billaudel B, Taxile M, Poulletier de Gannes F, Ruffie G, Lagroye I, Veyret B. Effects of exposure to DAMPS and GSM signals on Ornithine Decarboxylase (ODC) activity: II. SH-SY5Y human neuroblastoma cells. Int J Radiat Biol. 85(6):519-522, 2009.

Purpose: An increase in Ornithine Decarboxylase (ODC) activity was reported in L929 murine fibroblast cells after exposure to a digital cellular telephone signal. This result was not confirmed by several other studies, including the one reported in a companion paper. As a partner in the Perform-B programme, we extended this study to human neuroblastoma cells (SH-SY5Y), using well-defined waveguide systems to imitate exposure to radiofrequency radiation (RFR): Digital Advanced Mobile Phone System (DAMPS) or Global System for Mobile communications (GSM) signals emitted by mobile phones. Materials and methods: Human neuroblastoma cells (SH-SY5Y) were exposed at various Specific Absorption Rates (SAR) to DAMPS or GSM signals using different set-ups. Cell ODC activities were assayed using (14)CO(2) generation from (14)C-labeled L-ornithine. Results: SH-SY5Y cells were incubated for 20 hours, and were blindly exposed to 50 Hz-modulated DAMPS-835 or 217 Hz-modulated GSM-1800 for 8 or 24 h using Information Technologies in Society (IT'IS) waveguides equipped with fans. After cell lysis, ODC activity was determined using (14)C-labeled L-ornithine. ODC activity was estimated by the (14)CO(2) generated from (14)C-labeled L-ornithine, as generated d.p.m. (14)CO(2)/h/mg protein. The results showed that, irrespective of the signal used (835 MHz/DAMPS, or 1800 MHz/GSM) and exposure conditions (duration and SAR), human SH-SY5Y neuroblastoma cells did not exhibit any alteration in ODC enzyme activity. Conclusion: This work did not show a significant effect of mobile phone RFR exposure on ODC activity in neuroblastoma cells (SH-SY5Y).

Billaudel B, Taxile M, Ruffie G, Veyret B, Lagroye I. Effects of exposure to DAMPS and GSM signals on ornithine decarboxylase (ODC) activity: I. L-929 mouse fibroblasts. Int J Radiat Biol. 85(6):510-518, 2009.

Purpose: A temporary increase in ornithine decarboxylase (ODC) activity was reported in lysed L-929 fibroblasts after exposure to the microwaves emitted by Digital Advanced Mobile Phone System (DAMPS-835 MHz, 2.5 W/kg, 8 hours). Confirmation of these data was undertaken, given the suggested potential physiopathological consequences, i.e., tumour promotion. Materials and methods: Murine L-929 fibroblasts were exposed at various Specific Absorption rates (SAR) to (DAMPS) or Global System for Mobile communications (GSM) signals using different set-ups. Cell ODC activities were assayed using (14)CO(2) generation from (14)C-labeled L-ornithine. Results: ODC activity in live L-929 cells showed no significant alteration after exposure at an SAR of 2.5 W/kg, for one hour at the end of exposure to 50 Hz-modulated DAMPS-835 using Transverse Electro-Magnetic (TEM) cells. No significant alteration in ODC activity was observed at 6 W/kg, with active fans to regulate temperature (37 degrees C). Tests using cell lysed after exposure in another temperature-controlled set-up (waveguides) did not confirm the published studies reporting increased ODC activity in Radio-Frequency radiation (RFR)-exposed L-929 cells. In the second part of the study, no alteration of ODC activity was detected when L-929 cells were exposed to different RFR signals: 217 Hz modulated GSM-900 (wire-patch antenna) or GSM-1800 (waveguides), and lysed before ODC measurement. Conclusion: We conclude that under our exposure conditions, DAMPS-835 and GSM signals have no influence on ODC activity in L-929 cells.

Bin-Meferij MM, El-Kott AF. The radioprotective effects of Moringa oleifera against mobile phone electromagnetic radiation-induced infertility in rats.Int J Clin Exp Med. 2015 Aug 15;8(8):12487-97. eCollection 2015.

The present study has investigated the effects of mobile phone electromagnetic radiation (EMR) on fertility in rats. The purpose of this study was to explore the capability of polyphenolic-rich Moringa oleifera leaf extract in protecting rat testis against EMR-induced impairments based on evaluation of sperm count, viability, motility, sperm cell morphology, anti-oxidants (SOD & CAT), oxidative stress marker, testis tissue histopathology and PCNA immunohistochemistry. The sample consisted of sixty male Wistar rats which were divided into four equal groups. The first group (the control) received only standard diet while the second group was supplemented daily and for eight weeks with 200 mg/kg aqueous extract of Moringa leaves. The third group was exposed to 900 MHz fields for one hour a day and for (7) days a week. As for the fourth group, it was exposed to mobile phone radiation and received the Moringa extract. The results showed that the EMR treated group exhibited a significantly decrease sperm parameters. Furthermore, concurrent exposure to EMR and treated with MOE significantly enhanced the sperm parameters. However, histological results in EMR group showed irregular seminiferous tubules, few spermatogonia, giant multinucleated cells, degenerated spermatozoa and the number of Leydig cells was significantly reduced. PCNA labeling indices were significant in EMR group versus the control group. Also, EMR affects spermatogenesis and causes to apoptosis due to the heat and other stress-related EMR in testis tissue. This study concludes that chronic exposure to EMR marked testicular injury which can be prevented by Moringa oleifera leaf extract.

Birks L, Guxens M, Papadopoulou E, Alexander J, Ballester F, Estarlich M, Gallastegi M, Ha M, Haugen M, Huss A, Kheifets L, Lim H, Olsen J, Santa-Marina L, Sudan M, Vermeulen R, Vrijkotte T, Cardis E, Vrijheid M. Maternal cell phone **use**

during pregnancy and child behavioral problems in five birth cohorts. Environ Int. 104:122-131, 2017.

INTRODUCTION: Previous studies have reported associations between prenatal **cell phone** use and child behavioral problems, but findings have been inconsistent and based on retrospective assessment of **cell phone** use. This study aimed to assess this association in a multi-national analysis, using data from three cohorts with prospective data on prenatal **cell phone** use, together with previously published data from two cohorts with retrospectively collected **cell phone** use data.METHODS: We used individual participant data from 83,884 mother-child pairs in the five cohorts from Denmark (1996-2002), Korea (2006-2011), the Netherlands (2003-2004), Norway (2004-2008), and Spain (2003-2008). We categorized **cell phone** use into none, low, medium, and high, based on frequency of calls during pregnancy reported by the mothers. Child behavioral problems (reported by mothers using the Strengths and Difficulties Questionnaire or Child Behavior Checklist) were classified in the borderline/clinical and clinical ranges using validated cut-offs in children aged 5-7years. Cohort specific risk estimates were meta-analyzed.RESULTS: Overall, 38.8% of mothers, mostly from the Danish cohort, reported no **cell phone** use during pregnancy and these mothers were less likely to have a child with overall behavioral, hyperactivity/inattention or emotional problems. Evidence for a trend of increasing risk of child behavioral problems through the maternal **cell phone** use categories was observed for hyperactivity/inattention problems (OR for problems in the clinical range: 1.11, 95%CI 1.01, 1.22; 1.28, 95%CI 1.12, 1.48, among children of medium and high users, respectively). This association was fairly consistent across cohorts and between cohorts with retrospectively and prospectively collected **cell phone** use data.CONCLUSIONS: Maternal **cell phone** use during pregnancy may be associated with an increased risk for behavioral problems, particularly hyperactivity/inattention problems, in the offspring. The interpretation of these results is unclear as uncontrolled confounding may influence both maternal **cell phone** use and child behavioral problems..

Bisht KS, Moros EG, Straube WL, Baty JD, Roti Roti JL, The Effect of 835.62 MHz FDMA or 847.74 MHz CDMA Modulated Radiofrequency Radiation on the Induction of Micronuclei in C3H 10T½ Cells. Radiat. Res. 157, 506–515, 2002.

To determine if radiofrequency (RF) radiation induces the formation of micronuclei, C3H 10T½ cells were exposed to 835.62 MHz frequency division multiple access (FDMA) or 847.74 MHz code division multiple access (CDMA) modulated RF radiation. After the exposure to RF radiation, the micronucleus assay was performed by the cytokinesis block method using cytochalasin B treatment. The micronuclei appearing after mitosis were scored in binucleated cells using acridine orange staining. The frequency of micronuclei was scored both as the percentage of binucleated cells with micronuclei and as the number of micronuclei per 100 binucleated cells. Treatment of cells with cytochalasin B at a concentration of 2 μg/ml for 22 h was found to yield the maximum number of binucleated cells in C3H 10T½ cells. The method used for the micronucleus assay in the present study detected a highly significant dose response for both indices of micronucleus production in the dose range of 0.1–1.2 Gy and it was sensitive enough to detect a significant ($P > 0.05$) increase in micronuclei after doses of 0.3 Gy in exponentially growing cells and after 0.9 Gy in plateau-phase cells. Exponentially growing cells or plateau-phase cells were exposed to CDMA (3.2 or 4.8 W/kg) or FDMA (3.2 or 5.1 W/kg) RF radiation for 3, 8, 16 or 24 h. In three repeat experiments, no exposure condition was found by analysis of variance to result in a significant increase relative to sham-exposed cells either in the percentage of binucleated cells with micronuclei or in the number of micronuclei per 100 binucleated cells. In this study, data from cells exposed to different RF signals at two SARs were compared to a common sham-exposed sample. We used the Dunnett's test, which is specifically designed for this purpose, and found no significant exposure-related differences for either plateau-phase cells or exponentially growing cells. Thus the results of this study are not consistent with the possibility that these RF radiations induce micronuclei.

Bit-Babik G, Chou CK, Faraone A, Gessner A, Kanda M, Balzano Q. Estimation of the SAR in the human head and body due to radiofrequency radiation exposure from handheld mobile phones with hands-free accessories. Radiat Res 159(4):550-557, 2003.

It was reported by others that hands-free accessories increase the absorption of RF energy in a human head compared to a handset alone. The results of this study show that the opposite is observed when proper dosimetric methods are employed. It is pointed out that for correct estimation of the exposure level it is necessary to use appropriate physical and experimental models and measurement instrumentation, following internationally recommended standards. The human phantoms used for measurements involving the hands-free accessories should include the torso; i.e., measurements should not be performed on the head phantom alone. This has a significant impact on the results because the RF energy coupled into the leads of hands-free accessories is strongly attenuated by the body. Numerical simulations using the Finite-Difference Time-Domain (FDTD) method and experimental measurements with a miniature electric-field probe are in good agreement and show a decrease, not an increase, in RF energy exposure in the human head from hands-free accessories.

Bit-Babik, G., Guy, A. W., Chou, C-K., Faraone, A., Kanda, M., Gessner, A., Wang, J. and Fujiwara, O. Simulation of exposure and SAR estimation for adult and child heads exposed to radiofrequency energy from portable communication devices. Radiat. Res. 163: 580-590, 2005.

The level and distribution of radiofrequency energy absorbed in a child's head during the use of a mobile phone compared to those in an adult head has been a controversial issue in recent years. It has been suggested that existing methods that are used to determine specific absorption rate (SAR) and assess compliance with exposure standards using an adult head model may not adequately account for potentially higher levels of exposure in children due to their smaller head size. The present study incorporates FDTD computations of locally averaged SAR in two different anatomically correct adult and child head models using the IEEE standard (Std. C95.3-2002) SAR averaging algorithm. The child head models were obtained by linear scaling of the adult head model to replicate the conditions of previous studies reported in the literature and also by transforming the different adult head models based on data on the external shapes of children's heads. The tissue properties of the adult and corresponding child head models were kept the same. In addition, modeling and experimental measurements were made using three spheres filled with a tissue-equivalent mixture to approximate heads of increasing size. Results show that the peak local average SAR over 1 g and 10 g of tissue and the electromagnetic energy penetration depths are about the same in all of the head models under the same exposure conditions. When making interlaboratory comparisons, the model and the SAR averaging algorithm used must be standardized to minimize controversy.

Blettner M, Schlehofer B, Breckenkamp J, Kowall B, Schmiedel S, Reis U, Potthoff P, Schuez J, Berg-Beckhoff G. Mobile phone base stations and adverse health effects: Phase 1: A population-based cross-sectional study in Germany. Occup Environ Med. 66(2):118-123. 2009.

Abstract OBJECTIVE: The aim of this first phase of a cross-sectional study from Germany was to investigate whether proximity of residence to mobile phone base stations as well as risk perception is associated with health complaints. METHODS: We conducted a population-based multi-phase cross-sectional study within the context of a large panel survey regularly carried out by a private research institute in Germany. In the initial phase, which we will report on in this paper, 30,047 persons from a total of 51,444 who took part in the nationwide survey also answered questions on how mobile phone base stations affect their health. A list of 38 health complaints was used. A multiple linear regression model was used to identify predictors of health complaints including proximity of residence to mobile phone base stations and risk perception. RESULTS: Of the 30,047 participants (response rate 58.6%), 18.7% of participants were concerned about adverse health effects of mobile phone base stations, while an additional 10.3% attributed their personal adverse health effects to the exposure from them. Participants who are concerned about or attribute adverse health effects to mobile phone base stations and those living in the vicinity of a mobile phone base station (500 m) reported slightly more health complaints than others. CONCLUSIONS: A substantial proportion of the German population is concerned about adverse health effects caused by exposure from mobile phone base stations. The observed slightly higher prevalence of health complaints near base stations can however not be fully explained by attributions or concerns.

Blick DW, Adair ER, Hurt WD, Sherry CJ, Walters TJ, Merritt JH, Thresholds of microwave-evoked warmth sensations in human skin. Bioelectromagnetics 18(6):403-409, 1997.

We measured thresholds for microwave-evoked skin sensations of warmth at frequencies of 2.45, 7.5, 10, 35, and 94 GHz. In the same subjects, thresholds of warmth evoked by infrared radiation (IR) were also measured for comparison. Detection thresholds were measured on the skin in the middle of the back in 15 adult male human subjects at all microwave (MW) frequencies and with IR. Long duration (10-s), large area (327-cm2) stimuli were used to minimize any differential effects of temporal or spatial summation. Sensitivity increased monotonically with frequency throughout the range of microwave frequencies tested. The threshold at 94 GHz (4.5 +/- 0.6 mW/cm2) was more than an order of magnitude less than at 2.45 GHz (63.1 +/- 6.7 mW/cm2), and it was comparable to the threshold for IR (5.34 +/- 1.07 mW/cm2).

Bodera P, Stankiewicz W, Antkowiak B, Paluch M, Kieliszek J, Sobiech J, Zdanowski R, Wojdas A, Siwicki AK, Skopińska-Rózewska E. Suppressive effect of electromagnetic field on analgesic activity of tramadol in rats. Pol J Vet Sci. 15(1):95-100, 2012.

The electromagnetic fields (EMFs) have been shown to alter animal and human behavior, such as directional orientation, learning, pain perception (nociception or analgesia) and anxiety-related behaviors. The aim of this study was to evaluate the influence of electromagnetic fields of high-frequency microwaves on pain perception and anti-nociceptive activity of tramadol (TRAM) - analgetic effective in the treatment of moderate to severe acute and chronic pain states. Electromagnetic fields exposures of a)1500 MHz frequency and b) modulated, 1800 MHz (which is identical to that generated by mobile phones) were applied. Paw withdrawal latency (PWL) to thermal stimulus was measured in vehicle or tramadol (TRAM) treated animals before and after 30, 60 and 90 minutes from injections. The differences in the level of pain (PWL) between control group and rats exposed to EMF alone in three measurements, were not observed. Tramadol alone significantly increased PWLs to thermal stimulus in comparison to vehicle results at 30 ($p < 0.001$) and 60 minutes ($p < 0.05$) after drug injection. EMF exposure of both frequencies transiently suppressed analgesic effect of tramadol, significantly reducing paw withdrawal latency in animals treated with this drug at 30 minutes from the drug injection.

Bodera P, Stankiewicz W, Zawada K, Antkowiak B, Paluch M, Kieliszek J, Kalicki B, Bartosiński A, Wawer I. Changes in antioxidant capacity of blood due to mutual action of electromagnetic field (1800 MHz) and opioid drug (tramadol) in animal model of persistent inflammatory state. Pharmacol Rep. 65(2):421-428, 2013.

Background: The biological effects and health implications of electromagnetic field (EMF) associated with cellular mobile telephones and related wireless systems and devices have become a focus of international scientific interest and world-wide public concern. It has also been proved that EMF influences the production of reactive oxygen species (ROS) in different tissues. Methods: Experiments were performed in healthy rats and in rats with persistent inflammatory state induced by Complete Freund's Adjuvant (CFA) injection, which was given 24 h before EMF exposure and drug application. Rats were injected with CFA or the same volume of paraffin oil into the plantar surface of the left hind paw. Animals were exposed to the far-field range of an antenna at 1800 MHz with the additional modulation which was identical to that generated by mobile phone GSM 1800. Rats were given 15 min exposure, or were sham-exposed with no voltage applied to the field generator in control groups. Immediately before EMF exposure, rats were injected intraperitoneally with tramadol in the 20 mg/kg dose or vehicle in the 1 ml/kg volume. Results: Our study revealed that single EMF exposure in 1800 MHz frequency significantly reduced antioxidant capacity both in healthy animals and those with paw inflammation. A certain synergic mode of action between applied electromagnetic fields and administered tramadol in rats treated with CFA was observed. Conclusions: The aim of the study was to examine the possible, parallel/combined effects of electromagnetic radiation, artificially induced inflammation and a centrally-acting synthetic opioid analgesic drug, tramadol, (used in the treatment of severe pain) on the antioxidant capacity of blood of rats. The antioxidant capacity of blood of healthy rats was higher than that of rats which received only tramadol and were exposed to electromagnetic fields.

Bodera P, Stankiewicz W, Antkowiak B, Paluch M, Kieliszek J, Sobiech J, Niemcewicz M. Influence of electromagnetic field (1800 MHz) on lipid peroxidation in brain, blood, liver and kidney in rats. Int J Occup Med Environ Health. 2015;28(4):751-9. doi: 10.13075/ijomeh.1896.00255

OBJECTIVES: The aim of this study is the evaluation of the influence of repeated (5 times for 15 min) exposure to electromagnetic field (EMF) of 1800 MHz frequency on tissue lipid peroxidation (LPO) both in normal and inflammatory state, combined with analgesic treatment. MATERIAL AND METHODS: The concentration of malondialdehyde (MDA) as the end-product of the lipid peroxidation (LPO) was estimated in blood, liver, kidneys, and brain of Wistar rats, both healthy and those with complete Freund's adjuvant (CFA)-induced persistent paw inflammation. RESULTS: The slightly elevated levels of the MDA in blood, kidney, and brain were observed among healthy rats in electromagnetic field (EMF)-exposed groups, treated with tramadol (TRAM/EMF and exposed to the EMF). The malondialdehyde remained at the same level in the liver in all investigated groups: the control group (CON), the exposed group (EMF), treated with tramadol (TRAM) as well as exposed to and treated with tramadol (TRAM/EMF). In the group of animals treated with the complete Freund's adjuvant (CFA) we also observed slightly increased values of the MDA in the case of the control group (CON) and the exposed groups (EMF and TRAM/EMF). The MDA values concerning kidneys remained at the same levels in the control, exposed, and not-exposed group treated with tramadol. Results for healthy rats and animals with inflammation did not differ significantly. CONCLUSIONS: The electromagnetic field exposure (EMF), applied in the repeated manner together with opioid drug tramadol (TRAM), slightly enhanced lipid peroxidation level in brain, blood, and kidneys.

Boehmert C, Wiedemann P, Pye J, Croft R. The Effects of Precautionary Messages about Electromagnetic Fields from Mobile Phones and Base Stations Revisited: The Role of Recipient Characteristics. Risk Anal. 2016 May 10. doi: 10.1111/risa.12634. [Epub ahead of print]

Precautionary messages have been shown to increase recipients' threat perceptions about radio-frequency electromagnetic fields (RF-EMFs) emitted by mobile phones and mobile phone base stations. The current study explored the interplay of variables on the side of message recipients with this effect. The individual difference variables of interest were gender, trait anxiety, personal need for structure, and personal fear of invalidity. Furthermore, the study determined whether the increased threat perception is accompanied by emotional distress. A total of 298 university students answered a survey after reading either a basic text about RF-EMFs or a text including precautionary information. Linear multiple regression with interactions analyses showed that the effect of precautionary messages differed for people with different levels of trait anxiety. How trait anxiety was related to the effect of precautionary messages in turn depended on participants' gender. Personal need for structure and personal fear of invalidity were mostly unrelated to the effect of precautionary messages. Regarding participants' emotional distress, we found no difference in state anxiety scores between those participants who received precautionary information and those who did not. The findings show that the effects of precautionary messages on threat perception depend on individual difference variables such as recipients' trait anxiety and gender. Also, the fact that precautionary communication did not result in heightened state anxiety challenges the assumption that precautionary messages induce fear or anxiety.

Boga A, Emre M, Sertdemir Y, Akillioglu K, Binokay S, Demirhan O. The effect of 900 and 1800MHz GSM-like radiofrequency irradiation and nicotine sulfate administration on the embryonic development of Xenopus laevis. Ecotoxicol Environ Saf. 2014 Dec 19;113C:378-390. doi: 10.1016/j.ecoenv.2014.12.020. [Epub ahead of print]

The aim of this study was to investigate the effects of GSM-like radiofrequency electromagnetic radiation (RF EMR) and nicotine sulfate (NS) exposure on Xenopus embryonic development.The developmental effects of GSM-like RF-EMR (900-1800MHz, at a SAR value of 1W/kg and NS on Xenopus laevis embryos were investigated). Following the application of radiofrequency radiation and/or NS administration, the embryos were closely examined in order to determine their possible teratogenic effects. Xenopus frogs obtained from the Department of Physiology of the Cukurova University, in accordance described by the Standard Guide of the American Society for Testing and Materials (ASTM). Following the exposure of Xenopus embryos to RF-EMR at 900 and 1800MHz (1.0W/kg) for 4, 6 and 8h; the whole body specific energy absorption rate (SAR) of the embryos was calculated. With the exception of irradiation at 1800MHz no dramatic developmental anomalies were observed in the Xenopus embryos in association with RF-EMR applications. Combined RF-EMR and NS applications resulted in dramatic abnormalities and death among the Xenopus embryos.The study results indicated that GSM-like RF-EMR (e.g. radiation from cell phones) was not as harmful to Xenopus embryos as might have been expected. However, the combined effects of GSM-like RF-EMR and NS on Xenopus embryos were more severe than the effect of RF-EMR or NS alone. In conclusion, the study results appear to suggest that the combined use of nicotine and cell phones might result in more pronounced detrimental effects on the health of smokers.

Boga A, Emre M, Sertdemir Y, Uncu İ, Binokay S, Demirhan O. Effects of GSM-like radiofrequency irradiation during the oogenesis and spermiogenesis of Xenopus laevis. Ecotoxicol Environ Saf. 129:137-144, 2016.

We aimed to evaluate the effect of GSM-like radiofrequency electromagnetic radiation (RF-EMR) on the oogenesis, and spermiogenesis of Xenopus laevis, and so the development of the embryos obtained from Normal Females+Normal Males (i.e. "N(F)+N(M)"); Normal Females+RF-exposed Males (i.e. "N(F)+RF(M)"); RF-exposed Female+Normal Male (i.e. "RF(F)+N(M)"); and RF-exposed Female+RF-exposed Male (i.e. "RF(F)+RF(M)". Various, assessments were performed to determine potential teratogenic effects and mortality, body growth and behavior on first generation embryos. After exposing adults frogs of both sexes to 900MHz RF-EMR (at 1.0W/kg) for 8h a day over a 5-week period, the embryos' specific energy absorption rate (SAR) was calculated. In our present study (control group; 2.2% abnormal, 0.0% dead); with the N(F)+RF(M) combination, the long-term exposure of adult males to GSM-like radiation at 900MHz (RF: 2W) for 5 week/8h/day resulted in normal, abnormal and dead embryo ratios of 88.3%, 3.3% and 8.3%, respectively ($p<0.001$). In the RF(F)+N(M) combination, long-term exposure (5 week/8h/day) of adult females led to normal, abnormal and dead embryo ratios of 76.7%, 11.7%, and 11.7%, respectively ($p<0.001$). And in the RF(F)+RF(M) combination, long-term exposure (5 week/8h/day) of both adult males and females led to normal, abnormal and dead embryo ratios of 73.3%, 11.7%, and 15%, respectively ($p<0.001$). With the exception RF(F)+RF(M) group ($p<0.001$), no significant changes were observed on body growth (lengths) in comparison to the control group. It was also observed that the offspring of female adult Xenopus exposed to RF-EMR during oogenesis exhibited a more aggressive behavior compared to the control group. Cell phones radiation can thus lead to detrimental effects in humans' male and female reproductive cells.

Bogomazova AN, Vassina EM, Goryachkovskaya TN, Popik VM, Sokolov AS, Kolchanov NA, Lagarkova MA, Kiselev SL, Peltek SE. No DNA damage response and negligible genome-wide transcriptional changes in human embryonic stem cells exposed to terahertz radiation. Sci Rep. 2015 Jan 13;5:7749. doi: 10.1038/srep07749.

Terahertz (THz) radiation was proposed recently for use in various applications, including medical imaging and security scanners. However, there are concerns regarding the possible biological effects of non-ionising electromagnetic radiation in the THz range on cells. Human embryonic stem cells (hESCs) are extremely sensitive to environmental stimuli, and we therefore utilised this cell model to investigate the non-thermal effects of THz irradiation. We studied DNA damage and transcriptome responses in hESCs exposed to narrow-band THz radiation (2.3 THz) under strict temperature control. The transcription of approximately 1% of genes was subtly increased following THz irradiation. Functional annotation enrichment analysis of differentially expressed genes revealed 15 functional classes, which were mostly related to mitochondria. Terahertz irradiation did not induce the formation of γH2AX foci or structural chromosomal aberrations in hESCs. We did not observe any effect on the mitotic index or morphology of the hESCs following THz exposure.

Bohr, H, Bohr, J, Microwave enhanced kinetics observed in ORD studies of a protein. Bioelectromagnetics 21(1):68-72, 2000.

Microwaves are shown to affect the kinetics of conformational changes of the protein beta-lactoglobulin. Microwaves can accelerate conformational changes in the direction towards the equilibrium state. This applies both for the folding and the unfolding processes. Cold denaturing thermal unfolding of the proteins is accelerated by negative temperature gradients. Microwave irradiation of the protein solution heated it by about 0.3 degree, and hence the observed acceleration of denaturing is therefore non-thermal.

Bolshakov MA, Alekseev SI, Bursting responses of Lymnea neurons to microwave radiation. Bioelectromagnetics 13(2):119-129, 1992.

Microelectrode and voltage-clamp techniques were modified to record spontaneous electrical activity and ionic currents of Lymnea stagnalis neurons during exposure to a 900-MHz field in a waveguide-based apparatus. The field was pulse-modulated at repetition rates ranging from 0.5 to 110 pps, or it was applied as a continuous wave (CW). When subjected to pulsed waves (PW), rapid, burst-like changes in the firing rate of neurons occurred at SARs of a few W/kg. If the burst-like irregularity was present in the firing rate under control conditions, irradiation enhanced its probability of occurrence. The effect was dependent on modulation, but not on modulation frequency, and it had a threshold SAR near 0.5 W/kg. CW radiation had no effect on the firing rate pattern at the same SAR. Mediator-induced, current activation of acetylcholine, dopamine, serotonin, or gamma-aminobutyric-acid receptors of the neuronal soma was not altered during CW or PW exposures and, hence, could not have been responsible for the bursting effect.

Bolte JF, Eikelboom T. Personal radiofrequency electromagnetic field measurements in the Netherlands: Exposure level and variability for everyday activities, times of day and types of area. Environ Int. 48C:133-142, 2012.

Knowledge of the exposure to radiofrequency electromagnetic fields is necessary for epidemiological studies on possible health effects. The main goal of this study is to determine the exposure level and spatial and temporal variances during 39 everyday activities in 12 frequency bands used in mobile telecommunication and broadcasting. Therefore, 24h measurements were gathered from 98 volunteers living in or near Amsterdam and Purmerend, The Netherlands. They carried an activity diary to be kept to the minute, a GPS logger sampling at an interval of 1s, and an EME Spy exposimeter with a detection limit of 0.0066mW/m(2) sampling at an interval of 10s in 12 frequency bands. The mean exposure over 24h, excluding own mobile phone use, was 0.180mW/m(2). During daytime exposure was about the same, but during night it was about half, and in the evening it was about twice as high. The main contribution to environmental exposure (calling by participant not included) is from calling with mobile phones (37.5%), from cordless DECT phones and their docking stations (31.7%), and from the base stations (12.7%). The exposure to mobile phone base stations increases with the percentage of urban ground use, which is an indication for high people density. In agreement, the highest mean exposure relates to the activities with high people density, such as travelling by public transport, visiting social events, pubs or shopping malls. Exposure at home depends mainly on exposure from people calling in the neighbourhood of the participant and thus on the number of persons in a household. In addition just the possession of DECT docking stations leads to exposure as most models transmit continuously in stand-by. Also wireless internet routers continuously transmit in the WiFi band. Though the highest exposure peaks in the WiFi band, up to 0.265W/m(2), come from stray radiation of microwave ovens. The mean total exposure largely depends on phone calls of a high exposure level and short duration. These calls lead to potentially high contrasts as well in exposure levels between sessions of the same activity as between persons, thus posing a challenge for personal exposure prediction.

Borbely, AA, Huber, R, Graf, T, Fuchs, B, Gallmann, E, Achermann, P, Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram. Neurosci Lett 275(3):207-210, 1999.

To investigate whether the electromagnetic field (EMF) emitted by digital radiotelephone handsets affects the brain, healthy, young subjects were exposed during an entire night-time sleep episode to an intermittent radiation schedule (900 MHz; maximum specific absorption rate 1 W/kg) consisting of alternating 15-min on-15-min off intervals. Compared with a control night with sham exposure, the amount of waking after sleep onset was reduced from 18 to 12 min. Spectral power of the electroencephalogram in non-rapid eye movement sleep was increased. The maximum rise occurred in the 10-11 Hz and 13.5-14 Hz bands during the initial part of sleep and then subsided. The results demonstrate that pulsed high-frequency EMF in the range of radiotelephones may promote sleep and modify the sleep EEG.

Bornhausen M, Scheingraber H, Prenatal exposure to 900 MHz, cell-phone electromagnetic fields had no effect on operant-behavior performances of adult rats. Bioelectromagnetics 21(8):566-574, 2000.

To clarify potential health risks of radio-frequency electromagnetic fields (EMFs) used in cellular telephone technology to the developing brain, Wistar rats were continuously exposed during pregnancy to a low-level (0.1 mW/cm(2)) 900 MHz, 217 Hz pulse modulated EMF that approximated the highest legal exposure of normal populations to the radiation of base antennas of the GSM digital cell-phone technology. Whole body average specific absorption rate (SAR) values for the freely roaming, pregnant animals were measured in models; they ranged between 17.5 and 75 mW/kg. The offspring of exposed and of sham-exposed dams were coded and tested later as adults in a battery of ten simultaneously operated test chambers (Skinner boxes) during night time. Eight groups of ten coded animals in each group were tested for learning deficits in a sequence of nine, computer-controlled, 15 h sessions of the food-reinforced contingency Differential Reinforcement of Rate with increasing performance requirements. Two different sets of events were recorded: The food-reinforced lever-pressing activity of the animals and the inter-response intervals (IRIs) between consecutive lever presses. IRI-occurence patterns discriminated consistently between "learners" and "non-learners". Analyses of performance scores and of IRI-patterns both showed that exposure in-utero to the GSM field did not induce any measurable cognitive deficits.

Bornkessel C, Schubert M, Wuschek M, Schmidt P. Determination of the general public exposure around GSM and UMTS base stations. Radiat Prot Dosimetry. 124(1):40-47, 2007.

This paper summarises two studies, in which measurement and calculation methods to determine the exposure of the general public around GSM and UMTS base stations have been developed and applied to different scenarios. The electromagnetic field variations around the stations in space and time are accounted for by appropriate maximisation techniques. Measurements show a bandwidth of exposures from 0.01% to more than 10% of field strength exposure limits. The distance to the station is not a main influencing factor, whereas the orientation to the main lobe and the sight conditions greatly influence exposure. Several commercially available numerical simulation tools were tested for their applicability on exposure forecast. In line-of-sight scenarios, all programs are able to predict the exposure accurately, whereas in non-line-of-sight situations, free space models overestimate the real exposure by some orders of magnitude.

Bortkiewicz A, Zmyslony M, Gadzicka E, Szymczak W, [Evaluation of selected parameters of circulatory system function in various occupational groups exposed to high frequency electromagnetic fields. II. Electrocardiographic changes]. Med Pr 47(3):241-252, 1996. [Article in Polish]

The effect of electromagnetic fields (EMF) on the circulatory and nervous systems has been the subject of great interest for many years, since electric impulses generated in these systems by outer electric and magnetic fields can theoretically disturb their functions. The only data on chronic effect of weak EMFs on the human body come from the studies carried out in the Soviet Union between the fifties and the seventies. In view of a growing number of persons exposed to EMF, there is an urgent need for verifying those data by means of modern diagnostic methods. That is the reason why our study of the EMF effect on the circulatory system has been initiated. It covered 71 workers at four AM broadcast stations, 40 workers at ten radio link stations and 42 workers at three radioservices. Workers' exposure to EMF was evaluated (see part I). Subjective and objective medical examinations were performed in all workers in order to assess their state of health, then resting electrocardiogram, Holter measurements, and high intensity ECG were taken, and variation in cardiac rhythm was analysed by a long-term recording of blood pressure. The results of the analysis of the questionnaire survey as well as the Holter and resting ECG examinations are presented. The study indicated that exposure to EMF in parameters found in AM broadcast station increased risk for electrographic disturbances (detected by means of resting ECG and a 24-hour Holter recording) by six times in comparison with that in radio link station workers not exposed to medium wave EMF. In radioservice workers this risk was twice as high as that in link station workers. It seems that in AM broadcast station workers, resting ECG should be complemented by a 24-hour Holter measurements, particularly, if workers complain of the circulatory system disturbances.

Bortkiewicz A, Gadzicka E, Zmyslony M, Heart rate variability in workers exposed to medium-frequency electromagnetic fields. J Auton Nerv Syst 59(3):91-97, 1996

This study was undertaken to evaluate the neurovegetative regulation of the heart in workers occupationally exposed to medium frequency (MF) electromagnetic (EM) fields. The subjects were 71 workers of MF broadcast stations, aged 20-68 (mean 47.1) with the duration of work under exposure ranging from 2-40 years and 22 workers of radio link stations, aged 21-65 (mean 46.9) who were not exposed to MF EM fields. The distribution of age and work tenure in both groups did not differ significantly. Heart rate variability (HRV) was analysed basing on 512 normal heart evolutions registered in resting, from the body surface, using the Medea-HRV system. The analysis concerned time-domain and frequency-domain parameters of HRV using fast fourier transformation. Power spectrum in the low (0.05-0.15 Hz) and high (0.15-0.35 Hz) frequency bands (LF and HF, respectively) was determined. Statistically insignificant differences found between exposed and non-exposed groups were found either in time- or in frequency-domain parameters of HRV. No correlation between the power spectrum and the subjects age was noted. Such a relationship, however, could be observed in the control group. In the study group a statistically significant negative correlation was found between the maximum intensity of EM fields and HF power spectrum. Thus it was concluded that occupational exposure to EM fields brings about impairments in the neurovegetative regulation of the cardiovascular function.

Bortkiewicz, A, Zmyslony, M, Gadzicka, E, Palczynski, C, Szmigielski, S, Ambulatory ECG monitoring in workers exposed to electromagnetic fields. J Med Eng Technol 21(2):41-46, 1997.

The aim of this study was to evaluate the function of the circulatory system in workers occupationally exposed to medium frequency electromagnetic fields. The subjects were 71 workers at four AM broadcast stations [0.738-1.503 MHz] aged 20-68 (mean 46.9 +/- 13.1) years and 22 workers at radio link stations aged 23-67 (mean 48.2 +/- 17.4) years. Workers at AM broadcast stations experienced 2-40 (mean 18.6 +/- 12.1) years' exposure to electromagnetic fields (average daily exposure dose about 115 Vh m-1, maximum exposure levels during shift about 165 V m-1), workers at radio link stations had no history of regular exposure to electromagnetic fields. In all the subjects a general medical examination, resting ECG and 24 h Holter monitoring were performed. The work organization, work period structure, age, lifestyle, nutritional habits and health status in both groups remained fairly similar. The electrocardiographic abnormalities detected in the resting and/ or 24 h ECG were significantly more frequent (p = 0.006) in workers exposed to electromagnetic fields than in non-exposed subjects (75% versus 25%). A clear tendency for a higher number of rhythm disturbances (mostly ExV) was observed in AM broadcast station workers.

Bortkiewicz A, Pilacik B, Gadzicka E, Szymczak W. The excretion of 6-hydroxymelatonin sulfate in healthy young men exposed to electromagnetic fields emitted by cellular phone -- an experimental study. Neuroendocrinol Lett 23 Suppl 1:88-91, 2002.

OBJECTIVES: It is quite likely that non-visible electromagnetic fields (EMF) may affect melatonin production. Some studies confirmed this hypothesis and showed that extremely low EMF altered pineal function in animals and humans. Thus, it is reasonable to suppose that EMF emitted by cellular phones may also influence secretion of melatonin. The present study sought to evaluate possible effect of the exposure to EMF emitted by cellular phone on 6-hydroxymelatonin sulfate (6-OHMS) excretion, which reflects melatonin levels in blood. MATERIAL AND METHODS: The examined group consisted of 9 healthy males aged 19-29 years. The experiment was performed under controlled conditions (the light intensity-50 lx till midnight and 0 lx during night). Each person was examined twice: on a day without exposure (control day, C-day) and on a day with continuous exposure (60 min. exposure from cellular phone, frequency 900 MHz, pulsed with 217 Hz, pulse with 576 micros, SAR 1.23 W/kg, E-day). From 7 p.m. to 8 p.m. they used a cellular phone. The subjects did not know which day was E-day, and which was C-day. From 8 p.m. till midnight the subjects listened to music and than they slept till 7 a.m. next day. Urine samples were collected at 7 p.m., at midnight, and at 7 a.m. in the same way in C-day as in E-day. Sample were frozen for later ELISA analysis of 6-OHMS. The 6-OHMS ELISA kit from Immuno-Biological Laboratories (Hamburg) was used for measurement of 6-OHMS. The data were analysed using Wilcoxon matched-pairs signed-ranks test for each subject and for the whole group. We compared 6-OHMS level on the E-day and on the C-day separately for 3 time-points - 7 p.m., midnight, 7 a.m. RESULTS: Mean 6-OHMS level in both experiments did not differ significantly for any of the respective time points. Circadian variations of 6-OHMS level were detected in all subjects. CONCLUSIONS: The results of our investigation has demonstrated that EMF emitted by cellular phones has no distinct influence on the melatonin level.

Bortkiewicz A, Zmyslony M, Szyjkowska A, Gadzicka E. [Subjective symptoms reported by people living in the vicinity of cellular phone base stations: a review of the studies] Med Pr. 55(4):345-351, 2004. [Article in Polish]

The problem of health effects of electromagnetic fields (EMF) emitted by cellular phone base stations evokes much interest in view of the fact that people living in their vicinity are fated to continuous exposure to EMF. None of the studies carried out throughout the world have revealed excessive values of standards adopted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). A questionnaire was used as a study tool. The results of the questionnaire survey reveal that people living in the vicinity of base stations report various complaints mostly of the circulatory system, but also of sleep disturbances, irritability, depression, blurred vision, concentration difficulties, nausea, lack of appetite, headache and vertigo. The performed studies showed the relationship between the incidence of individual symptoms, the level of exposure, and the distance between a residential area and a base station. This association was observed in both groups of persons, those who linked their complaints with the presence of the base station and those who did not notice such a relation. Further studies, clinical and those based on questionnaires, are needed to explain the background of reported complaints.

Bortkiewicz A, Gadzicka E, Szyjkowska A, Politański P, Mamrot P, Szymczak W, Zmyślony M. Subjective complaints of people living near mobile phone base stations in Poland. Int J Occup Med Environ Health. 25(1):31-40, 2012.

OBJECTIVES: The aim of our study was to assess the health conditions and subjective symptoms of the inhabitants living in the base stations vicinity and to analyse the relationship between the complaints and level of exposure to electromagnetic fields (EMF).MATERIALS AND METHODS: Our study was performed in housing estates located in five regions of Łódź. The electric field measurements were performed in the buildings located closest to the azimuth of the antennas. Respondents were selected by trained interviewers using an uniform procedure. The number of the households to be examined was set at a minimum of 420. The questionnaire contained: demographic data, occupational and environmental exposure to EMF, health condition, subjective complaints. Results were adjusted for confounders (age, gender, EMF at the workplace and EMF emitted by household equipment) using multiple regression model.RESULTS: 181 men and 319 women from 500 households were examined. Electric field above 0.8 V/m was recorded in 12% of flats. There was no significant correlation between electric field strength and the distance of examined flats from the base stations. To make possible comparison with relevant literature, we analysed also the frequency of the reported symptoms vs. the distance. Headache was declared by 57% people, most frequently (36.4%) living 100-150 m away from the base station compared to people living at longer distances ($p = 0.013$). 24.4% subjects, mostly living at a distance above 150 m, declared impaired memory. Difference was statistically significant in comparison with people living at other distances ($p = 0.004$).CONCLUSIONS: The explanation why we did not find any correlation between the electric field strength and frequency of subjective symptoms but found a correlation between subjective symptoms and distance from base station needs further studies. Maybe new metrics of exposure assessment should be adopted for this purpose.

Bortkiewicz A, Gadzicka E, Szymczak W, Zmyślony M. Changes in tympanic temperature during the exposure to electromagnetic fields emitted by mobile phone. Int J Occup Med Environ Health. 25(2): 145-150, 2012.

OBJECTIVE: Mobile phones generate microwave radiation which is absorbed by exposed tissue and converted into heat. It may cause detrimental health effects. The aim of the experiment was to check if exposure to EMF emitted by mobile phone influenced the tympanic temperature.MATERIAL AND METHODS: Human volunteer study was performed on ten healthy young men, aged 22.1±4.7 years, examined three times: 1. on a day with 2×60 min of no exposure (sham day), 2. on a day with continuous, 60 min exposure and 60 min of no exposure, 3. on a day with intermittent exposure (4×15 min "on" and 4×15 min "off"). Exposure was generated by mobile phone (frequency 900 MHz, SAR 1.23 W/kg). The study was double-blind, performed under controlled conditions (at 24°C and 70% humidity). The tympanic temperature (T(ty)) was monitored every 10 sec by a thermistor probe placed close to the aural canal membrane in the ear opposite the one in contact with mobile phone (contralateral position). Multivariate repeated-measures analysis of variance was used to calculate the results.RESULTS: The mean T(ty) in the whole group during continuous exposure was significantly higher than during sham exposure ($p = 0.0001$). During intermittent exposure the temperature was lower than during sham day (difference was up to 0.11°C). Within an hour after continuous exposure, T(ty) was higher by 0.03°C and after intermittent exposure T(ty) was lower by 0.18°C in comparison with sham day. Two hours after exposure T(ty) was significantly lower ($p = 0.0001$) than after sham exposure (0.06°C and 0.26°C respectively). The trends in T(ty) during experiment differed significantly in relation to exposure conditions ($p < 0.05$).CONCLUSIONS: The results of this analysis indicate that the physiological response to EMF exposure from mobile phone was mostly related to type of exposure (continuous or intermittent).

Bortkiewicz A, Gadzicka E, Szymczak W, Zmyślony M. Heart rate variability (HRV) analysis in radio and TV broadcasting stations workers. Int J Occup Med Environ Health. 25(4):446-455, 2012.

OBJECTIVES: The aim of the study was to assess the mechanism of cardiovascular impairments in workers exposed to UHF-VHF radio frequency electromagnetic fields (EMF). **MATERIALS AND METHODS:** Heart rate variability (HRV) was analysed using 512 normal heart beats registered at rest. The analysis concerned time-domain (STD R-R) and frequency-domain (VLF, LF, HF) parameters of HRV. Fifty nine workers (group I) with low-level and 12 workers (group II) with high-level exposure were examined. The mean age of the subjects was 47 ± 9 years and 41 ± 14 years, and mean exposure duration 19.1 ± 8.8 years and 13 ± 4 years, in groups I and II, respectively. The groups were divided according to: E(max), E(dose), E(mean) for frequencies UHF, VHF and UHF+VHF: The control group consisted of 42 non-exposed subjects, aged 49 ± 8 years. Statistical analysis comprised one-way analysis of variance, covariance analysis and logistic regression models. **RESULTS:** In the exposed groups, the heart rate was higher than in the control one. Standard deviation of R-R intervals (STD R-R) was found to be significantly ($p = 0.0285$) lower in group I (42.5 ± 24.7 ms) compared to the control group (62.9 ± 53.5 ms). The risk of lowered STD R-R was significantly increased (OR = 2.37, $p = 0.023$) in group II. Both exposed groups presented significantly higher VLF and LF values than the control group ($p = 0.005$ and $p = 0.0025$, respectively). The EMF-exposed groups were characterised by the dominance of the sympathetic system (LF/HF 1.3 ± 0.35). **CONCLUSIONS:** The results indicate that exposure to radiofrequency EMF may affect the neurovegetative regulation.

Boscol P, Di Sciascio MB, D'Ostilio S, Del Signore A, Reale M, Conti P, Bavazzano P, Paganelli R, Di Gioacchino M. Effects of electromagnetic fields produced by radiotelevision broadcasting stations on the immune system of women. Sci Total Environ 273(1-3):1-10, 2001.

The object of this study was to investigate the immune system of 19 women with a mean age of 35 years, for at least 2 years (mean = 13 years) exposed to electromagnetic fields (ELMFs) induced by radiotelevision broadcasting stations in their residential area. In September 1999, the ELMFs (with range 500 KHz-3 GHz) in the balconies of the homes of the women were (mean +/- S.D.) 4.3 +/- 1.4 V/m. Forty-seven women of similar age, smoking habits and atopy composed the control group, with a nearby resident ELMF exposure of < 1.8 V/m. Blood lead and urinary trans-trans muconic acid (a metabolite of benzene), markers of exposure to urban traffic, were higher in the control women. The ELMF exposed group showed a statistically significant reduction of blood NK CD16+-CD56+, cytotoxic CD3(-)-CD8+, B and NK activated CD3(-)-HLA-DR+ and CD3(-)-CD25+ lymphocytes. 'In vitro' production of IL-2 and interferon-gamma (INF-gamma) by peripheral blood mononuclear cells (PBMC) of the ELMF exposed group, incubated either with or without phytohaemoagglutinin (PHA), was significantly lower; the 'in vitro' production of IL-2 was significantly correlated with blood CD16+-CD56+ lymphocytes. The stimulation index (S.I.) of blastogenesis (ratio between cell proliferation with and without PHA) of PBMC of ELMF exposed women was lower than that of the control subjects. The S.I. of blastogenesis of the ELMF exposed group (but not blood NK lymphocytes and the 'in vitro' production of IL-2 and INF-gamma by PBMC) was significantly correlated with the ELMF levels. Blood lead and urinary trans-trans muconic acid were barely correlated with immune parameters: the urinary metabolite of benzene of the control group was only correlated with CD16+-CD56+ cells indicating a slight effect of traffic on the immune system. In conclusion, this study demonstrates that high frequency ELMFs reduce cytotoxic activity in the peripheral blood of women without a dose-response effect.

Bouji M, Lecomte A, Hode Y, de Seze R, Villégier AS. Effects of 900MHz radiofrequency on corticosterone, emotional memory and neuroinflammation in middle-aged rats. Exp Gerontol.47(6): 444-451, 2012.

The widespread use of mobile phones raises the question of the effects of electromagnetic fields (EMF, 900MHz) on the brain. Previous studies reported increased levels of the glial fibrillary acidic protein (GFAP) in the rat's brain after a single exposure to 900MHz global system for mobile (GSM) signal, suggesting a potential inflammatory process. While this result was obtained in adult rats, no data is currently available in older animals. Since the transition from middle-age to senescence is highly dependent on environment and lifestyle, we studied the reactivity of middle-aged brains to EMF exposure. We assessed the effects of a single 15min GSM exposure (900MHz; specific absorption rate (SAR)=6W/kg) on GFAP expression in young adults (6week-old) and middle-aged rats (12month-old). Brain interleukin (IL)-1β and IL-6, plasmatic levels of corticosterone (CORT), and emotional memory were also assessed. Our data indicated that, in contrast to previously published work, acute GSM exposure did not induce astrocyte activation. Our results showed an IL-1β increase in the olfactory bulb and enhanced contextual emotional memory in GSM-exposed middle-aged rats, and increased plasmatic levels of CORT in GSM-exposed young adults. Altogether, our data showed an age dependency of reactivity to GSM exposure in neuro-immunity, stress and behavioral parameters. Reproducing these effects and studying their mechanisms may allow a better understanding of mobile phone EMF effects on neurobiological parameters.

Bouji M, Lecomte A, Gamez C, Blazy K, Villégier AS. Neurobiological effects of repeated radiofrequency exposures in male senescent rats. Biogerontology. 17(5-6):841-857, 2016.

The increasing use of mobile phones by aging people raises issues about the effects of radiofrequency electromagnetic fields (RF-EMF) on the aging central nervous system. Here, we tested if mobile phone RF-EMF exposures could exacerbate senescence-typical neurobiological deficits. Thus, aged (22-24 months) and young (4-6 months) adult male rats were subjected to head RF-EMF exposures (900 MHz, specific absorption rate (SAR) of 6 W/kg, 45 min/day for 1 month in restraint rockets). To assess senescence-typical neurobiological deficits, spatial memory, emotional memory, anxiety-related behavior, locomotor activity, interleukins (IL)-1β and 6, glial fibrillary acidic protein and corticosterone were measured. Aged rats presented deficits in spatial learning, exploration, anxiety-related behaviors, and increased hippocampal ILs and cortical IL-1β.

Results showed that senescence-typical neurobiological deficits were not modified by RF-EMF exposures. RF-EMF-exposed rats (young and aged adults pooled) had decreased anxiety-related behaviors in the elevated plus maze. This study which is the first to assess RF-EMF exposures during late aging did not support the hypothesis of a specific cerebral vulnerability to RF-EMF during senescence. More investigations using longer RF-EMF exposures should be performed to conclude regarding the inoffensiveness of RF-EMF exposures.

Bourdineaud JP, Šrut M, Štambuk A, Tkalec M, Brèthes D, Malarić K, Klobučar GIV. Electromagnetic fields at a mobile phone frequency (900 MHz) trigger the onset of general stress response along with DNA modifications in Eisenia fetida earthworms. Arh Hig Rada Toksikol. 68(2):142-152, 2017.

Eisenia fetida earthworms were exposed to electromagnetic field (EMF) at a mobile phone frequency (900 MHz) and at field levels ranging from 10 to 120 V m-1 for a period of two hours (corresponding to specific absorption rates ranging from 0.13 to 9.33 mW kg-1). Potential effects of longer exposure (four hours), field modulation, and a recovery period of 24 h after two hours of exposure were addressed at the field level of 23 V m-1. All exposure treatments induced significant DNA modifications as assessed by a quantitative random amplified polymorphic DNA-PCR. Even after 24 h of recovery following a two hour-exposure, the number of probe hybridisation sites displayed a significant two-fold decrease as compared to untreated control earthworms, implying a loss of hybridisation sites and a persistent genotoxic effect of EMF. Expression of genes involved in the response to general stress (HSP70 encoding the 70 kDa heat shock protein, and MEKK1 involved in signal transduction), oxidative stress (CAT, encoding catalase), and chemical and immune defence (LYS, encoding lysenin, and MYD, encoding a myeloid differentiation factor) were up-regulated after exposure to 10 and modulated 23 V m-1 field levels. Western blots showing an increased quantity of HSP70 and MTCO1 proteins confirmed this stress response. HSP70 and LYS genes were up-regulated after 24 h of recovery following a two hour-exposure, meaning that the effect of EMF exposure lasted for hours.

Bourthoumieu S, Joubert V, Marin B, Collin A, Leveque P, Terro F, Yardin C. Cytogenetic studies in human cells exposed in vitro to GSM-900 MHz radiofrequency radiation using R-banded karyotyping. Radiat Res 174:712-718, 2010.

It is important to determine the possible effects of exposure to radiofrequency (RF) radiation on the genetic material of cells since damage to the DNA of somatic cells may be linked to cancer development or cell death and damage to germ cells may lead to genetic damage in next and subsequent generations. The objective of this study was to investigate whether exposure to radiofrequency radiation similar to that emitted by mobile phones of second-generation standard Global System for Mobile Communication (GSM) induces genotoxic effects in cultured human cells. The cytogenetic effects of GSM-900 MHz (GSM-900) RF radiation were investigated using R-banded karyotyping after in vitro exposure of human cells (amniotic cells) for 24 h. The average specific absorption rate

(SAR) was 0.25 W/kg. The exposures were carried out in wire-patch cells (WPCs) under strictly controlled conditions of temperature. The genotoxic effect was assessed immediately or 24 h after exposure using four different samples. One hundred metaphase cells were analyzed per assay. Positive controls were provided by using bleomycin. We found no direct cytogenetic effects of GSM-900 either 0 h or 24 h after exposure. To the best of our knowledge, our work is the first to study genotoxicity using complete R-banded karyotyping, which allows visualizing all the chromosomal rearrangements, either numerical or structural.

Bourthoumieu S, Terro F, Leveque P, Collin A, Joubert V, Yardin C. Aneuploidy studies in human cells exposed in vitro to GSM-900 MHz radiofrequency radiation using FISH. Int J Radiat Biol 87:400-408, 2011.

PURPOSE: Since previous research found an increase in the rate of aneuploidies in human lymphocytes exposed to radiofrequencies, it seems important to perform further studies. The objective of this study was then to investigate whether the exposure to RF (radiofrequency) radiation similar to that emitted by mobile phones of a second generation standard, i.e., Global System for Mobile communication (GSM) may induce aneuploidy in cultured human cells. MATERIALS AND METHODS: The potential induction of genomic instability by GSM-900 MHz radiofrequency (GSM-900) was investigated after in vitro exposure of human amniotic cells for 24 h to average-specific absorption rates (SAR) of 0.25, 1, 2 and 4 W/kg in the temperature range of 36.3-39.7°C. The exposures were carried out in a wire-patch cell (WPC). The rate of aneuploidy of chromosomes 11 and 17 was determined by interphase FISH (Fluorescence In Situ Hybridisation) immediately after independent exposure of three different donors for 24 h. At least 100 interphase cells were analysed per assay. RESULTS: No significant change in the rate of aneuploidy of chromosomes 11 and 17 was found following exposure to GSM-900 for 24 h at average SAR up to 4 W/kg. CONCLUSION: Our study did not show any in vitro aneuploidogenic effect of GSM using FISH and is not in agreement with the results of previous research.

Bourthoumieu S, Magnaudeix A, Terro F, Leveque P, Collin A, Yardin C. Study of p53 expression and post-transcriptional modifications after GSM-900 radiofrequency exposure of human amniotic cells.Bioelectromagnetics. 2012 Jul 5. doi: 10.1002/bem.21744. [Epub ahead of print]

The potential effects of radiofrequency (RF) exposure on the genetic material of cells are very important to determine since genome instability of somatic cells may be linked to cancer development. In response to genetic damage, the p53 protein is activated and can induce cell cycle arrest allowing more time for DNA repair or elimination of damaged cells through apoptosis. The objective of this study was to investigate whether the exposure to RF electromagnetic fields, similar to those emitted by mobile phones of the second generation standard, Global System for Mobile Communications (GSM), may induce expression of the p53 protein and its activation by post-translational modifications in cultured human cells. The potential induction of p53 expression and activation by GSM-900 was investigated after in vitro exposure of human amniotic cells for 24 h to average specific absorption rates (SARs) of 0.25, 1, 2, and 4 W/kg in the temperature range of

36.3-39.7 °C. The exposures were carried out using a wire-patch cell (WPC) under strictly controlled conditions of temperature. Expression and activation of p53 by phosphorylation at serine 15 and 37 were studied using Western blot assay immediately after three independent exposures of cell cultures provided from three different donors. Bleomycin-exposed cells were used as a positive control. According to our results, no significant changes in the expression and activation of the p53 protein by phosphorylation at serine 15 and 37 were found following exposure to GSM-900 for 24 h at average SARs up to 4 W/kg in human embryonic cells.

Brande FV, Martens P. A false positive arrhythmia on electrocardiogram induced by a cell phone. Eur J Emerg Med. 10(4):357-360, 2003.

A case report.

Braune, S, Wrocklage, C, Raczek, J, Gailus, T, Lucking, CH, Resting blood pressure increase during exposure to a radio-frequency electromagnetic field. Lancet 351(9119):1857-1858, 1998.

Exposure of the right hemisphere to a radiofrequency EMF for 35 min causes in human subjects an increase in sympathetic efferent activity with increases the resting blood pressure between 5-10 mm Hg. The effect is likely caused by vasoconstriction.

Braune S, Riedel A, Schulte-Monting J, Raczek J. Influence of a radiofrequency electromagnetic field on cardiovascular and hormonal parameters of the autonomic nervous system in healthy individuals. Radiat Res 158(3):352-356, 2002.

The potential health risks of radiofrequency electromagnetic fields (EMFs) emitted by mobile phones are of considerable public interest. The present study investigated the hypothesis, based on the results of our previous study, that exposure to EMFs can increase sympathetic vasoconstrictor activity. Forty healthy young males and females underwent a single-blind, placebo-controlled protocol once on each of two different days. Each investigation included successive periods of placebo and EMF exposure, given in a randomized order. The exposure was implemented by a GSM-like signal (900 MHz, pulsed with 217 Hz, 2 W) using a mobile phone mounted on the right-hand side of the head in a typical telephoning position. Each period of placebo exposure and of EMF exposure consisted of 20 min of supine rest, 10 min of 70 degrees upright tilt on a tilt table, and another 20 min of supine rest. Blood pressure, heart rate and cutaneous capillary perfusion were measured continuously. In addition, serum levels of norepinephrine, epinephrine, cortisol and endothelin were analyzed in venous blood samples taken every 10 min. Similar to the previous study, systolic and diastolic blood pressure each showed slow, continuous, statistically significant increases of about 5 mmHg during the course of the protocol. All other parameters either decreased in parallel or remained constant. However, analysis of variance showed that the changes in blood pressure and in all other parameters were independent of the EMF exposure. These findings do not support the assumption of a nonthermal influence of EMFs emitted by mobile phones on the cardiovascular autonomic nervous system in healthy humans.

Brautbar N. Rapid development of brain tumors in 2 cellular phone testers. Arch Environ Health. 58(9):606, 2003.

Two case reports. Comment on [Richter ED, Berman T, Levy O. Brain cancer with induction periods of less than 10 years in young military radar workers. Arch Environ Health. 2002 Jul-Aug;57(4):270-272.]

Breckenkamp J, Blettner M, Schüz J, Bornkessel C, Schmiedel S, Schlehofer B, Berg-Beckhoff G. Residential characteristics and radiofrequency electromagnetic field exposures from bedroom measurements in Germany. Radiat Environ Biophys. 51(1):85-92, 2012.

The objectives of this study were to assess total exposure to radiofrequency electromagnetic fields (RF-EMF) in bedrooms and the contribution of different radioservices (FM radio, analogue TV and DVB-T, TETRA, GSM900 downlink, GSM1800 downlink, UMTS downlink, DECT, and wireless LAN and blue tooth) to the total exposure. Additional aims were to describe the proportion of measuring values above the detection limit of the dosimeters and to characterize the differences in exposure patterns associated with self-reported residential characteristics. Exposure to RF sources in bedrooms was measured using Antennessa(®) EME Spy 120 dosimeters in 1,348 households in Germany; 280 measures were available for each frequency band per household. Mean electrical field strengths and power flux densities were calculated. Power flux densities allow the calculation of proportions of different radioservices on total exposure. Exposure was often below the detection limit (electrical field strength: 0.05 V/m) of the dosimeter. Total exposure varied, depending on residential characteristics (urban vs. rural areas and floor of a building the measurement took place). Major sources of exposure were cordless phones (DECT standard) and wireless LAN/blue tooth contributing about 82% of total exposure (20.5 μW/m(2)). Exposure to RF-EMF is ubiquitous, but exposure levels are-if at all measurable-very low and far below the ICNIRP's exposure reference levels.

Brescia F, Sarti M, Massa R, Calabrese ML, Sannino A, Scarfi MR. Reactive oxygen species formation is not enhanced by exposure to UMTS 1950 MHz radiation and co-exposure to ferrous ions in Jurkat cells. Bioelectromagnetics.30(7):525-535, 2009.

This study was designed to assess if radiofrequency (RF) radiation induces oxidative stress in cultured mammalian cells when given alone or in combination with ferrous ions (FeSO(4)). For this purpose the production of reactive oxygen species (ROS) was measured by flow cytometry in human lymphoblastoid cells exposed to 1950 MHz signal used by the third generation wireless technology of the Universal Mobile Telecommunication System (UMTS) at Specific Absorption Rate of 0.5 and 2.0 W/kg. Short (5-60 min) or long (24 h) duration exposures were carried out in a waveguide system under strictly controlled conditions of both dosimetry and environment. Cell viability was also measured after 24 h RF exposure using the Resazurin and Neutral Red assays. Several co-exposure protocols were applied to test if RF radiation is able to alter ROS formation induced by FeSO(4) (RF given before or concurrently to FeSO(4)). The results obtained indicate that non-thermal RF exposures do not increase spontaneous ROS formation in any of the experimental conditions investigated. Consistent with the lack of ROS production, no change in cell viability was observed in Jurkat cells exposed to RF radiation for 24 h. Similar results were obtained when co-exposures were considered: combined exposures to RF radiation and FeSO(4) did not increase ROS formation induced by the chemical treatment alone. In contrast, in cultures treated with FeSO(4) as positive control, a dose-dependent increase in ROS formation was recorded, validating the sensitivity of the method employed.

Brezitskaia HV, Timchenko OI, [On the mechanism of cytogenetic effect of electromagnetic radiation: a role of oxidation homeostasis]. Radiats Biol Radioecol 40(2):149-153, 2000. [Article in Russian]

It was established in the experiments on rats that the changes in free radical oxidation under the influence of non-ionizing radiation had a wavy character. It was revealed that the changes in oxidation homeostasis preceded development of cytogenetic effects and could be their reason.

Briggs D, Beale L, Bennett J, Toledano MB, de Hoogh K. A geographical model of radio-frequency power density around mobile phone masts. Sci Total Environ.426:233-243, 2012.

Public concern about possible health effects of EMF radiation from mobile phone masts has led to an increase of epidemiological studies and health risk assessments which, in turn, require adequate methods of exposure estimation. Difficulties in exposure modelling are exacerbated both by the complexity of the propagation processes, and the need to obtain estimates for large study populations in order to provide sufficient statistical power to detect or exclude the small relative risks that might exist. Use of geographical information system (GIS) techniques offers the means to make such computations efficiently. This paper describes the development and field validation of a GIS-based exposure model (Geomorf). The model uses a modified Gaussian formulation to represent spatial variations in power densities around mobile phone masts, on the basis of power output, antenna height, tilt and the surrounding propagation environment. Obstruction by topography is allowed for, through use of a visibility function. Model calibration was done using field data from 151 measurement sites (1510 antenna-specific measurements) around a group of masts in a rural location, and 50 measurement sites (658 antenna-specific measurements) in an urban area. Different parameter settings were found to be necessary in urban and rural areas to obtain optimum results. The calibrated models were then validated against independent sets of data gathered from measurement surveys in rural and urban areas, and model performance was compared with that of two commonly used path-loss models (the COST-231 adaptations of the Hata and Walfisch-Ikegami models). Model performance was found to vary somewhat between the rural and urban areas, and at different measurement levels (antenna-specific power density, total power density), but overall gave good estimates (R(2)=0.641 and 0.615, RMSE=10.7 and 6.7dBm at the antenna and site-level respectively). Performance was considerably better than that of both path loss models.

Brillaud E, Piotrowski A, de Seze R. Effect of an acute 900MHz GSM exposure on glia in the rat brain: A time-dependent study. Toxicology.238(1):23-33,2007.

Because of the increasing use of mobile phones, the possible risks of radio frequency electromagnetic fields adverse effects on the human brain has to be evaluated. In this work we measured GFAP expression, to evaluate glial evolution 2, 3, 6 and 10 days after a single GSM exposure (15min, brain averaged SAR=6W/kg, 900MHz signal) in the rat brain. A statistically significant increase of GFAP stained surface area was observed 2 days after exposure in the frontal cortex and the caudate putamen. A smaller statistically significant increase was noted 3 days after exposure in the same areas and in the cerebellum cortex. Our results confirm the Mausset-Bonnefont et al. study [Mausset-Bonnefont, A.L., Hirbec, H., Bonnefont, X., Privat, A., Vignon, J., de Seze, R., 2004. Acute exposure to GSM 900MHz electromagnetic fields induces glial reactivity and biochemical modifications in the rat brain. Neurobiol. Dis. 17, 445-454], showing the existence of glial reactivity after a 15min GSM acute exposure at a brain averaged SAR of 6W/kg. We conclude to a temporary effect, probably due to a hypertrophy of glial cells, with a temporal and a spatial modulation of the effect. Whether this effect could be harmful remains to be studied.

Brown HD, Chattopadhyay SK, Ouabain inhibition of kidney ATPase is altered by 9.14 GHz radiation. Bioelectromagnetics 12(3):137-143, 1991.

At each of several stabilized temperatures between 7.0 and 43.8 degrees C, increases in dog-kidney, Na(+)-, K(+)-ATPase catalytic activity were usually observed in association with exposure for 5 min to 9.14 GHz CW microwave radiation in a thin tubular reactor. However, at 24.9 degrees C, a 23% decrease occurred. Comparisons of activity of ouabain-inhibited reactions revealed that the efficacy of the cardiac glycoside as an inhibitor of ATPase activity was severely diminished by the microwave field. The ouabain-site control mechanism may be a specific microwave target at this exposure frequency. Experimental results can be interpreted in terms of molecular structural changes or direct energy input. The estimated SAR of energy that was incident on preparations is 20 W/kg.

Brown DO, Lu ST, Elson EC, Characteristics of microwave evoked body movements in mice. Bioelectromagnetics 15(2):143-161, 1994.

Microwave evoked body movements were studied in mice. A resonant cavity was used to provide head and neck exposure of the mouse to pulsed and gated continuous wave (CW) 1.25 GHz microwaves. No difference in response to pulsed and gated CW stimuli of equal average power was found. The incidence of the microwave evoked body movements increased proportionally with specific absorption (dose) when the whole-body average specific absorption rate was at a constant level (7300 W/kg). Under a constant average specific absorption rate, the response incidence reached a plateau at 0.9 kJ/kg. For doses higher than 0.9 kJ/kg, response incidence was proportional to the specific absorption rate and reached a plateau at 900 W/kg. Body movements could be evoked by a single microwave pulse. The lowest whole-body specific absorption (SA) tested was 0.18 kJ/kg, and the corresponding brain SA was 0.29 kJ/kg. Bulk heating potentials of these SAs were less than 0.1 degree C. For doses higher than 0.9 kJ/kg, the response incidence was also proportional to subcutaneous temperature increment and subcutaneous heating rate. The extrapolated absolute thresholds (0% incidence) were

1.21 degrees C temperature increment and 0.24 degree C/s heating rate. Due to high subcutaneous heating rates, these microwaves must be perceived by the mouse as an intense thermal sensation but not a pain sensation because the temperature increment was well below the threshold for thermal pain. Results of the present study should be considered in promulgation of personnel protection guideline against high peak power but low average power microwaves.

Buckner CA, Buckner AL, Koren SA, Persinger MA, Lafrenie RM. Exposure to a specific time-varying electromagnetic field inhibits cell proliferation via cAMP and ERK signaling in cancer cells. Bioelectromagnetics. 2017 Nov 10. doi: 10.1002/bem.22096.

Exposure to specific electromagnetic field (EMF) patterns can affect a variety of biological systems. We have shown that exposure to Thomas-EMF, a low-intensity, frequency-modulated (25-6 Hz) EMF pattern, inhibited growth and altered cell signaling in malignant cells. Exposure to Thomas-EMF for 1 h/day inhibited the growth of malignant cells including B16-BL6 mouse melanoma cells, MDA-MB-231, MDA-MB-468, BT-20, and MCF-7 human breast cancer and HeLa cervical cancer cells but did not affect non-malignant cells. The Thomas-EMF-dependent changes in cell proliferation were mediated by adenosine 3',5'-cyclic monophosphate (cAMP) and extracellular-signal-regulated kinase (ERK) signaling pathways. Exposure of malignant cells to Thomas-EMF transiently changed the level of cellular cAMP and promoted ERK phosphorylation. Pharmacologic inhibitors (SQ22536) and activators (forskolin) of cAMP production both blocked the ability of Thomas-EMF to inhibit cell proliferation, and an inhibitor of the MAP kinase pathway (PD98059) was able to partially block Thomas-EMF-dependent inhibition of cell proliferation. Genetic modulation of protein kinase A (PKA) in B16-BL6 cells also altered the effect of Thomas-EMF on cell proliferation. Cells transfected with the constitutively active form of PKA (PKA-CA), which interfered with ERK phosphorylation, also interfered with the Thomas-EMF effect on cell proliferation. The non-malignant cells did not show any EMF-dependent changes in cAMP levels, ERK phosphorylation, or cell growth. These data indicate that exposure to the specific Thomas-EMF pattern can inhibit the growth of malignant cells in a manner dependent on contributions from the cAMP and MAP kinase pathways.

Buckus R, Strukcinskiene B, Raistenskis J, Stukas R. Modelling and assessment of the electric field strength caused by mobile phone to the human head. Vojnosanit Pregl. 73(6):538-543, 2016.

BACKGROUND/AIM: Electromagnetic field exposure is the one of the most important physical agents that actively affects live organisms and environment. Active use of mobile phones influences the increase of electromagnetic field radiation. The aim of the study was to measure and assess the electric field strength caused by mobile phones to the human head. METHODS: In this paper the software "COMSOL Multiphysics" was used to establish the electric field strength created by mobile phones around the head. RESULTS: The second generation (2G) Global System for Mobile (GSM) phones that operate in the frequency band of 900 MHz and reach the power of 2 W have a stronger electric field than (2G) GSM mobile phones that operate in the higher frequency band of 1,800 MHz and reach the power up to 1 W during conversation. The third generation of (3G) UMTS smart phones that effectively use high (2,100 MHz) radio frequency band emit the smallest electric field strength values during conversation. The highest electric field strength created by mobile phones is around the ear, i.e. the mobile phone location. The strength of mobile phone electric field on the phantom head decreases exponentially while moving sidewards from the center of the effect zone (the ear), and constitutes 1-12% of the artificial head's surface.CONCLUSION: The highest electric field strength values of mobile phones are associated with their higher power, bigger specific energy absorption rate (SAR) and lower frequency of mobile phone. The stronger electric field emitted by the more powerful mobile phones takes a higher percentage of the head surface. The highest electric field strength created by mobile phones is distributed over the user's ear.

Budak GG, Muluk NB, Budak B, Oztürk GG, Apan A, Seyhan N. Effects of GSM-like radiofrequency on distortion product otoacoustic emissions of rabbits: comparison of infants versus adults. Int J Pediatr Otorhinolaryngol. 73(8):1143-1147, 2009.

OBJECTIVES: The aim of this study is to investigate the potential hazardous effects of 1800 MHz Global System for Mobile Communications-like (GSM-like) Radiofrequency (RF) exposure on the cochlear functions of female infant and adult rabbits by measuring Distortion Product Otoacoustic Emission (DPOAE) response amplitudes. METHODS: Eighteen each one-month-old New Zealand White female rabbits and eighteen each 13-month-old adult rabbits were included into the study. They were randomly divided into four groups. Nine infant rabbits (Group 1) were not exposed to 1800 MHz GSM-like RF (Infant Control, C-In). Nine infant rabbits (Group 2) were exposed to 1800 MHz GSM-like RF, 15 min daily for 7 days after they reached one-month of age (Infant RF, RF-In). Nine adult rabbits were not exposed to 1800 MHz GSM-like RF, 15 min daily for 7 (Adult Control, C-Ad). Nine adult rabbits were exposed to 1800 MHz GSM-like RF, 15 min daily for 7 days (Adult RF, RF-Ad). Cochlear functions were assessed by DPOAEs at 1.0-8.0 kHz. RESULTS: At 1.0-2.0 and 6.0 kHz, the mean DPOAE values of Group 2 were significantly higher than that of Group 1. At 3.0-8.0 kHz, the mean DPOAE values of Group 4 were significantly lower than that of Group 1. At 6.0-8.0 kHz, the mean DPOAE values of Group 2 were significantly higher than that of Group 3. At 1.0-8.0 kHz, the mean DPOAE values of Group 4 were significantly lower than that of Group 2. At 1.0-8.0 kHz, the mean DPOAE values of Group 4 were significantly lower than that of Group 3. CONCLUSION: Harmful effects of GSM-like 1800 MHz RF exposure was detected more in the adult female rabbits than infant female rabbits by DPOAE measurement. Prolonged exposure and hyperthermia related to the power density of applied RFR, increasing the temperature in the ear canal, may decrease the DPOAE amplitudes. Water containing medium in the middle ear of infant rabbits may play the protective role from the RF damage.

Budak GG, Muluk NB, Oztürk GG, Budak B, Apan A, Seyhan N, Sanli C. Effects of GSM-like radiofrequency on distortion product otoacoustic emissions in pregnant

adult rabbits. Clin Invest Med. 32(2):E112-116, 2009.

OBJECTIVES: To determine the effects of 1800 MHz GSM-like Radiofrequency (RFR) on the cochlear functions of pregnant adult rabbits by Distortion Product Otoacoustic Emissions (DPOAEs). METHODS: Eighteen 13-month-old pregnant and eighteen 13-month-old non-pregnant New Zealand White rabbits were studied. They were randomly divided into four groups. Nine pregnant rabbits (Group 2) and nine non-pregnant rabbits (Group 4) were exposed to 1800 MHz GSM-like RFR 15 min daily for 7 days. Nine pregnant (Group 1) and nine non-pregnant rabbits (Group 3) were not exposed to GSM like RFR. Cochlear functions were assessed by DPOAEs at 1.0-8.0 kHz. RESULTS: In all pregnant groups except 2.0 kHz, DPOAE amplitudes were not different in Group 2 and Group1. In Group 4, DPOAE amplitudes at 1.0-4.0 kHz (-1.68 dB SPL at 1.0 kHz, 3.05 dB SPL at 1.5 kHz, 2.96 dB SPL at 2.0 kHz, 1.30 dB SPL at 3.0 kHz and 12.22 dB SPL at 4.0 kHz) were lower than Group 3 (8.67 dB SPL at 1.0 kHz, 17.67 dB SPL at 1.5 kHz, 26.10 dB SPL at 2.0 kHz, 18.10 dB SPL at 3.0 kHz and 35.13 dB SPL at 4.0 kHz) ($P < 0.0125$). In the pregnant group, harmful effects of GSM-like RFR were less than in the non-pregnant group. CONCLUSION: GSM-like RFR caused decreases in DPOAE amplitudes mainly in non-pregnant adult rabbits. Prolonged exposure may affect the DPOAE amplitude. Recommendations are given to prevent the potential hazardous effects of RF in humans.

Budak GG, **Muluk NB**, **Budak B**, **Oztürk GG**, **Apan A**, **Seyhan N**. **Effects of intrauterine and extrauterine exposure to GSM-like radiofrequency on distortion product otoacoustic emissions in infant male rabbits. Int J Pediatr Otorhinolaryngol. 73(3):391-399, 2009.**

OBJECTIVES: The aim of this study was to investigate the potential hazardous effects of intrauterine (IU) and/or extrauterine (EU) exposure to 1800 MHz Global System for Mobile Communications-like (GSM-like) radiofrequency (RF) on the cochlear functions of infant rabbits by measuring distortion product otoacoustic emission (DPOAE) response amplitudes. METHODS: Thirty-six white infant male New Zealand rabbits each 1-month-old were included in the study. The animals were randomly divided into four groups. Nine infant rabbits (Group 1) were not exposed to 1800 MHz GSM-like RF (Control-C). Nine infant rabbits (Group 2) were exposed to 1800 MHz GSM-like RF, 15 min daily for 14 days after they reached 1-month of age (extrauterine-EU). Nine infant rabbits (Group 3) were exposed to 1800 MHz GSM-like RF, 15 min daily for 7 days in the intrauterine period (between 15th and 22nd days of the gestational period) (intrauterine-IU). Nine infant rabbits (Group 4) were exposed to 1800 MHz GSM-like RF, 15 min daily for 7 days in the intrauterine period (between 15th and 22nd days of the gestational period) and 15 min daily for 14 days after they reached to 1-month of age (IU+EU). The cochlear functions were assessed by DPOAEs at 1.0-8.0 kHz. RESULTS: At 1.5 kHz, the mean DPOAE amplitude of Group 3 was higher than that of the controls and Group 2; and the mean DPOAE value of Group 4 was higher than that of the controls and Group 2. At 2.0 kHz, the mean DPOAE amplitude of Group 4 was higher than that of Group 2. At 3.0 kHz, the mean DPOAE amplitude of Group 4 was higher than that of the controls and Group 2. At 4.0 kHz, the mean DPOAE amplitude of Group 2 was lower than that of the controls, while the mean value of Group 4 was higher than the mean value of the controls and Group 2. At 6.0 kHz, the mean DPOAE amplitude of Group 2 was lower than that of the control group; however, the mean value of Group 4 was higher than that of Group 2. At 1.0 and 8.0 kHz, no significant differences were found among the four groups. CONCLUSION: Prolonged exposure and hyperthermia related to the power density of applied RF, increasing the temperature in the ear canal, may affect DPOAE amplitudes. Harmful effects of RF are mainly observed as a decrease in DPOAE amplitudes at 4.0-6.0 kHz during extrauterine exposure in infancy. During the intrauterine period, the water content of the middle and inner ear and amnion fluid may play a protective role. Therefore, children must be protected from RF exposure. The use of mobile phones at short distances from the ear of the infants should be avoided because of the lower thickness of the anatomical structure in infancy.

Budinscak V, Goldoni J, Saric M, [Hematologic changes in workers exposed to radio wave radiation]. Arh Hig Rada Toksikol 42(4):367-373, 1991. [Article in Serbo-Croatian (Roman)]

Haematological parameters were measured in 43 radar operators employed in air traffic control occupationally exposed to microwave radiation of low intensity over a period of four years. Exposure to heat, soft X-ray radiation and noise were within maximally allowed limits. The haematological changes included a decreased number of erythrocytes, reticulocytes, platelets, segmented granulocytes and monocytes, and an increased number of leucocytes and lymphocytes. The changes were not pathologically significant and most of them were reversible.

Burch JB, Reif JS, Noonan CW, Ichinose T, Bachand AM, Koleber TL, Yost MG. Melatonin metabolite excretion among cellular telephone users. Int J Rad Biol 78: 1029-1036, 2002.

Abstract: Purpose: The relationship between cellular telephone use and excretion of the melatonin metabolite 6-hydroxymelatonin sulfate (6-OHMS) was evaluated in two populations of male electric utility workers (Study 1, n=149; Study 2, n=77). Materials and methods: Participants collected urine samples and recorded cellular telephone use over 3 consecutive workdays. Personal 60-Hz magnetic field (MF) and ambient light exposures were characterized on the same days using EMDEX II meters. A repeated measures analysis was used to assess the effects of cellular telephone use, alone and combined with MF exposures, after adjustment for age, participation month and light exposure. Results: No change in 6-OHMS excretion was observed among those with daily cellular telephone use >25 min in Study 1 (5 worker-days). Study 2 workers with >25 min cellular telephone use per day (13 worker-days) had lower creatinine-adjusted mean nocturnal 6-OHMS concentrations (p=0.05) and overnight 6-OHMS excretion (p=0.03) compared with those without cellular telephone use. There was also a linear trend of decreasing mean nocturnal 6-OHMS/creatinine concentrations (p=0.02) and overnight 6-OHMS excretion (p=0.08) across categories of increasing cellular telephone use. A combined effect of cellular telephone use and occupational 60-Hz MF exposure in reducing 6-OHMS excretion was also observed in Study 2. Conclusions: Exposure-related reductions in 6-OHMS excretion were observed in Study 2, where daily cellular telephone use of >25min was more prevalent. Prolonged use of cellular telephones may lead to reduced melatonin production, and elevated 60-Hz MF exposures may potentiate the effect.

Burch JB, Clark M, Yost MG, Fitzpatrick CT, Bachand AM, Ramaprasad J, Reif JS.

Radio frequency nonionizing radiation in a community exposed to radio and television broadcasting. Environ Health Perspect. 114(2):248-253, 2006.

Exposure to radio frequency (RF) nonionizing radiation from telecommunications is pervasive in modern society. Elevated disease risks have been observed in some populations exposed to radio and television transmissions, although findings are inconsistent. This study quantified RF exposures among 280 residents living near the broadcasting transmitters for Denver, Colorado. RF power densities outside and inside each residence were obtained, and a global positioning system (GPS) identified geographic coordinates and elevations. A viewshed model within a geographic information system (GIS) characterized the average distance and percentage of transmitters visible from each residence. Data were collected at the beginning and end of a 2.5-day period, and some measurements were repeated 8-29 months later. RF levels logged at 1-min intervals for 2.5 days varied considerably among some homes and were quite similar among others. The greatest differences appeared among homes within 1 km of the transmitters. Overall, there were no differences in mean residential RF levels compared over 2.5 days. However, after a 1- to 2-year follow-up, only 25% of exterior and 38% of interior RF measurements were unchanged. Increasing proximity, elevation, and line-of-sight visibility were each associated with elevated RF exposures. At average distances from > 1-3 km, exterior RF measurements were 13-30 times greater among homes that had > 50% of the transmitters visible compared with homes with </= 50% visibility at those distances. This study demonstrated that both spatial and temporal factors contribute to residential RF exposure and that GPS/GIS technologies can improve RF exposure assessment and reduce exposure misclassification. Key words: broadcasting, electromagnetic fields, exposure assessment, GIS, nonionizing radiation, radio, television.

Bürgi A , Scanferla D, Lehmann H. Time Averaged Transmitter Power and Exposure to Electromagnetic Fields from Mobile Phone Base Stations. Int. J. Environ. Res. Public Health 11(8), 8025-8037, 2014.

Models for exposure assessment of high frequency electromagnetic fields from mobile phone base stations need the technical data of the base stations as input. One of these parameters, the *Equivalent Radiated Power* (ERP), is a time-varying quantity, depending on communication traffic. In order to determine temporal averages of the exposure, corresponding averages of the ERP have to be available. These can be determined as *duty factors,* the ratios of the time-averaged power to the maximum output power according to the transmitter setting. We determine duty factors for UMTS from the data of 37 base stations in the Swisscom network. The UMTS base stations sample contains sites from different regions of Switzerland and also different site types (rural/suburban/urban/hotspot). Averaged over all regions and site types, a UMTS duty factor for the 24 h-average is obtained, *i.e.*, the average output power corresponds to about a third of the maximum power. We also give duty factors for GSM based on simple approximations and a lower limit for LTE estimated from the base load on the signalling channels.

Burlaka A, Tsybulin O, Sidorik E, Lukin S, Polishuk V, Tsehmistrenko S, Yakymenko I. Overproduction of free radical species in embryonal cells exposed to

low intensity radiofrequency radiation. Exp Oncol. 2013 Sep;35(3):219-225.

Aim: Long-term exposure of humans to low intensity radiofrequency electromagnetic radiation (RF-EMR) leads to a statistically significant increase in tumor incidence. Mechanisms of such the effects are unclear, but features of oxidative stress in living cells under RF-EMR exposure were previously reported. Our study aims to assess a production of initial free radical species, which lead to oxidative stress in the cell. Materials and Methods: Embryos of Japanese quails were exposed in ovo to extremely low intensity RF-EMR of GSM 900 MHz (0.25 μW/cm2) during 158-360 h discontinuously (48 c - ON, 12 c - OFF) before and in the initial stages of development. The levels of superoxide (O2·-), nitrogen oxide (NO·), thiobarbituric acid reactive substances (TBARS), 8-oxo-2'-deoxyguanosine (8-oxo-dG) and antioxidant enzymes' activities were assessed in cells/tissues of 38-h, 5- and 10-day RF-EMR exposed and unexposed embryos. Results: The exposure resulted in a significant persistent overproduction of superoxide and nitrogen oxide in embryo cells during all period of analyses. As a result, significantly increased levels of TBARS and 8-oxo-dG followed by significantly decreased levels of superoxide dismutase and catalase activities were developed in the exposed embryo cells. Conclusion: Exposure of developing quail embryos to extremely low intensity RF-EMR of GSM 900 MHz during at least one hundred and fifty-eight hours leads to a significant overproduction of free radicals/reactive oxygen species and oxidative damage of DNA in embryo cells. These oxidative changes may lead to pathologies up to oncogenic transformation of cells.

Burlaka A, Selyuk M, Gafurov M, Lukin S, Potaskalova V, Sidorik E. Changes in mitochondrial functioning with electromagnetic radiation of ultra high frequency as revealed by electron paramagnetic resonance methods. Int J Radiat Biol. 2014 Mar 6. [Epub ahead of print]

Purpose: To study the effects of electromagnetic radiation (EMR) of ultra high frequency (UHF) in the doses equivalent to the maximal permitted energy load for the staffs of the radar stations on the biochemical processes that occur in the cell organelles. Materials and Methods: Liver, cardiac and aorta tissues from the male rats exposed to non-thermal UHF EMR in pulsed and continuous modes were studied during 28 days after the irradiation by the electron paramagnetic resonance (EPR) methods including a spin trapping of superoxide radicals. Results: The qualitative and quantitative disturbances in electron transport chain (ETC) of mitochondria are registered. A formation of the iron-nitrosyl complexes of nitric oxide (NO) radicals with the iron-sulphide (FeS) proteins, the decreased activity of FeS-protein N2 of NADH-ubiquinone oxidoreductase complex and flavo ubisemiquinone growth combined with the increased rates of superoxide production are obtained. Conclusions: (1) Abnormalities in the mitochondrial ETC of liver and aorta cells are more pronounced for animals radiated in a pulsed mode. (2) The alterations in the functioning of the mitochondrial ETC cause increase of superoxide radicals generation rate in all samples, formation of cellular hypoxia, and intensification of the oxide-initiated metabolic changes. (3) Electron paramagnetic resonance methods could be used to track the qualitative and quantitative changes in the mitochondrial ETC caused by the UHF EMR.

Busljeta I, Trosic I, Milkovic-Kraus S. Erythropoietic changes in rats after 2.45 GJz nonthermal irradiation. Int J Hyg Environ Health.207(6):549-554, 2004.

The purpose of this study was to observe the erythropoietic changes in rats subchronically exposed to radiofrequency microwave (RF/MW) irradiation at nonthermal level. Adult male Wistar rats (N=40) were exposed to 2.45 GHz continuous RF/MW fields for 2 hours daily, 7 days a week, at 5-10 mW/cm2. Exposed animals were divided into four subgroups (n=10 animals in each subgroup) in order to be irradiated for 2, 8, 15 and 30 days. Animals were sacrified on the final irradiation day of each treated subgroup. Unexposed rats were used as control (N=24). Six animals were included into the each control subgroup. Bone marrow smears were examined to determine absolute counts of anuclear cells and erythropoietic precursor cells. The absolute erythrocyte count, haemoglobin and haematocrit values were observed in the peripheral blood by an automatic cell counter. The bone marrow cytogenetic analysis was accomplished by micronucleus (MN) tests. In the exposed animals erythrocyte count, haemoglobin and haematocrit were increased in peripheral blood on irradiation days 8 and 15. Concurrently, anuclear cells and erythropoietic precursor cells were significantly decreased ($p < 0.05$) in the bone marrow on day 15, but micronucleated cells' frequency was increased. In the applied experimental condition, RF/MW radiation might cause disturbance in red cell maturation and proliferation, and induce micronucleus formation in erythropoietic cells.

Buttiglione M, Roca L, Montemurno E, Vitiello F, Capozzi V, Cibelli G. Radiofrequency radiation (900 MHz) induces Egr-1 gene expression and affects cell-cycle control in human neuroblastoma cells. J Cell Physiol. 213(3):759-767, 2007.

Many environmental signals, including ionizing radiation and UV rays, induce activation of Egr-1 gene, thus affecting cell growth and apoptosis. The paucity and the controversial knowledge about the effect of electromagnetic fields (EMF) exposure of nerve cells prompted us to investigate the bioeffects of radiofrequency (RF) radiation on SH-SY5Y neuroblastoma cells. The effect of a modulated RF field of 900 MHz, generated by a wire patch cell (WPC) antenna exposure system on Egr-1 gene expression, was studied as a function of time. Short-term exposures induced a transient increase in Egr-1 mRNA level paralleled with activation of the MAPK subtypes ERK1/2 and SAPK/JNK. The effects of RF radiations on cell growth rate and apoptosis were also studied. Exposure to RF radiation had an anti-proliferative activity in SH-SY5Y cells with a significant effect observed at 24 h. RF radiation impaired cell cycle progression, reaching a significant G2-M arrest. In addition, the appearance of the sub-G1 peak, a hallmark of apoptosis, was highlighted after a 24-h exposure, together with a significant decrease in mRNA levels of Bcl-2 and survivin genes, both interfering with signaling between G2-M arrest and apoptosis. Our results provide evidence that exposure to a 900 MHz-modulated RF radiation affect both Egr-1 gene expression and cell regulatory functions, involving apoptosis inhibitors like Bcl-2 and survivin, thus providing important insights into a potentially broad mechanism for controlling in vitro cell viability.

Byun YH, Ha M, Kwon HJ, Hong YC, Leem JH, Sakong J, Kim SY, Lee CG, Kang D, Choi HD, Kim N.Mobile phone use, blood lead levels, and attention deficit hyperactivity symptoms in children: a longitudinal study. PLoS One. 2013;8(3):e59742.

BACKGROUND: Concerns have developed for the possible negative health effects of radiofrequency electromagnetic field (RF-EMF) exposure to children's brains. The purpose of this longitudinal study was to investigate the association between mobile phone use and symptoms of Attention Deficit Hyperactivity Disorder (ADHD) considering the modifying effect of lead exposure. METHODS: A total of 2,422 children at 27 elementary schools in 10 Korean cities were examined and followed up 2 years later. Parents or guardians were administered a questionnaire including the Korean version of the ADHD rating scale and questions about mobile phone use, as well as socio-demographic factors. The ADHD symptom risk for mobile phone use was estimated at two time points using logistic regression and combined over 2 years using the generalized estimating equation model with repeatedly measured variables of mobile phone use, blood lead, and ADHD symptoms, adjusted for covariates. RESULTS: The ADHD symptom risk associated with mobile phone use for voice calls but the association was limited to children exposed to relatively high lead. CONCLUSIONS:The results suggest that simultaneous exposure to lead and RF from mobile phone use was associated with increased ADHD symptom risk, although possible reverse causality could not be ruled out.

Cabot E, Christ A, Bühlmann B, Zefferer M, Chavannes N, Bakker JF, van Rhoon GC, Kuster N. Quantification Of RF-exposure of the Fetus Using Anatomical CAD-Models in Three Different Gestational Stages. Health Phys. 107(5):369-381, 2014.

This study analyzes the exposure of pregnant women and their fetuses in three different gestational stages to electromagnetic radiation in the radio frequency range in the near- and the far-field using numerical modeling. For far-field exposure, the power density at which the basic restriction for the whole body SAR is reached is calculated for both the mother and the fetus at whole body resonance and at frequencies between 450 MHz and 2,450 MHz. The near-field exposure is assessed at 450 MHz, 900 MHz, and 2,450 MHz using half wavelength dipoles as generic sources located at different locations around the abdomen of the mother. For the investigated cases, the exposure of the mother is always below or on the order of magnitude of the basic restriction for exposure at the reference level. When applying the reference levels for the general public, the fetus is sufficiently shielded by the mother. However, the basic restrictions for general public exposure can be exceeded in the fetus when the mother is exposed at reference levels for occupational conditions. For plane wave exposure at occupational levels, the whole body SAR in the fetus can exceed the basic restrictions for the general population by at least 1.8 dB, and in the near-field of professional devices, the 10 g SAR can be non-compliant with the product standard for the general public by > 3.5 dB.

Cain CD, Thomas DL, Adey WR, Focus formation of C3H/10T1/2 cells and exposure to a 836.55 MHz modulated radiofrequency field. Bioelectromagnetics 18(3):237-243, 1997.

Disruption of communication between transformed cells and normal cells is involved in tumor promotion. We have tested the hypothesis that exposures to radiofrequency (RF) fields using a form of digital modulation (TDMA) and a chemical tumor promoter, 12-O-tetradecanoylphorbol-13-acetate (TPA), are copromoters that enhance focus formation of transformed cells in coculture with parental C3H/10T1/2 murine fibroblasts. RF field exposures did not influence TPA's dose-dependent promotion of focus formation in coculture. Cell cultures were exposed to an 836.55 MHz TDMA-modulated field in TEM transmission line chambers, with incident energies that simulated field intensities at a user's head. Specific absorption rates (SARs) of 0.15, 1.5, and 15 muW/g were used during each digital packet, and the packet frequency was 50/s. The TEM chambers were placed in a commercial incubator at 37 degrees C and 95% humidity/5% CO2. The RF field exposures were in a repeating cycle, 20 min on, 20 min off, 24 h/day for 28 days. At 1.5 muW/g, TPA-induced focus formation (at 10, 30, and 50 ng/ml) was not significantly different in RF-exposed cultures compared to parallel sham-exposed cultures in ten independent experiments in terms of the number, density, and area of foci. Similarly, at 0.15 and 15.0 muW/g, in two and four experiments, respectively, RF exposure did not alter TPA-induced focus formation. The findings support a conclusion that repeated exposures to this RF field do not influence tumor promotion in vitro, based on the RF field's inability to enhance TPA-induced focus formation.

Calabrò E, Condello S, Currò M, Ferlazzo N, Caccamo D, Magazù S, Ientile R. Modulation of heat shock protein response in SH-SY5Y by mobile phone microwaves. World J Biol Chem. 3(2):34-40, 2012.

AIM: To investigate putative biological damage caused by GSM mobile phone frequencies by assessing electromagnetic fields during mobile phone working. METHODS: Neuron-like cells, obtained by retinoic-acid-induced differentiation of human neuroblastoma SH-SY5Y cells, were exposed for 2 h and 4 h to microwaves at 1800 MHz frequency bands. RESULTS: Cell stress response was evaluated by MTT assay as well as changes in the heat shock protein expression (Hsp20, Hsp27 and Hsp70) and caspase-3 activity levels, as biomarkers of apoptotic pathway. Under our experimental conditions, neither cell viability nor Hsp27 expression nor caspase-3 activity was significantly changed. Interestingly, a significant decrease in Hsp20 expression was observed at both times of exposure, whereas Hsp70 levels were significantly increased only after 4 h exposure. CONCLUSION: The modulation of the expression of Hsps in neuronal cells can be an early response to radiofrequency microwaves.

Calabrò E, Magazù S.The α-helix alignment of proteins in water solution toward a high-frequency electromagnetic field: A FTIR spectroscopy study. Electromagn Biol Med. 36(3):279-288, 2017.

The aim of this article was to study the effects of mobile phone electromagnetic waves at 1750 MHz on the Amide I and Amide II vibration bands of some proteins in bidistilled water solution by means of Fourier transform infrared (FTIR) spectroscopy and Fourier self-deconvolution (FSD) analysis. The proteins that were used for the experiment were hemoglobin, myoglobin, bovine serum albumin and lysozyme. The exposure system consisted of microwaves emitted by an operational mobile phone at the frequency at 1750 MHz at the average power density of 1 W/m^2. Exposed and control samples were analyzed using FTIR spectroscopy and FSD analysis. The main result was that Amide I band of the proteins that were used increased significantly ($p < 0.05$) after 4 h of exposure to MWs, whereas Amide II band did not change significantly. This result can be explained assuming that the α-helix structure of the proteins aligned itself with the direction of the electromagnetic field due to the alignment of C = O stretching and N - H bending ligands that are oriented along with the α-helix axis that give rise to the Amide I mode.

Calcagnini G, Floris M, Censi F, Cianfanelli P, Scavino G, Bartolini P. Electromagnetic interference with infusion pumps from GSM mobile phones. Health Phys. 90(4):357-360, 2006.

Electromagnetic interference with critical medical care devices has been reported by various groups. Previous studies have demonstrated that volumetric and syringe pumps are susceptible to false alarm buzzing and blocking when exposed to various electromagnetic sources. The risk of electromagnetic interference depends on several factors such as the phone-emitted power, distance, and carrier frequency. The aim of this study was to assess the risk of GSM phone-induced electromagnetic interference with volumetric and syringe pumps, at various distances and emitted powers. Malfunctions were observed in 6 out of 8 volumetric pumps and in 1 out of 4 syringe pumps exposed to mobile phones at their maximum output, at distances up to 30 cm. The maximum power that did not induce any malfunction at zero distance was 50 mW at 900 MHz and 2.5 mW at 1,800 MHz. In state-of-the-art pumps, the presence of moderate-good base station coverage would significantly reduce the risk of electromagnetic interference.

Calderón C, Addison D, Mee T, Findlay R, Maslanyj M, Conil E, Kromhout H, Lee AK, Sim MR, Taki M, Varsier N, Wiart J, Cardis E. Assessment of extremely low frequency magnetic field exposure from GSM mobile phones. Bioelectromagnetics. 2013 Nov 6. doi: 10.1002/bem.21827. [Epub ahead of print]

Although radio frequency (RF) electromagnetic fields emitted by mobile phones have received much attention, relatively little is known about the extremely low frequency (ELF) magnetic fields emitted by phones. This paper summarises ELF magnetic flux density measurements on global system for mobile communications (GSM) mobile phones, conducted as part of the MOBI-KIDS epidemiological study. The main challenge is to identify a small number of generic phone models that can be used to classify the ELF exposure for the different phones reported in the study. Two-dimensional magnetic flux density measurements were performed on 47 GSM mobile phones at a distance of 25 mm. Maximum resultant magnetic flux density values at 217 Hz had a geometric mean of 221 (+198/-104) nT. Taking into account harmonic data, measurements suggest that mobile phones could make a substantial contribution to ELF exposure in the general population. The maximum values and easily available variables were poorly correlated. However, three groups could be defined on the basis of field pattern indicating that manufacturers and shapes of mobile phones may be the important parameters linked to the spatial characteristics of the magnetic field, and the categorization of ELF magnetic field exposure for GSM phones in the MOBI-KIDS study may be achievable on the basis of a small number of representative phones. Such categorization would result in a twofold exposure gradient between high and low exposure based on type of phone used, although there was overlap in the grouping.

Calvente I, Fernández MF, Pérez-Lobato R, Dávila-Arias C, Ocón O, Ramos R, Ríos-Arrabal S, Villalba-Moreno J, Olea N, Núñez MI. Outdoor characterization of radio frequency electromagnetic fields in a Spanish birth cohort. Environ Res. 2015 Feb 20;138C:136-143. doi: 10.1016/j.envres.2014.12.013. [Epub ahead of print]

There is considerable public concern in many countries about the possible adverse effects of exposure to non-ionizing radiation electromagnetic fields, especially in vulnerable populations such as children. The aim of this study was to characterize environmental exposure profiles within the frequency range 100kHz-6GHz in the immediate surrounds of the dwellings of 123 families from the INMA-Granada birth cohort in Southern Spain, using spot measurements. The arithmetic mean root mean-square electric field (E_{RMS}) and power density (S_{RMS}) values were, respectively, 195.79mV/m (42.3% of data were above this mean) and 799.01µW/m^2 (30% of values were above this mean); median values were 148.80mV/m and 285.94µW/m^2, respectively. Exposure levels below the quantification limit were assigned a value of 0.01V/m. Incident field strength levels varied widely among different areas or towns/villages, demonstrating spatial variability in the distribution of exposure values related to the surface area population size and also among seasons. Although recorded values were well below International Commission for Non-Ionizing Radiation Protection reference levels, there is a particular need to characterize incident field strength levels in vulnerable populations (e.g., children) because of their chronic and ever-increasing exposure. The effects of incident field strength have not been fully elucidated; however, it may be appropriate to apply the precautionary principle in order to reduce exposure in susceptible groups.

Calvente I, Pérez-Lobato R, Núñez MI, Ramos R, Guxens M, Villalba J, Olea N, Fernández MF. Does exposure to environmental radiofrequency electromagnetic fields cause cognitive and behavioral effects in 10-year-old boys? Bioelectromagnetics. 37(1):25-36, 2016.

The relationship between exposure to electromagnetic fields from non-ionizing radiation and adverse human health effects remains controversial. We aimed to explore the association of environmental radiofrequency-electromagnetic fields (RF-EMFs) exposure with neurobehavioral function of children. A subsample of 123 boys belonging to the Environment and Childhood cohort from Granada (Spain), recruited at birth from 2000 through 2002, were evaluated at the age of 9-11 years. Spot electric field measurements within the 100 kHz to 6 GHz frequency range, expressed as both root mean-square

(SRMS) and maximum power density (SMAX) magnitudes, were performed in the immediate surrounds of childreńs dwellings. Neurocognitive and behavioral functions were assessed with a comprehensive battery of tests. Multivariate linear and logistic regression models were used, adjusting for potential confounders. All measurements were lower than reference guideline limits, with median SRMS and SMAX values of 285.94 and 2759.68 μW/m(2) , respectively. Most of the cognitive and behavioral parameters did not show any effect, but children living in higher RF exposure areas (above median SRMS levels) had lower scores for verbal expression/comprehension and higher scores for internalizing and total problems, and obsessive-compulsive and post-traumatic stress disorders, in comparison to those living in areas with lower exposure. These associations were stronger when SMAX values were considered. Although some of our results may suggest that low-level environmental RF-EMF exposure has a negative impact on cognitive and/or behavior development in children; given limitations in the study design and that the majority of neurobehavioral functioning tasks were not affected, definitive conclusions cannot be drawn.

Cam ST, Seyhan N. Single-strand DNA breaks in human hair root cells exposed to mobile phone radiation. Int J Radiat Biol.88(5):420-424, 2012.

Abstract. Purpose: To analyze the short term effects of radiofrequency radiation (RFR) exposure on genomic deoxyribonucleic acid (DNA) of human hair root cells. Subjects and methods: Hair samples were collected from 8 healthy human subjects immediately before and after using a 900-MHz GSM (Global System for Mobile Communications) mobile phone for 15 and 30 minutes. Single-strand DNA breaks of hair root cells from the samples were determined using the 'comet assay'. Results: The data showed that talking on a mobile phone for 15 or 30 minutes significantly increased ($p< .05$) single-strand DNA breaks in cells of hair roots close to the phone. Comparing the 15-min and 30-min data using the paired t-test also showed that significantly more damages resulted after 30 minutes than after 15 minutes of phone use. Conclusions: A short-term exposure (15 and 30 minutes) to RFR (900-MHz) from a mobile phone caused a significant increase in DNA single-strand breaks in human hair root cells located around the ear which is used for the phone calls.

Cam ST, Seyhan N, Kavaklı C, Celikbıçak O. Effects of 900 MHz Radiofrequency Radiation on Skin Hydroxyproline Contents. Cell Biochem Biophys. 2014 Apr 24. [Epub ahead of print]

The present study aimed to investigate the possible effect of pulse-modulated radiofrequency radiation (RFR) on rat skin hydroxyproline content, since skin is the first target of external electromagnetic fields. Skin hydroxyproline content was measured using liquid chromatography mass spectrometer method. Two months old male wistar rats were exposed to a 900 MHz pulse-modulated RFR at an average whole body specific absorption rate (SAR) of 1.35 W/kg for 20 min/day for 3 weeks. The radiofrequency (RF) signals were pulse modulated by rectangular pulses with a repetition frequency of 217 Hz and a duty cycle of 1:8 (pulse width 0.576 ms). A skin biopsy was taken at the upper part of the abdominal costa after the exposure. The data indicated that whole body exposure to a pulse-modulated RF radiation that is similar to that emitted by the global system for mobile communications (GSM) mobile phones caused a statistically significant increase in the skin hydroxyproline level (p = 0.049, Mann-Whitney U test). Under our experimental conditions, at a SAR less than the International Commission on Non-Ionizing Radiation Protection safety limit recommendation, there was evidence that GSM signals could alter hydroxyproline concentration in the rat skin.

Cammaerts MC, De Doncker P, Patris X, Bellens F, Rachidi Z, Cammaerts D. GSM 900 MHz radiation inhibits ants' association between food sites and encountered cues. Electromagn Biol Med. 31(2):151-165, 2012.

The kinetics of the acquisition and loss of the use of olfactory and visual cues were previously obtained in six experimental colonies of the ant Myrmica sabuleti meinert 1861, under normal conditions. In the present work, the same experiments were conducted on six other naive identical colonies of M. sabuleti, under electromagnetic radiation similar to those surrounding GSM and communication masts. In this situation, no association between food and either olfactory or visual cues occurred. After a recovery period, the ants were able to make such an association but never reached the expected score. Such ants having acquired a weaker olfactory or visual score and still undergoing olfactory or visual training were again submitted to electromagnetic waves. Not only did they lose all that they had memorized, but also they lost it in a few hours instead of in a few days (as under normal conditions when no longer trained). They kept no visual memory at all (instead of keeping 10% of it as they normally do). The impact of GSM 900 MHz radiation was greater on the visual memory than on the olfactory one. These communication waves may have such a disastrous impact on a wide range of insects using olfactory and/or visual memory, i.e., on bees.

Cammaerts MC, Debeir O, Cammaerts R. Changes in Paramecium caudatum (protozoa) near a switched-on GSM telephone. Electromagn Biol Med. 30(1):57-66, 2011.

The protozoan Paramecium caudatum was examined under normal conditions versus aside a switched-on GSM telephone (900 MHz; 2 Watts). Exposed individuals moved more slowly and more sinuously than usual. Their physiology was affected: they became broader, their cytopharynx appeared broader, their pulse vesicles had difficult in expelling their content outside the cell, their cilia less efficiently moved, and trichocysts became more visible. All these effects might result from some bad functioning or damage of the cellular membrane. The first target of communication electromagnetic waves might thus be the cellular membrane.

Cammaerts MC, Rachidi Z, Bellens F, De Doncker P. Food collection and response to pheromones in an ant species exposed to electromagnetic radiation. Electromagn Biol Med. 2013 Jan 15. [Epub ahead of print]

We used the ant species Myrmica sabuleti as a model to study the impact of electromagnetic waves on social insects' response to their pheromones and their food collection. We quantified M. sabuleti workers' response to their trail, area marking and alarm pheromone under normal conditions. Then, we quantified the same responses while under the influence of electromagnetic waves. Under such an influence, ants followed trails for only short distances, no longer arrived at marked areas and no longer orientated themselves to a source of alarm pheromone. Also when exposed to electromagnetic waves, ants became unable to return to their nest and recruit congeners; therefore, the number of ants collecting food increases only slightly and slowly. After 180 h of exposure, their colonies deteriorated. Electromagnetic radiation obviously affects social insects' behavior and physiology.

Cammaerts M-C, Vandenbosch GAE, Volski V. Effect of short-term GSM radiation at representative levels in society on a biological model: the ant Myrmica sabuleti. J Insect Beh. 27(4):514-526. 2014.

Well-controlled electromagnetic exposure conditions were set up at a representative societal GSM radiation intensity level, 1.5 V/m, which is the legally allowed level in Brussels. Two nests of the ant species Myrmica sabuleti were repeatedly irradiated during 10 min. before their behavior was observed, based on the analysis of the ant trajectories. Under these exposure conditions, behavioral effects were detected. The ants' locomotion slightly changed. The ants' orientation towards their attractive alarm pheromone statistically became of lower quality. The ants still presented their trail following behavior but less efficiently. In this controversial issue, ants could be considered as possible bioindicators.

Campisi A, Gulino M, Acquaviva R, Bellia P, Raciti G, Grasso R, Musumeci F, Vanella A, Triglia A. Reactive oxygen species levels and DNA fragmentation on astrocytes in primary culture after acute exposure to low intensity microwave electromagnetic field. Neurosci Lett.31 473(1):52-55, 2010.

The exposure of primary rat neocortical astroglial cell cultures to acute electromagnetic fields (EMF) in the microwave range was studied. Differentiated astroglial cell cultures at 14 days in vitro were exposed for 5, 10, or 20min to either 900MHz continuous waves or 900MHz waves modulated in amplitude at 50Hz using a sinusoidal waveform and 100% modulation index. The strength of the electric field (rms value) at the sample position was 10V/m. No change in cellular viability evaluated by MTT test and lactate dehydrogenase release was observed. A significant increase in ROS levels and DNA fragmentation was found only after exposure of the astrocytes to modulated EMF for 20min. No evident effects were detected when shorter time intervals or continuous waves were used. The irradiation conditions allowed the exclusion of any possible thermal effect. Our data demonstrate, for the first time, that even acute exposure to low intensity EMF induces ROS production and DNA fragmentation in astrocytes in primary cultures, which also represent the principal target of modulated EMF. Our findings also suggest the hypothesis that the effects could be due to hyperstimulation of the glutamate receptors, which play a crucial role in acute and chronic brain damage. Furthermore, the results show the importance of the amplitude modulation in the interaction between EMF and neocortical astrocytes.

Canseven AG, Esmekaya MA, Kayhan H, Tuysuz MZ, Seyhan N. Effects of microwave exposure and Gemcitabine treatment on apoptotic activity in Burkitt's lymphoma (Raji) cells. Electromagn Biol Med. 2014 Jun 5:1-5. [Epub ahead of print]

We investigated the effects of 1.8 MHz Global System for Mobile Communications (GSM)-modulated microwave (MW) radiation on apoptotic level and cell viability of Burkitt's lymphoma (Raji) cells with or without Gemcitabine, which exhibits cell phase specificity, primarily killing cells undergoing DNA synthesis (S-phase). Raji cells were exposed to 1.8 GHz GSM-modulated MW radiation at a specific absorption rate (SAR) of 0.350 W/kg in a CO_2 incubator. The duration of the exposure was 24 h. The amount of apoptotic cells was analyzed using Annexin V-FITC and propidium iodide (PI) staining with flow cytometer. The apoptotic activity of MW exposed Raji cells was increased significantly. In addition, cell viability of exposed samples was significantly decreased. Combined exposure of MW and Gemcitabine increased the amount of apoptotic cells than MW radiation alone. Moreover, viability of MW + Gemcitabine exposed cells was lower than that of cells exposed only to MW. These results demonstrated that MW radiation exposure and Gemcitabine treatment have a synergistic effect on apoptotic activity of Raji cells.

Cao G, Liu LM, Cleary SF, Cell cycle alterations induced by isothermal 27 MHz radio-frequency radiation exposure. Bioelectrochem Bioenerg 37(2):131-140, 1995.

The purpose of this study was to test the hypothesis that 27 MHz continuous-wave radio-frequency radiation can alter the mammalian cell cycle in the absence of radiation-induced heating. Relative effects of r.f. radiation on specific phases of the cell cycle were determined by exposing synchronized Chinese hamster ovary (CHO) cells in G_0/G_1 -, S- or G_0/G_1 -phase. The dose-rate dependence of r.f. radiation-induced direct cell-cycle alterations was investigated by exposing CHO cells for 2 h to 5 or 25 W kg^{-1} under isothermal conditions in vitro. Cell cycle alterations were determined by flow cytofluorometric DNA determinations conducted over a period of 4 days after exposure. The DNA distributions of r.f.- or sham-exposed CHO cell samples were compared qualitatively by direct comparison of overlaid and difference distribution. A quantitative measure of the magnitude of the r.f.-induced CHO cell-cycle alterations was obtained by summation of the absolute value of the difference in the number of cells in all regions of the DNA distribution. The precision of the cytoflorometric assay was determined by comparison of DNA distributions of replicate CHO cell samples. The r.f. exposure induced time- and dose-rate-dependent cell cycle alterations. Maximum responses occurred 3 days after exposure at a specific absorption rate (SAR) of 25 W kg^{-1}. Comparison of temporal responses of cells exposed to 5 W kg^{-1} vs. 25 W kg^{-1} indicated an interaction of r.f. exposure intensity with cell cycle phase. In contrast to r.f.-radiation-induced alterations in the cycles of CHO cells exposed during G_0/G_1 - or S-phase, there were minimal effects on G_2/M -phase CHO cells at either SAR, indicating lessened sensitivity of this cell cycle phase. Whereas G_0/G_1 - or S-phase cells exposed to either SAR approached baseline levels of alteration by 4 days after exposure, there was a statistically significant increased alteration in cells exposed at 25 W kg^{-1} relative to cells exposed at 5 W kg^{-1}. This indicated an r.f.-dose-rate-dependent effect on the duration of cell cycle alterations.

Cao H, Qin F, Liu X, Wang J, Cao Y, Tong J, Zhao H. Circadian Rhythmicity of Antioxidant Markers in Rats Exposed to 1.8 GHz Radiofrequency Fields. Int J Environ Res Public Health. 12(2):2071-2087, 2015.

BACKGROUND: The potential health risks of exposure to Radiofrequency Fields (RF) emitted by mobile phones are currently of considerable public interest, such as the adverse effects on the circadian rhythmicities of biological systems. To determine whether circadian rhythms of the plasma antioxidants (Mel, GSH-Px and SOD) are affected by RF, we performed a study on male Sprague Dawley rats exposed to the 1.8 GHz RF. METHODS: All animals were divided into seven groups. The animals in six groups were exposed to 1.8 GHz RF (201.7 μW/cm2 power density, 0.05653 W/kg specific absorption rate) at a specific period of the day (3, 7, 11, 15, 19 and 23 h GMT, respectively), for 2 h/day for 32 consecutive days. The rats in the seventh group were used as sham-exposed controls. At the end of last RF exposure, blood samples were collected from each rat every 4 h (total period of 24 h) and also at similar times from sham-exposed animals. The concentrations of three antioxidants (Mel, GSH-Px and SOD) were determined. The data in RF-exposed rats were compared with those in sham-exposed animals. RESULTS: circadian rhythms in the synthesis of Mel and antioxidant enzymes, GSH-Px and SOD, were shifted in RF-exposed rats compared to sham-exposed animals: the Mel, GSH-Px and SOD levels were significantly decreased when RF exposure was given at 23 and 3 h GMT. CONCLUSION: The overall results indicate that there may be adverse effects of RF exposure on antioxidant function, in terms of both the daily antioxidative levels, as well as the circadian rhythmicity.

Cao XZ, Zhao ML, Wang DW, Dong B. [Apoptosis of human lung carcinoma cell line GLC-82 induced by high power electromagnetic pulse] Ai Zheng 21(9):929-933, 2002. [Article in Chinese]

BACKGROUND & OBJECTIVE: Electromagnetic pulse (EMP) could be used for sterilization of food and the efficiency is higher than 2450 MHz continuous microwave done. This study was designed to evaluate the effect of electromagnetic pulse (EMP) on apoptosis of human lung carcinoma cell line GLC-82, so that to explore and develop therapeutic means for cancer. METHODS: The injury changes in GLC-82 cells after irradiated with EMP (electric field intensity was 60 kV/m, 5 pulses/2 min) were analyzed by cytometry, MTT chronometry, and flow cytometry. The immunohistochemical SP staining was used to determine the expressions of bcl-2 protein and p53 protein. The stained positive cells were analyzed by CMIAS-II image analysis system at a magnification 400. All data were analyzed by SPSS8.0 software. RESULTS: EMP could obviously inhibited proliferation and activity of lung carcinoma cell line GLC-82. The absorbance value (A570) of MTT decreased immediately, at 0 h, 1 h, and 6 h after the GLC-82 cells irradiated by EMP as compared with control group. The highest apoptosis rate was found to reach 13.38% by flow cytometry at 6 h after EMP irradiation. Downregulation of bcl-2 expression and up-regulation of p53 expression were induced by EMP. CONCLUSION: EMP promotes apoptosis of GLC-82 cells. At same time, EMP can down-regulate bcl-2 expression and up-regulate p53 expression in GLC-82 cells. The bcl-2 and the p53 protein may involve the apoptotic process.

Cao Y, Xu Q, Lu MX, Jin ZD, DU HB, Li JX, Nie JH, Tong J. [Antagonistic effect of microwave on hematopoietic damage of mice induced by gamma-ray irradiation.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 27(9):525-529, 2009. [Article in Chinese]

OBJECTIVE: To investigate antagonistic effect of microwave on hematopoietic damage of mice induced by gamma-ray irradiation. METHODS: Male healthy Kunning mice were treated with low dose microwave radiation before exposure to (60)Co gamma-ray irradiation of 8.0 Gy. The 30-day survival rate and average survival time of the mice after the treatment were examined. Peripheral blood parameters and the organ indexes of thymus and spleen were also observed in the irradiated mice. After exposure to 5.0 Gy gamma irradiation, indexes of hematopoietic foci formation of bone marrow cells (CFU-GM) and the proliferation activity of BMNCs were examined. The serum concentration of hemopoietic factors (GM-CSF and IL-3) were detected by ELISA kits. RESULTS: Pre-exposure with 120 microW/cm(2) 900 MHz microwave increased the 30-day survival rate ($P < 0.05$) and the number of white blood cells of gamma-ray treated mice. The increases of the organ indexes of thymus and spleen, proliferation activity of BMNCs and CFU-GM hematopoietic foci numbers, as well as the higher serum concentration of GM-CSF and IL-3 were observed in the microwave pre-exposure group. CONCLUSION: Low dose microwave radiation may exert potential antagonistic effects on hematopoietic injuries induced by ionizing radiation. The underlying mechanisms might be related with stimulation of hematopoietic growth factors expression, promotion of HSCs/HPCs proliferation, suppression on the reduction of HSCs/HPCs caused by (60)Co gamma-ray, and enhanced construction of the hematopoietic system.

Cao Y, Zhang W, Lu MX, Xu Q, Meng QQ, Nie JH, Tong J. 900-MHz microwave radiation enhances gamma-ray adverse effects on SHG44 cells. J Toxicol Environ Health A. 72(11):727-732, 2009.

Mobile phones are widely used globally. However, the biological effects due to exposure to electromagnetic fields (EMF) produced by mobile phones are largely unknown. Environmental and occupational exposure of humans to gamma-rays is a biologically relevant phenomenon. Consequently studies were undertaken to examine the interactions between gamma-rays and EMF on human health. In this study, exposure to 900-MHz EMF expanded gamma-ray damage to SHG44 cells. Preexposure EMF enhanced the decrease in cell proliferation induced by gamma-ray irradiation and the rate of apoptosis. The combination of EMF and gamma-ray exposure resulted in a synergistic effect by triggering stress response, which increased reactive oxygen species, but the expression of hsp70 at both mRNA and protein levels remained unaltered. Data indicate that the adverse effects of gamma-rays on cellular functions are strengthened by EMF.

Cao Y, Xu Q, Lu MX, Jin ZD, DU HB, Li JX, Nie JH, Tong J. [Antagonistic effect of microwave on hematopoietic damage of mice induced by gamma-ray

irradiation.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 27(9):525-529, 2009. [Article in Chinese]

OBJECTIVE: To investigate antagonistic effect of microwave on hematopoietic damage of mice induced by gamma-ray irradiation. METHODS: Male healthy Kunning mice were treated with low dose microwave radiation before exposure to (60)Co gamma-ray irradiation of 8.0 Gy. The 30-day survival rate and average survival time of the mice after the treatment were examined. Peripheral blood parameters and the organ indexes of thymus and spleen were also observed in the irradiated mice. After exposure to 5.0 Gy gamma irradiation, indexes of hematopoietic foci formation of bone marrow cells (CFU-GM) and the proliferation activity of BMNCs were examined. The serum concentration of hemopoietic factors (GM-CSF and IL-3) were detected by ELISA kits. RESULTS: Pre-exposure with 120 microW/cm(2) 900 MHz microwave increased the 30-day survival rate ($P < 0.05$) and the number of white blood cells of gamma-ray treated mice. The increases of the organ indexes of thymus and spleen, proliferation activity of BMNCs and CFU-GM hematopoietic foci numbers, as well as the higher serum concentration of GM-CSF and IL-3 were observed in the microwave pre-exposure group. CONCLUSION: Low dose microwave radiation may exert potential antagonistic effects on hematopoietic injuries induced by ionizing radiation. The underlying mechanisms might be related with stimulation of hematopoietic growth factors expression, promotion of HSCs/HPCs proliferation, suppression on the reduction of HSCs/HPCs caused by (60)Co gamma-ray, and enhanced construction of the hematopoietic system.

Cao Y, Xu Q, Jin ZD, Zhang J, Lu MX, Nie JH, Tong J. Effects of 900-MHz microwave radiation on gamma-ray-induced damage to mouse hematopoietic system. J Toxicol Environ Health A. 73(7):507-513, 2010.

Exposure of humans simultaneously to microwave and gamma-ray irradiation may be a commonly encountered phenomenon. In a previous study data showed that low-dose microwave radiation increased the survival rate of mice irradiated with 8Gy gamma-ray; however, the mechanisms underlying these findings remain unclear. Consequently, studies were undertaken to examine the effects of microwave exposure on hematopoietic system adversely altered by gamma-ray irradiation in mice. Preexposure to low-dose microwaves attenuated the damage produced by gamma-ray irradiation as evidenced by less severe pathological alterations in bone marrow and spleen. The protective effects of microwaves were postulated to be due to up-expression of some hematopoietic growth factors, stimulation of proliferation of the granulocyte-macrophages in bone marrow, and inhibition of the gamma-ray induced suppression of hematopoietic stem cells/hematopoietic progenitor cells. Data thus indicate that prior exposure to microwaves may be beneficial in providing protection against injuries produced by gamma-ray on the hematopoietic system in mice.

Cao Y, Xu Q, Jin ZD, Zhou Z, Nie JH, Tong J. Induction of adaptive response: pre-exposure of mice to 900 MHz radiofrequency fields reduces hematopoietic damage

caused by subsequent exposure to ionising radiation. Int J Radiat Biol. 87(7):720-728, 2011.

PURPOSE: To investigate whether an adaptive response can be induced in mice which were pre-exposed to 900 MHz radiofrequency fields. MATERIALS AND METHODS: Adult male Kunming mice were exposed to 900 MHz radiofrequency fields (RF) at power intensities of 12, 120 and 1200 μW/cm(2) for 1 h/day for 14 days and then subjected to whole body gamma-irradiation. The results were compared with those in unexposed control animals and those exposed to gamma-irradiation alone (without pre-exposure to RF). The extent of survival and hematopoietic tissue damage (assessed in the form of nucleated colony forming cells in the bone marrow and colony forming cells in the spleen of lethally irradiated 'recipient' mice) as well as the expression of cell cycle-related genes were investigated. RESULTS: The results indicated a significant increase in survival time, reduction in the hematopoietic tissue damage in RF pre-exposed mice which were gamma-irradiated (as compared with those exposed to gamma-radiation alone). This was accompanied by significantly increased expression of cell cycle-related genes, namely, cyclin-D1, cyclin-E, cyclin-DK4 and cyclin-DK2 in hematopoietic cells. CONCLUSIONS: Pre-exposure of mice to 900 MHz radiofrequency fields has resulted in a significant reduction in hematopoietic damage caused by subsequent exposure to ionising radiation. This phenomenon appears to be similar to that of the 'adaptive response' which is well documented in scientific literature.

Cao Z, Liu J, Li S, Zhao X. [Effects of electromagnetic radiation from handsets of cellular telephone on neurobehavioral function] Wei Sheng Yan Jiu 29(2):102-103, 2000. [Article in Chinese]

In order to study the effects of electromagnetic radiation from handsets of cellular telephone on neurobehavioral function, 81 staff with handsets of cellular telephone and 63 staff without handsets of cellular telephone from corporations were selected as the subjects. The subjects were investigated by questionnaire on their general health, lifestyle habit, suppress of spirit, handset using of cellular telephone, environmental exposure, morbidity, and the neurobehavioral core test battery(NCTB). The data was analyzed by chi-square, stepwise regression analysis and covariance statistics. The results showed that the average reaction time in user's group was longer than that in control group ($P < 0.01$). The time of using handset was negatively associated with corrected reaction number ($P < 0.01$). The fast reaction time and the slowest reaction time were positively associated with the length of handset using ($P < 0.01$, $P < 0.05$). The results suggested that the handset using could cause adverse health effects in neurobehavioral function.

Capri M, Scarcella E, Bianchi E, Fumelli C, Mesirca P, Agostini C, Remondini D, Schuderer J, Kuster N, Franceschi C, Bersani F.1800 MHz radiofrequency (mobile phones, different global system for mobile communication modulations) does not affect apoptosis and heat shock protein 70 level in peripheral blood mononuclear cells from young and old donors. Int J Radiat Biol. 80(6):389-397, 2004.

PURPOSE: To study if prolonged in vitro exposure to 1800MHz radiofrequency (RF) could exert an effect on human peripheral blood mononuclear cells (PBMC) from young and elderly donors by affecting apoptosis, mitochondrial membrane potential and heat shock protein (HSP) 70 levels. MATERIALS AND METHODS: Endpoints were analysed in the presence or absence of the apoptosis-inducing agent 2-deoxy-D-ribose. Three different signal modulations typical of the Global System for Mobile communication (GSM) system were applied. The modulations are widely used in mobile telephony (GSM Basic, discontinuous transmission [DTX] and Talk) at specific absorption rates of 1.4 and 2.0 W kg(-1). RESULTS: In all conditions and for all endpoints tested, there was no significant difference between RF- and sham-exposed cells. CONCLUSION: 1800MHz RF could not induce apoptosis by itself or affect the apoptotic phenomenon when induced by an apoptotic agent. Moreover, RF did not modify the mitochondrial functionality and the expression of HSP 70.

Capri M, Scarcella E, Fumelli C, Bianchi E, Salvioli S, Mesirca P, Agostini C, Antolini A, Schiavoni A, Castellani G, Bersani F, Franceschi C. In vitro exposure of human lymphocytes to 900 MHz CW and GSM modulated radiofrequency: studies of proliferation, apoptosis and mitochondrial membrane potential. Radiat Res. 162(2):211-218, 2004.

The aim of this study was to investigate the nonthermal effects of radiofrequency (RF) fields on human immune cells exposed to a Global System for Mobile Communication (GSM) signal generated by a commercial cellular phone and by a sinusoidal non-modulated signal. To assess whether mobile phone RF-field exposure affects human immune cell functions, peripheral blood mononuclear cells (PBMCs) from healthy donors were exposed in vitro to a 900 MHz GSM or continuous-wave (CW) RF field 1 h/day for 3 days in a transverse electromagnetic mode (TEM) cell system (70-76 mW/kg average specific absorption rate, SAR). The cells were cultured for 48 or 72 h, and the following end points were studied: (1) mitogen-induced proliferation; (2) cell cycle progression; (3) spontaneous and 2-deoxy-D-ribose (dRib)-induced apoptosis; (4) mitochondrial membrane potential modifications during spontaneous and dRib-induced-apoptosis. Data obtained from cells exposed to a GSM-modulated RF field showed a slight decrease in cell proliferation when PBMCs were stimulated with the lowest mitogen concentration and a slight increase in the number of cells with altered distribution of phosphatidylserine across the membrane. On the other hand, cell cycle phases, mitochondrial membrane potential and susceptibility to apoptosis were found to be unaffected by the RF field. When cells were exposed to a CW RF field, no significant modifications were observed in comparison with sham-exposed cells for all the end points investigated.

Capri M, Salvioli S, Altilia S, Sevini F, Remondini D, Mesirca P, Bersani F, Monti D, Franceschi CAge-Dependent Effects of in Vitro Radiofrequency Exposure (Mobile Phone) on CD95+ T Helper Human Lymphocytes. Ann N Y Acad Sci. 1067:493-499, 2006.

.Recent studies on "nonthermal" effects of mobile phone radiofrequency (RF) suggest that RF can interact with cellular functions and molecular pathways. To study the possible RF effects on human lymphocyte activation, we analyzed CD25, CD95, CD28 molecules in unstimulated and stimulated CD4+ e CD8+ T cells in vitro. Peripheral blood mononuclear cells (PBMCs) from young and elderly donors were exposed or sham-exposed to RF (1,800 MHz, Specific Absorption Rate 2 W/kg) with or without mitogenic stimulation. No significant changes in the percentage of these cell subsets were found between exposed and sham-exposed lymphocytes in both young and elderly donors. Nevertheless, after RF exposure we observed a slight, but significant, downregulation of CD95 expression in stimulated CD4+ T lymphocytes from elderly, but not from young donors. This age-related result is noteworthy given the importance of such a molecule in regulation of the immune response.

Caraglia M, Marra M, Mancinelli F, D'Ambrosio G, Massa R, Giordano A, Budillon A, Abbruzzese A, Bismuto E. Electromagnetic fields at mobile phone frequency induce apoptosis and inactivation of the multi-chaperone complex in human epidermoid cancer cells. J Cell Physiol. 204(2):539-548, 2005.

The exposure to non-thermal microwave electromagnetic field (MW-EMF) at 1.95 MHz, a frequency used in mobile communication, affects the refolding kinetics of eukaryotic proteins (Mancinelli et al., 2004). On these basis we have evaluated the in vivo effect of MW-EMF in human epidermoid cancer KB cells. We have found that MW-EMF induces time-dependent apoptosis (45% after 3 h) that is paralleled by an about 2.5-fold decrease of the expression of ras and Raf-1 and of the activity of ras and Erk-1/2. Although also the expression of Akt was reduced its activity was unchanged likely as a consequence of the increased expression of its upstream activator PI3K. In the same experimental conditions an about 2.5-fold increase of the ubiquitination of ras and Raf-1 was also found and the addition for 12 h of proteasome inhibitor lactacystin at 10 microM caused an accumulation of the ubiquitinated isoforms of ras and Raf-1 and counteracted the effects of MW-EMF on ras and Raf-1 expression suggesting an increased proteasome-dependent degradation induced by MW-EMF. The exposure of KB cells to MW-EMF induced a differential activation of stress-dependent pathway with an increase of JNK-1 activity and HSP70 and 27 expression and with a reduction of p38 kinase activity and HSP90 expression. The overexpression of HSP90 induced by transfection of KB cells with a plasmid encoding for the factor completely antagonized the apoptosis and the inactivation of the ras --> Erk-dependent survival signal induced by MW-EMF. Conversely, the inhibition of Erk activity induced by 12 h exposure to 10 mM Mek-1 inhibitor U0126 antagonized the effects induced by HSP90 transfection on apoptosis caused by MW-EMF. In conclusion, these results demonstrate for the first time that MW-EMF induces apoptosis through the inactivation of the ras --> Erk survival signaling due to enhanced degradation of ras and Raf-1 determined by decreased expression of HSP90 and the consequent increase of proteasome dependent degradation.

Carballo-Quintás M, Martínez-Silva I, Cadarso-Suárez C, Alvarez-Figueiras M, Ares-Pena FJ, López-Martín E. A study of neurotoxic biomarkers, c-fos and GFAP after acute exposure to GSM radiation at 900 MHz in the picrotoxin model of rat brains. Neurotoxicology. 32(4):478-494, 2011.

The acute effects of microwave exposure from the Global System for Mobile Communication (GSM) were studied in rats, using 900MHz radiation at an intensity similar to mobile phone emissions. Acute subconvulsive doses of picrotoxin were then administered to the rats and an experimental model of seizure-proneness was created from the data. Seventy-two adult male Sprague-Dawley rats underwent immunochemical testing of relevant anatomical areas to measure induction of the c-fos neuronal marker after 90min and 24h, and of the glial fibrillary acidic protein (GFAP) 72h after acute exposure to a 900MHz electromagnetic field (EMF). The experimental set-up facilitated measurement of absorbed power, from which the average specific absorption rate was calculated using the finite-difference time-domain (FDTD) 2h after exposure to EMF radiation at 1.45W/kg in picrotoxin-treated rats and 1.38W/kg in untreated rats. Ninety minutes after radiation high levels of c-fos expression were recorded in the neocortex and paleocortex along with low hippocampus activation in picrotoxin treated animals. Most brain areas, except the limbic cortical region, showed important increases in neuronal activation 24h after picrotoxin and radiation. Three days after picrotoxin treatment, radiation effects were still apparent in the neocortex, dentate gyrus and CA3, but a significant decrease in activity was noted in the piriform and entorhinal cortex. During this time, glial reactivity increased with every seizure in irradiated, picrotoxin-treated brain regions. Our results reveal that c-fos and glial markers were triggered by the combined stress of non-thermal irradiation and the toxic effect of picrotoxin on cerebral tissues.

Carlberg M, Hardell L. Decreased Survival of Glioma Patients with Astrocytoma Grade IV (Glioblastoma Multiforme) Associated with Long-Term Use of Mobile and Cordless Phones. Int J Environ Res Public Health. 11(10):10790-10805, 2014.

On 31 May 2011 the WHO International Agency for Research on Cancer (IARC) categorised radiofrequency electromagnetic fields (RF-EMFs) from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields, as a Group 2B, i.e., a "possible", human carcinogen. A causal association would be strengthened if it could be shown that the use of wireless phones has an impact on the survival of glioma patients. We analysed survival of 1678 glioma patients in our 1997-2003 and 2007-2009 case-control studies. Use of wireless phones in the >20 years latency group (time since first use) yielded an increased hazard ratio (HR) = 1.7, 95% confidence interval (CI) = 1.2-2.3 for glioma. For astrocytoma grade IV (glioblastoma multiforme; n = 926) mobile phone use yielded HR = 2.0, 95% CI = 1.4-2.9 and cordless phone use HR = 3.4, 95% CI = 1.04-11 in the same latency category. The hazard ratio for astrocytoma grade IV increased statistically significant per year of latency for wireless phones, HR = 1.020, 95% CI = 1.007-1.033, but not per 100 h cumulative use, HR = 1.002, 95% CI = 0.999-1.005. HR was not statistically significant increased for other types of glioma. Due to the relationship with survival the classification of IARC is strengthened and RF-EMF should be regarded as human carcinogen requiring urgent revision of current exposure guidelines.

Carlberg M, Hardell L. Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation. Biomed Res Int. 2017:9218486, 2017.

Objective. Bradford Hill's viewpoints from 1965 on association or causation were used on glioma risk and use of mobile or cordless phones. *Methods.* All nine viewpoints were evaluated based on epidemiology and laboratory studies. *Results.* Strength: meta-analysis of case-control studies gave odds ratio (OR) = 1.90, 95% confidence interval (CI) = 1.31-2.76 with highest cumulative exposure. Consistency: the risk increased with latency, meta-analysis gave in the 10+ years' latency group OR = 1.62, 95% CI = 1.20-2.19. Specificity: increased risk for glioma was in the temporal lobe. Using meningioma cases as comparison group still increased the risk. Temporality: highest risk was in the 20+ years' latency group, OR = 2.01, 95% CI =1.41-2.88, for wireless phones. Biological gradient: cumulative use of wireless phones increased the risk. Plausibility: animal studies showed an increased incidence of glioma and malignant schwannoma in rats exposed to radiofrequency (RF) radiation. There is increased production of reactive oxygen species (ROS) from RF radiation. Coherence: there is a change in the natural history of glioma and increasing incidence. Experiment: antioxidants reduced ROS production from RF radiation. Analogy: there is an increased risk in subjects exposed to extremely low-frequency electromagnetic fields. *Conclusion.* RF radiation should be regarded as a human carcinogen causing glioma.

Cardis E, Deltour I, Mann S, Moissonnier M, Taki M, Varsier N, Wake K, Wiart J. Distribution of RF energy emitted by mobile phones in anatomical structures of the brain. Phys Med Biol. 53(11):2771-2783, 2008.

The rapid worldwide increase in mobile phone use in the last decade has generated considerable interest in possible carcinogenic effects of radio frequency (RF). Because exposure to RF from phones is localized, if a risk exists it is likely to be greatest for tumours in regions with greatest energy absorption. The objective of the current paper was to characterize the spatial distribution of RF energy in the brain, using results of measurements made in two laboratories on 110 phones used in Europe or Japan. Most (97-99% depending on frequency) appears to be absorbed in the brain hemisphere on the side where the phone is used, mainly (50-60%) in the temporal lobe. The average relative SAR is highest in the temporal lobe (6-15%, depending on frequency, of the spatial peak SAR in the most exposed region of the brain) and the cerebellum (2-10%) and decreases very rapidly with increasing depth, particularly at higher frequencies. The SAR distribution appears to be fairly similar across phone models, between older and newer phones and between phones with different antenna types and positions. Analyses of risk by location of tumour are therefore important for the interpretation of results of studies of brain tumours in relation to mobile phone use.

Carlberg M, Hardell L. On the association between glioma, wireless phones, heredity and ionising radiation. Pathophysiology. 19(4):243-252, 2012.

We performed two case-control studies on brain tumours diagnosed during 1 January 1997 to 30 June 2000 and 1 July 2000 to 31 December 2003, respectively. Living cases and controls aged 20-80 years were included. An additional study was performed on deceased cases with a malignant brain tumour using deceased controls. Pooled results for glioma yielded for ipsilateral use of mobile phone odds ratio (OR)=2.9, 95% confidence interval (CI)=1.8-4.7 in the >10 years latency group. The corresponding result for cordless phone was OR=3.8, 95% CI=1.8-8.1. OR increased statistically significant for cumulative use of wireless phones per 100h and per year of latency. For high-grade glioma ipsilateral use of mobile phone gave OR=3.9, 95% CI=2.3-6.6 and cordless phone OR=5.5, 95% CI=2.3-13 in the >10 years latency group. Heredity for brain tumour gave OR=3.4, 95% CI=2.1-5.5 for glioma. There was no interaction with use of wireless phones. X-ray investigation of the head gave overall OR=1.3, 95% CI=1.1-1.7 for glioma without interaction with use of wireless phones or heredity. In conclusion use of mobile and cordless phone increased the risk for glioma with highest OR for ipsilateral use, latency >10 years and third tertile of cumulative use in hours. In total, the risk was highest in the age group <20 years for first use of a wireless phone.

Carlberg M, Hardell L. Pooled analysis of Swedish case-control studies during 1997-2003 and 2007-2009 on meningioma risk associated with the use of mobile and cordless phones. Oncol Rep. 33(6):3093-3098, 2015.

A pooled analysis of two case-control studies on meningioma with patients diagnosed during 1997-2003 and 2007-2009 was conducted. Both genders were included, aged 20-80 and 18-75 years, respectively, at the time of diagnosis. Population-based controls, matched according to age and gender, were enrolled. Exposure was assessed by questionnaire. In the entire study, cases with all brain tumor types were included. The whole reference group was used in the unconditional logistic regression analysis on meningioma, with adjustments for gender, age, year of diagnosis and socio-economic index (SEI). In total, 1,625 meningioma cases and 3,530 controls were analyzed. Overall no association with use of mobile or cordless phones was found. In the fourth quartile of use (>1,436 h) somewhat increased risk was found for mobile phones yielding an odds ratio (OR)=1.2, 95% confidence intervals (CI)=0.9-1.6 and cordless phones OR=1.7, 95% CI=1.3-2.2. Higher risk was calculated in the highest decile (>3,358 h), OR=1.5, 95% CI=0.99-2.1 and OR=2.0, 95% CI=1.4-2.8, respectively. In addition, the longest latency time gave somewhat increased risk for both phone types although the result was not statistically significant. There was no association for ipsilateral use or anatomical tumor location. The present study showed a somewhat increased risk among heavy users of mobile and cordless phones. Since meningioma is generally a slow-growing tumor, longer latency period is necessary for definitive conclusions.

Carlberg M, Söderqvist F, Hansson Mild K, Hardell L. Meningioma patients diagnosed 2007--2009 and the association with use of mobile and cordless phones: a case--control study. Environ Health. 2013 Jul 19;12(1):60. [Epub ahead of print]

BACKGROUND: To study the association between use of wireless phones and meningioma. METHODS: We performed a case--control study on brain tumour cases of both genders aged 18--75 years and diagnosed during 2007--2009. One population-based control matched on gender and age was used to each case. Here we report on meningioma cases including all available controls. Exposures were assessed by a questionnaire. Unconditional logistic regression analysis was performed. RESULTS: In total 709 meningioma cases and 1,368 control subjects answered the questionnaire. Mobile phone use in total produced odds ratio (OR) = 1.0, 95% confidence interval (CI) =

0.7-1.4 and cordless phone use gave OR = 1.1, 95% CI = 0.8-1.5. The risk increased statistically significant per 100 h of cumulative use and highest OR was found in the fourth quartile (>2,376 hours) of cumulative use for all studied phone types. There was no statistically significant increased risk for ipsilateral mobile or cordless phone use, for meningioma in the temporal lobe or per year of latency. Tumour volume was not related to latency or cumulative use in hours of wireless phones. CONCLUSIONS: No conclusive evidence of an association between use of mobile and cordless phones and meningioma was found. An indication of increased risk was seen in the group with highest cumulative use but was not supported by statistically significant increasing risk with latency. Results for even longer latency periods of wireless phone use than in this study are desirable**.**

Carrubba S, Frilot C 2nd, Chesson AL Jr, Marino AA. Mobile-phone pulse triggers evoked potentials. Neurosci Lett. 469(1):164-168, 2010.

If mobile-phone electromagnetic fields (EMFs) are hazardous, as suggested in the literature, processes or mechanisms must exist that allow the body to detect the fields. We hypothesized that the low-frequency pulses produced by mobile phones (217Hz) were detected by sensory transduction, as evidenced by the ability of the pulses to trigger evoked potentials (EPs). Electroencephalograms (EEGs) were recorded from six standard locations in 20 volunteers and analyzed to detect brain potentials triggered by a pulse of the type produced by mobile phones. Evoked potentials having the expected latency were found in 90% of the volunteers, as assessed using a nonlinear method of EEG analysis. Evoked potentials were not detected when the EEG was analyzed using time averaging. The possibility of systematic error was excluded by sham-exposure analyses. The results implied that mobile-phones trigger EP at the rate of 217Hz during ordinary phone use. Chronic production of the changes in brain activity might be pertinent

Cassel JC, Cosquer B, Galani R, Kuster N. Whole-body exposure to 2.45 GHz electromagnetic fields does not alter radial-maze performance in rats. Behav Brain Res. 155(1):37-43, 2004.

Mobile communication is based on utilization of electromagnetic fields (EMFs) in the frequency range of 0.3-300GHz. Human and animal studies suggest that EMFs, which are in the 0.1MHz-300GHz range, might interfere with cognitive processes. In 1994, a report by Lai et al. [Bioelectromagnetics 15 (1994) 95-104] showed that whole-body exposure of rats to pulsed 2.45GHz microwaves (2micros pulse width, 500pps, and specific absorption rate [SAR] 0.6W/kg) for 45min resulted in altered spatial working memory assessed in a 12-arm radial-maze task. Surprisingly, there has been only one attempt to replicate this experiment so far [Bioelectromagnetics 25 (2004) 49-57]; confirmation of the Lai et al. experiment failed. In the present study, rats were tested in a 12-arm radial-maze subsequently to a daily exposure to 2.45GHz microwaves (2micros pulse width, 500pps, and SAR 0.6W/kg) for 45min. The performance of exposed rats was comparable to that found in sham-exposed or in naive rats (no contact with the exposure system). Regarding the methodological details provided by Lai et al. on their testing protocol, our results might suggest that the microwave-induced behavioral alterations measured by these authors might have had more to do with factors liable to performance bias than with spatial working memory per se.

Cassel JC, Cosquer B, Galani R, Kuster N. Whole-body exposure to 2.45 GHz electromagnetic fields does not alter radial-maze performance in rats. Behav Brain Res. 155(1):37-43, 2004.

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Cecil S, Neubauer G, Rauscha F, Stix G, Müller W, Breithuber C, Glanzer M. Possible risks due to exposure of workers and patients with implants by TETRA transmitters. Bioelectromagnetics. 2014 Jan 16. doi: 10.1002/bem.21839. [Epub ahead of print]

Several studies have demonstrated that mobile telephones that use different technologies, such as Global System for Mobile Communication (GSM) or Universal Mobile Telecommunication System (UMTS), have the potential to influence the functionality of active electronic implants, including cardiac pacemakers. According to these studies, a few safety measures, such as maintaining minimum distances of 25 cm between implants and transmitters, are sufficient to avoid such effects. Terrestrial Trunked Radio (TETRA) has become a well-established communication standard in many countries, including Germany and Austria. TETRA transmitters are typically used by police forces and emergency services. Employees and volunteers working for such institutions are often in close contact with patients, causing TETRA transmitters to potentially have an impact on the functionality of the implants of patients. Therefore, the main focus of our study was to investigate the functionality of several types of implants when exposed to TETRA transmitters. Moreover, we investigated the difference in the degree of exposure of users of TETRA transmitters when they carry the devices in different locations near the body, and when they use them in different positions near the head. Our results show that a compliance distance of 30 cm between implant and transmitter is sufficient to exclude any influence on the examined implants. All examined exposure conditions demonstrated that the levels were well below recommended limits. If a user wants to minimize their exposure, use of transmitters in front of the mouth leads to somewhat lower exposure when compared to typical mobile phone like use.

Celik O, Hascalik S. Effect of electromagnetic field emitted by cellular phones on fetal heart rate patterns. Eur J Obstet Gynecol Reprod Biol. 112(1):55-56, 2004.

The study was planned to determine the effects of electromagnetic fields produced by cellular phones on baseline fetal heart rate, acceleration and deceleration. Forty pregnant women undergoing non-stress test were admitted to the study. Non-stress test was obtained while the subjects were holding the CP on stand by mode and on dialing mode, each for 5 min. Similar recordings were taken while there were no phones around for 10 min. Electromagnetic fields produced by cellular phones do not cause any demonstrable affect in fetal heart rate, acceleration and deceleration.

Celik S, Aridogan IA, Izol V, Erdoğan S, Polat S, Doran S. An Evaluation of the effects of long-term cell phone use on the testes via light and electron microscope analysis. Urology. 79(2):346-350, 2012

Abstract. OBJECTIVE: To investigate whether the low-intensity electromagnetic waves transmitted by cell phones cause histopathological or ultrastructural changes in the testes of rats. MATERIALS AND METHODS: Wistar-Kyoto male rats were placed into either a control group or a group that was exposed to an electromagnetic field (EMF). Two cell phones with Specific Absorbation Rate values of 1.58 were placed and left off in cages that housed 15 rats included in the control group, and four cell phones were placed and left on in cages that housed 30 rats included in the experimental group. After 3 months, weights, seminiferous tubule diameters, and spermatogenic cell conditions of all testes of the rats were evaluated. One half of each testis was examined also under an electron microscope. RESULTS: No significant differences were observed between the testis weights, seminiferous tubule diameters, and histopathological evaluations between rats that had and had not been exposed to EMF. Electron microscope analysis revealed that the membrana propria thickness and the collagen fiber contents were increased and the capillary veins extended in the experimental group. Common vacuolization in the cytoplasm of the Sertoli cells, growth of electron-dense structures, and existence of large lipid droplets were noted as the remarkable findings of this study.

Çeliker M, Özgür A, Tümkaya L, Terzi S, Yılmaz M, Kalkan Y, Erdoğan E. Effects of exposure to 2100MHz GSM-like radiofrequency electromagnetic field on auditory system of rats. Braz J Otorhinolaryngol. 2016 Nov 5. pii: S1808-8694(16)30222-1. doi: 10.1016/j.bjorl.2016.10.004. [Epub ahead of print]

INTRODUCTION: The use of mobile phones has become widespread in recent years. Although beneficial from the communication viewpoint, the electromagnetic fields (EMF) generated by mobile phones may cause unwanted biological changes in the human body. OBJECTIVE: In this study, we aimed to evaluate the effects of 2100MHz Global System for Mobile communication (GSM-like) electromagnetic field (EMF), generated by an EMF generator, on the auditory system of rats by using electrophysiological, histopathologic and immunohistochemical methods. METHODS: Fourteen adult Wistar albino rats were included in the study. The rats were divided randomly into two groups of seven rats each. The study group was exposed continuously for 30days to a 2100MHz EMF with a signal level (power) of 5.4dBm (3.47mW) to simulate the talk mode on a mobile phone. The control group was not exposed to the aforementioned EMF. After 30days, the Auditory Brainstem Responses (ABRs) of both groups were recorded and the rats were sacrificed. The cochlear nuclei were evaluated by histopathologic and immunohistochemical methods. RESULTS: The ABR records of the two groups did not differ significantly. The histopathologic analysis showed increased degeneration signs in the study group (p=0.007). In addition, immunohistochemical analysis revealed increased apoptotic index in the study group compared to that in the control group (p=0.002). CONCLUSION: The results support that long-term exposure to a GSM-like 2100MHz EMF causes an increase in neuronal degeneration and apoptosis in the auditory system.

Celikozlu SD, Ozyurt MS, Cimbiz A, Yardimoglu MY, Cayci MK, Ozay Y. The effects of long-term exposure of magnetic field via 900-MHz GSM radiation on some biochemical parameters and brain histology in rats. Electromagn Biol Med. 31(4):344-355, 2012.

The aim of this study is to determine the effects of magnetic field via cell phones on some blood parameters and neurons in the brain of rats. Animals have been classified into three groups: control, Magnetic Field (MF), and F2 groups. Throughout this study, cell phones were placed on the wall of the cages. Rats were exposed to the effects of cell phones during prenatal and postnatal periods until they were 80 days old. During the study, the exposure procedure of rats was that the phone was in standby mode for a whole day and in talking mode for 30 min per day. The waves of cell phones caused an increased blood glucose level from 96.52 ± 5.64 mg/dl to 132.14 ± 5.93 mg/dl and an increased serum protein level from 131.14 ± 6.19 mg/dl to 319.29 ± 6.73 mg/dl compared to control. Statistically, significant differences wasn't observed in the blood cholesterol concentration between the groups compared to the control. Weekly weight gain decreased in all groups compared to the control. MF exposure decreased pyramidal neuron numbers 51.15% and increased ischemic neuron numbers 73% at cortex region of brain. In addition, vascular dilatations have increased clearly in group F2.Whereas the procedure of MF did not have any effects on hippocampal pyramidal cell numbers, magnetic fields increased the amount of ischemic neurons three-fold compared to the control. In conclusion, MF affected some biochemical parameters, especially the cortex region of the brain.

Cervellati F, Valacchi G, Lunghi L, Fabbri E, Valbonesi P, Marci R, Biondi C, Vesce F. 17-β-estradiol counteracts the effects of high frequency electromagnetic fields on trophoblastic connexins and integrins. Oxid Med Cell Longev. 2013;2013:280850. doi: 10.1155/2013/280850.

We investigated the effect of high-frequency electromagnetic fields (HF-EMFs) and 17-β-estradiol on connexins (Cxs), integrins (Ints), and estrogen receptor (ER) expression, as well as on ultrastructure of trophoblast-derived HTR-8/SVneo cells. HF-EMF, 17-β-estradiol, and their combination induced an increase of Cx40 and

Cx43 mRNA expression. HF-EMF decreased Int alpha1 and β 1 mRNA levels but enhanced Int alpha5 mRNA expression. All the Ints mRNA expressions were increased by 17-β-estradiol and exposure to both stimuli. ER-β mRNA was reduced by HF-EMF but augmented by 17-β-estradiol alone or with HF-EMF. ER-β immunofluorescence showed a cytoplasmic localization in sham and HF-EMF exposed cells which became nuclear after treatment with hormone or both stimuli. Electron microscopy evidenced a loss of cellular contact in exposed cells which appeared counteracted by 17-β-estradiol. We demonstrate that 17-β-estradiol modulates Cxs and Ints as well as ER-β expression induced by HF-EMF, suggesting an influence of both stimuli on trophoblast differentiation and migration.

Cetin H, Nazıroğlu M, Celik O, Yüksel M, Pastacı N, Ozkaya MO. Liver antioxidant stores protect the brain from electromagnetic radiation (900 and 1800 MHz)-induced oxidative stress in rats during pregnancy and the development of offspring. J Matern Fetal Neonatal Med. 2014 Mar 3. [Epub ahead of print]

Objectives: The present study determined the effects of mobile phone (900 and 1800 MHz)-induced electromagnetic radiation (EMR) exposure on oxidative stress in the brain and liver as well as the element levels in growing rats from pregnancy to 6 weeks of age. Methods: Thirty-two rats and their offspring were equally divided into 3 different groups: the control, 900 MHz, and 1800 MHz groups. The 900 MHz and 1800 MHz groups were exposed to EMR for 60 min/day during pregnancy and neonatal development. At the 4th, 5th, and 6th weeks of the experiment, brain samples were obtained. Results: Brain and liver glutathione peroxidase (GSH-Px) activities, as well as liver vitamin A and β-carotene concentrations decreased in the EMR groups, although brain iron, vitamin A, and β-carotene concentrations increased in the EMR groups. In the 6th week, selenium concentrations in the brain decreased in the EMR groups. There were no statistically significant differences in glutathione, vitamin E, chromium, copper, magnesium, manganese, and zinc concentrations between the 3 groups. Conclusion: EMR-induced oxidative stress in the brain and liver was reduced during the development of offspring. Mobile phone-induced EMR could be considered as a cause of oxidative brain and liver injury in growing rats.

Çetkin M, Demirel C, Kızılkan N, Aksoy N, Erbağcı H. Evaluation of the mobile phone **electromagnetic radiation on serum iron parameters in rats. Afr Health Sci. 17(1):186-190, 2017.**

BACKGROUND: Electromagnetic fields (EMF) created by **mobile phones** during communication have harmful effects on different organs. OBJECTIVES: It was aimed to investigate the effects of an EMF created by a **mobile phone** on serum iron level, ferritin, unsaturated iron binding capacity and total iron binding capacity within a rat experiment model. METHODS: A total of 32 male Wistar albino rats were randomly divided into the control, sham, **mobile phone** speech (2h/day) and stand by (12 h/day) groups. The speech and stand by groups were subjected to the EMF for a total of 10 weeks. RESULTS: No statistically significant difference was observed between the serum iron and ferritin values of the rats in the speech and stand by groups than the control and sham groups ($p>0.05$). The unsaturated iron binding capacity and total iron capacity values of the rats in the speech and stand by groups were significantly lower in comparison to the control group ($p<0.01$). CONCLUSION: It was found that exposure to EMF created by **mobile phones** affected unsaturated iron binding capacity and total iron binding capacity negatively.

Ceyhan AM, Akkaya VB, Güleçol ŞC, Ceyhan BM, Özgüner F, Chen W. Protective effects of β-glucan against oxidative injury induced by 2.45-GHz electromagnetic radiation in the skin tissue of rats. Arch Dermatol Res. 304(7):521-527, 2012.

In recent times, there is widespread use of 2.45-GHz irradiation-emitting devices in industrial, medical, military and domestic application. The aim of the present study was to investigate the effect of 2.45-GHz electromagnetic radiation (EMR) on the oxidant and antioxidant status of skin and to examine the possible protective effects of β-glucans against the oxidative injury. Thirty-two male Wistar albino rats were randomly divided into four equal groups: control; sham exposed; EMR; and EMR + β-glucan. A 2.45-GHz EMR emitted device from the experimental exposure was applied to the EMR group and EMR + β-glucan group for 60 min daily, respectively, for 4 weeks. β-glucan was administered via gavage at a dose of 50 mg/kg/day before each exposure to radiation in the treatment group. The activities of antioxidant enzymes, superoxide dismutase (SOD), glutathione peroxidase (GSH-Px) and catalase (CAT), as well as the concentration of malondialdehyde (MDA) were measured in tissue homogenates of the skin. Exposure to 2.45-GHz EMR caused a significant increase in MDA levels and CAT activity, while the activities of SOD and GSH-Px decreased in skin tissues. Systemic β-glucan significantly reversed the elevation of MDA levels and the reduction of SOD activities. β-glucan treatment also slightly enhanced the activity of CAT and prevented the depletion of GSH-Px activity caused by EMR, but not statistically significantly. The present study demonstrated the role of oxidative mechanisms in EMR-induced skin tissue damages and that β-glucan could ameliorate oxidative skin injury via its antioxidant properties.

Chandel S, Kaur S, Singh HP, Batish DR, Kohli RK. Exposure to 2100 MHz electromagnetic field radiations induces reactive oxygen species generation in Allium cepa roots. Journal of Microscopy and Ultrastructure, 5(4):225-229, 2017.

During the last few decades there has been an enormous increase in the usage of cell phones as these are one of the most convenient gadgets and provide excellent mode of communication without evoking any hindrance to movement. However, these are significantly adding to the electromagnetic field radiations (EMF-r) in the environment and thus, are required to be analysed for their impacts on living beings. The present study investigated the role of cell phone EMF-r in inciting oxidative damage in onion (Allium cepa) roots at a frequency of 2100 MHz. Onion roots were exposed to continuous wave homogenous EMF-r for 1, 2 and 4 h for single day and generation of reactive oxygen species (ROS) in terms of malondialdehyde (MDA), hydrogen peroxide (H_2O_2) and superoxide anion (O_2^-) content and changes in the activities of antioxidant enzymes-superoxide dismutases (SOD) and catalases (CAT) were measured. The results showed that EMF-r exposure enhanced the content of MDA, H_2O_2 and O_2^-. Also, there was an upregulation in the activity of antioxidant enzymes− SOD and CAT− in onion roots. The study concluded that 2100 MHz cell phone EMF-r incite oxidative damage in onion roots by altering the oxidative metabolism.

Chagnaud JL, Veyret B In vivo exposure of rats to GSM-modulated microwaves: flow cytometry analysis of lymphocyte subpopulations and of mitogen stimulation. Int J Radiat Biol 75(1):111-113, 1999.

The effects of GSM-modulated microwaves on lymphocyte sub-populations of Sprague-Dawley rats and their normal mitogenic responses were investigated using flow cytometry analysis and a colorimetric method. No alterations were found in the surface phenotype of splenic lymphocytes or in their mitogenic activity, indicating that low-level pulsed microwaves do not seem to affect the integrity of the immune system.

Chagnaud, JL, Moreau, JM, Veyret, B, No effect of short-term exposure to GSM-modulated low-power microwaves on benzo(a)pyrene-induced tumours in rat. Int J Radiat Biol 75(10):1251-1256, 1999.

PURPOSE: In view of current interest in the biological effects of amplitude-modulated microwaves arising from the rapid development of mobile communications, the effects of low-level microwaves on cancer development were investigated using a rat sarcoma model. MATERIALS AND METHODS: Two-month-old female Sprague-Dawley rats were treated by injection of benzo(a)pyrene and irradiated with GSM (Global System for Mobile)-modulated 900-MHz microwaves in an anechoic chamber at 55 or 200 microW cm(-2) (75 and 270 mW kg(-1) average whole-body SAR, 2h daily for 2 weeks). Rats were exposed from day 20, 40 or 75 after carcinogen injection. Additional groups of rats were sham-exposed in a second anechoic chamber. Anti-phosphatidylinositol autoantibody levels were evaluated in sera to monitor malignant transformation. RESULTS: Microwave exposure had no effect on the development of tumours. No acceleration or delays in tumour onset were observed. Animal survival was not modified and serum autoantibody levels were similar in exposed and sham-exposed groups. CONCLUSION: Low-level GSM microwave exposure of rat bearing benzo(a)pyrene-induced tumours had no effect on auto-antibody levels, tumour appearance and survival. The low exposure levels used here correspond to exposure limits for whole-body exposure of humans.

Chang SK, Choi JS, Gil HW, Yang JO, Lee EY, Jeon YS, Lee ZW, Lee M, Hong MY, Ho Son T, Hong SY. Genotoxicity evaluation of electromagnetic fields generated by 835-MHz mobile phone frequency band. Eur J Cancer Prev. 14(2):175-179, 2005.

It is still unclear whether the exposure to electromagnetic fields (EMFs) generated by mobile phone radiation is directly linked to cancer. We examined the biological effects of an EMF at 835 MHz, the most widely used communication frequency band in Korean CDMA mobile phone networks, on bacterial reverse mutation (Ames assay) and DNA stability (in vitro DNA degradation). In the Ames assay, tester strains alone or combined with positive mutagen were applied in an artificial mobile phone frequency EMF generator with continuous waveform at a specific absorption rate (SAR) of 4 W/kg for 48 h. In the presence of the 835-MHz EMF radiation, incubation with positive mutagen 4-nitroquinoline-1-oxide and cumene hydroxide further increased the mutation rate in

Escherichia coli WP2 and TA102, respectively, while the contrary results in Salmonella typhimurium TA98 and TA1535 treated with 4-nitroquinoline-1-oxide and sodium azide, respectively, were shown as antimutagenic. However, these mutagenic or co-mutagenic effects of 835-MHz radiation were not significantly repeated in other relevant strains with same mutation type. In the DNA degradation test, the exposure to 835-MHz EMF did not change the rate of degradation observed using plasmid pBluescript SK(+) as an indicator. Thus, we suggest that 835-MHz EMF under the conditions of our study neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro.

Chapman S, Azizi L, Luo Q, Sitas F. Has the incidence of brain cancer risen in Australia since the introduction of mobile phones 29 years ago? Cancer Epidemiology. Available online May 5, 2016. doi:10.1016/j.canep.2016.04.010

Background. Mobile phone use in Australia has increased rapidly since its introduction in 1987 with whole population usage being 94% by 2014. We explored the popularly hypothesised association between brain cancer incidence and mobile phone use. Study methods. Using national cancer registration data, we examined age and gender specific incidence rates of 19,858 male and 14,222 females diagnosed with brain cancer in Australia between 1982 and 2012, and mobile phone usage data from 1987 to 2012. We modelled expected age specific rates (20–39, 40–59, 60–69, 70–84 years), based on published reports of relative risks (RR) of 1.5 in ever-users of mobile phones, and RR of 2.5 in a proportion of 'heavy users' (19% of all users), assuming a 10-year lag period between use and incidence. Summary answers. Age adjusted brain cancer incidence rates (20–84 years, per 100,000) have risen slightly in males ($p < 0.05$) but were stable over 30 years in females ($p > 0.05$) and are higher in males 8.7 (CI = 8.1–9.3) than in females, 5.8 (CI = 5.3–6.3). Assuming a causal RR of 1.5 and 10-year lag period, the expected incidence rate in males in 2012 would be 11.7 (11–12.4) and in females 7.7 (CI = 7.2–8.3), both $p < 0.01$; 1434 cases observed in 2012, vs. 1867 expected. Significant increases in brain cancer incidence were observed (in keeping with modelled rates) only in those aged ≥70 years (both sexes), but the increase in incidence in this age group began from 1982, before the introduction of mobile phones. Modelled expected incidence rates were higher in all age groups in comparison to what was observed. Assuming a causal RR of 2.5 among 'heavy users' gave 2038 expected cases in all age groups. Limitations. This is an ecological trends analysis, with no data on individual mobile phone use and outcome. What this study adds. The observed stability of brain cancer incidence in Australia between 1982 and 2012 in all age groups except in those over 70 years compared to increasing modelled expected estimates, suggests that the observed increases in brain cancer incidence in the older age group are unlikely to be related to mobile phone use. Rather, we hypothesize that the observed increases in brain cancer incidence in Australia are related to the advent of improved diagnostic procedures when computed tomography and related imaging technologies were introduced in the early 1980s.

Charlton SG. Perceptual and attentional effects on drivers' speed selection at curves. Accid Anal Prev. 36(5):877-884, 2004.

This paper describes an experiment comparing the relative effectiveness of various types of warnings on drivers' speed selection at curves. The experiment compared three types of curve warnings across three different curve types in a driving simulator. All of the warnings worked reasonably well for severe curves (45 km/h), regardless of demands from a secondary (cell phone) task. For less demanding curves, only those warnings with a strong perceptual component (i.e., implicit cues) were effective in reducing drivers' curve speeds in the presence of the cell phone task. The design implications of these data appear straightforward; curve warnings that contain perceptual components or emphasise the physical features of the curve work best, particularly in cognitively demanding situations. The cell phone task added to driver workload and drivers became less responsive to primary task demands (i.e., speeds were elevated and reaction times were longer).

Chattopadhyay SK, Toews KA, Butt S, Barlett R, Brown HD, Reverse-micelle model: pH, electromagnetic field and inhibitor enzyme interaction. Cancer Biochem Biophys 15:245-255, 1997.

The reverse micelle is one of many models thought to have properties more nearly resembling the biological cellular environment, than does the traditional dilute-solution biochemical reaction system. In order to evaluate the results of EMF perturbation of enzyme-catalyzed reactions, the description of the AOT reverse-micelle model, with respect to its internal pH, effect of chemical inhibitors, temperature, and electromagnetic-field perturbation has herein been extended. Acetylcholinesterase and NADPH cytochrome-P450 reductase, reacting within the AOT reverse-micelle, exhibit a temperature vs. activity profile equivalent to the same reaction in a buffered dilute-solution environment. In reverse micelles, some inhibitors of AChE (propidium, and d-tubocurarine) have much less effect upon indophenol-acetate hydrolysis than they do in a dilute solution environment. Other inhibitors act in the same manner within the structured environment of the reverse micelle as in the conventional dilute solution reaction model. These differences are explicable in terms of mechanism of action of the individual inhibitors. Perturbation by low-intensity microwave fields has a similar inhibitory effect upon dilute-solution reactions, as those in the 'low-water-activity' environment of the reverse micelle. However, the interactions between physical and chemical perturbants are differently limited by the structure of the aqueous phase of the reverse micelle. pH of the 'internal' reverse-micelle environment is a function of the availability of H-ions supplied by system components. Use of indicator dyes show that the low-molarity buffers which are compatible with reverse-micelle stability, are often insufficient to maintain a constant pH. Too, in the reverse micelle, reaction rate, for proton yielding reactions, is dramatically greater than the rate of the same reaction in dilute solution at the same acidic pH.

Chaturvedi CM, Singh VP, Singh P, Basu P, Singaravel M, Shukla RK, Dhawan A, Pati AK, Gangwar RK, and Singh SP, "," *Progress In Electromagnetics Research B*, Vol. 29, 23-42, 2011.

Present study examines biological effects of 2.45 GHz microwave radiation in Parkes strain mice. Forty-day-old mice were exposed to CW (continuous wave) microwave radiation (2 h/day for 30 days). Locomotor activity was recorded on running wheel for 12 days prior to microwave exposure (pre-exposure), 7 days during the first week of exposure (short-term exposure) and another 7-day spell during the last week of the 30-day exposure period (long-term exposure). Morris water maze test was performed from

17th to 22nd day of exposure. At the termination of the exposure, blood was processed for hematological parameters, brain for comet assay, epididymis for sperm count and motility and serum for SGOT (serum glutamate oxaloacetate transaminase) and SGPT (serum glutamate pyruvate transaminase). The results show that long-term radiation-exposed group exhibited a positive ψ□(phase angle difference) forthe onset of activity with reference to lights-off timing and most of the activity occurred within the light fraction of the LD (light: dark) cycle. Microwave radiation caused an increase in erythrocyte and leukocyte counts, a significant DNA strand break in brain cells and the loss of spatial memory in mice. This report for the first time provides experimental evidence that continuous exposure to low intensity microwave radiation may have an adverse effect on the brain function by altering circadian system and rate of DNA damage.

Chauhan V, Mariampillai A, Bellier PV, Qutob SS, Gajda GB, Lemay E, Thansandote A, McNamee JP. Gene expression analysis of a human lymphoblastoma cell line exposed in vitro to an intermittent 1.9 GHz pulse-modulated radiofrequency field. Radiat Res. 165(4):424-429, 2006.

This study was designed to determine whether radiofrequency (RF) fields of the type used for wireless communications could elicit a cellular stress response. As general indicators of a cellular stress response, we monitored changes in proto-oncogene and heat-shock protein expression. Exponentially growing human lymphoblastoma cells (TK6) were exposed to 1.9 GHz pulse-modulated RF fields at average specific absorption rates (SARs) of 1 and 10 W/kg. Perturbations in the expression levels of the proto-oncogenes FOS, JUN and MYC after exposure to sham and RF fields were assessed by real-time RT-PCR. In addition, the transcript levels of the cellular stress proteins HSP27 and inducible HSP70 were also monitored. We demonstrated that transcript levels of these genes in RF-field-exposed cells showed no significant difference in relation to the sham treatment group. However, concurrent positive (heat-shock) control samples displayed a significant elevation in the expression of HSP27, HSP70, FOS and JUN. Conversely, the levels of MYC mRNA were found to decline in the positive (heat-shock) control. In conclusion, our study found no evidence that the 1.9 GHz RF-field exposure caused a general stress response in TK6 cells under our experimental conditions.

Chauhan V, Mariampillai A, Gajda GB, Thansandote A, McNamee JP. Analysis of proto-oncogene and heat-shock protein gene expression in human derived cell-lines exposed in vitro to an intermittent 1.9 GHz pulse-modulated radiofrequency field. Int J Radiat Biol. 82(5):347-354, 2006.

Purpose: Several studies have reported that radiofrequency (RF) fields, as emitted by mobile phones, may cause changes in gene expression in cultured human cell-lines. The current study was undertaken to evaluate this possibility in two human-derived immune cell-lines.Materials and methods: HL-60 and Mono-Mac-6 (MM6) cells were individually exposed to intermittent (5 min on, 10 min off) 1.9 GHz pulse-modulated RF fields at a average specific absorption rate (SAR) of 1 and 10 W/kg at 37 +/- 0.5 degrees C for 6 h. Concurrent negative and positive (heat-shock for 1 h at 43 degrees C) controls were conducted with each experiment. Immediately following RF field exposure (T = 6 h) and 18 h post-exposure (T = 24 h), cell pellets were collected from each of the culture dishes and analyzed for transcript levels of proto-oncogenes (c-jun, c-myc and c-fos) and the stress-related genes (heat shock proteins (HSP) HSP27 and HSP70B) by quantitative reverse transcriptase polymerase chain reaction (RT-PCR).Results: No significant effects were observed in mRNA expression of HSP27, HSP70, c-jun, c-myc or c-fos between the sham and RF-exposed groups, in either of the two cell-lines. However, the positive (heat-shock) control group displayed a significant elevation in the expression of HSP27, HSP70, c-fos and c-jun in both cell-lines at T = 6 and 24 h, relative to the sham and negative control groups.Conclusion: This study found no evidence that exposure of cells to non-thermalizing levels of 1.9 GHz pulse-modulated RF fields can cause any detectable change in stress-related gene expression.

Chauhan V, Qutob SS, Lui S, Mariampillai A, Bellier PV, Yauk CL, Douglas GR, Williams A, McNamee JP. Analysis of gene expression in two human-derived cell lines exposed in vitro to a 1.9 GHz pulse-modulated radiofrequency field. Proteomics. 7(21):3896-3905, 2007.

There is considerable controversy surrounding the biological effects of radiofrequency (RF) fields, as emitted by mobile phones. Previous work from our laboratory has shown no effect related to the exposure of 1.9 GHz pulse-modulated RF fields on the expression of 22,000 genes in a human glioblastoma-derived cell-line (U87MG) at 6 h following a 4 h RF field exposure period. As a follow-up to this study, we have now examined the effect of RF field exposure on the possible expression of late onset genes in U87MG cells after a 24 h RF exposure period. In addition, a human monocyte-derived cell-line (Mono-Mac-6, MM6) was exposed to intermittent (5 min ON, 10 min OFF) RF fields for 6 h and then gene expression was assessed immediately after exposure and at 18 h postexposure. Both cell lines were exposed to 1.9 GHz pulse-modulated RF fields for 6 or 24 h at specific absorption rates (SARs) of 0.1-10.0 W/kg. In support of our previous results, we found no evidence that nonthermal RF field exposure could alter gene expression in either cultured U87MG or MM6 cells, relative to nonirradiated control groups. However, exposure of both cell-lines to heat-shock conditions (43 degrees C for 1 h) caused an alteration in the expression of a number of well-characterized heat-shock proteins.

Chauhan V, Mariampillai A, Kutzner BC, Wilkins RC, Ferrarotto C, Bellier PV, Marro L, Gajda GB, Lemay E, Thansandote A, McNamee JP. Evaluating the biological effects of intermittent 1.9 GHz pulse-modulated radiofrequency fields in a series of human-derived cell lines. Radiat Res. 167(1):87-93, 2007.

Several recent studies have suggested that radiofrequency (RF) fields may cause changes in a variety of cellular functions that may eventually lead to potential long-term health effects. In the present study, we have assessed the ability of non-thermal RF-field exposure to affect a variety of biological processes (including apoptosis, cell cycle progression, viability and cytokine production) in a series of human-derived cell lines (TK6, HL60 and Mono-Mac-6). Exponentially growing cells were exposed to intermittent (5 min on, 10 min off) 1.9 GHz pulse-modulated RF fields for 6 h at mean specific absorption rates (SARs) of 0, 1 and 10 W/kg. Concurrent negative (incubator) and positive (heat shock for 1 h at 43 degrees C) controls were included in each experiment. Immediately after the 6-h exposure period and 18 h after exposure, cell pellets were collected and analyzed for cell viability, the incidence of apoptosis, and alterations in cell cycle kinetics. The cell culture supernatants were assessed for the presence of a series of human inflammatory cytokines (TNFA, IL1B, IL6, IL8, IL10, IL12) using a cytometric bead array assay. No detectable changes in cell viability, cell cycle kinetics, incidence of apoptosis, or cytokine expression were observed in any of RF-field-exposed groups in any of the cell lines tested, relative to the sham controls. However, the positive (heat-shock) control samples displayed a significant decrease in cell viability, increase in apoptosis, and alteration in cell cycle kinetics (G(2)/M block). Overall, we found no evidence that non-thermal RF-field exposure could elicit any detectable biological effect in three human-derived cell lines.

Chauvin S, Gibergues ML, Wüthrich G, Picard D, Desreumaux JP, Bouillet JC. Occupational exposure to ambient electromagnetic fields of technical operational personnel working for a mobile telephone operator.Radiat Prot Dosimetry.136(3):185-195, 2009.

In order to investigate the exposure of operational personnel to radiofrequency electromagnetic fields when working for a mobile telephone operator, exposimeters were used to make individual records on 23 Technical Operations personnel (mobile telephone maintenance staff) and also on 22 Other Workers. The exposure densities, to which each of the 45 subjects was subjected, were quantified using 229 exposure indicators. Cluster analysis techniques were applied to the data, in an attempt to show that they would re-emerge as belonging to one of the two groups, i.e. the Technical Operational Personnel group or the Other Workers group. This exploratory investigation has shown that the cluster analysis does not reveal a sufficiently reliable emergence of the two groups, even though certain exposure indicators were significantly different for the two groups. In addition, the use of a Learning Group method does not lead to the discovery of a predictive law that could identify the Technical Operational Personnel as a sub-group within the overall group.

Chavdoula ED, Panagopoulos DJ, Margaritis LH. Comparison of biological effects between continuous and intermittent exposure to GSM-900-MHz mobile phone radiation: detection of apoptotic cell-death features. Mutat Res. 700(1-2):51-61, 2010.

In the present study we used a 6-min daily exposure of dipteran flies, Drosophila melanogaster, to GSM-900MHz (Global System for Mobile Telecommunications) mobile phone electromagnetic radiation (EMR), to compare the effects between the continuous and four different intermittent exposures of 6min total duration, and also to test whether intermittent exposure provides any cumulative effects on the insect's reproductive capacity as well as on the induction of apoptotic cell death. According to our previous experiments, a 6-min continuous exposure per day for five days to GSM-900MHz and DCS-1800MHz (Digital Cellular System) mobile phone radiation, brought about a large decrease in the insect's reproductive capacity, as defined by the number of F(1) pupae. This decrease was found to be non thermal and correlated with an increased percentage of induced fragmented DNA in the egg chambers' cells at early- and mid-oogenesis. In the present experiments we show that intermittent exposure also decreases the reproductive capacity and alters the actin cytoskeleton network of the egg chambers, another known aspect of cell death that was not investigated in previous experiments, and that the effect is also due to DNA fragmentation. Intermittent exposures with 10-min intervals between exposure sessions proved to be almost equally effective as continuous exposure of the same total duration, whereas longer intervals between the exposures seemed to allow the organism the time required to recover and partly overcome the above-mentioned effects of the GSM exposure.

Cheever KL, Swearengin TF, Edwards RM, Nelson BK, Werren DW, Conover DL, DeBord DG. 2-Methoxyethanol metabolism, embryonic distribution, and macromolecular adduct formation in the rat: the effect of radiofrequency radiation-induced hyperthermia. Toxicol Lett 122(1):53-67, 2001.

Exposure of pregnant rats to the solvent 2-methoxyethanol (2ME) and radiofrequency (RF) radiation results in greater than additive fetal malformations (Nelson, B.K., Conover, D.L., Brightwell, W.S., Shaw, P.B., Werren, D.W., Edwards, R.M., Lary, J.M., 1991. Marked increase in the teratogenicity of the combined administration of the industrial solvent 2-methoxyethanol and radiofrequency radiation in rats. Teratology 43, 621-34; Nelson, B.K., Conover, D.L., Shaw, P.B., Werren, D.W., Edwards, R.M., Hoberman, A.M., 1994. Interactive developmental toxicity of radiofrequency radiation and 2-methoxyethanol in rats. Teratology 50, 275-93). The current study evaluated the metabolism of 14C-labeled 2ME and the distribution of methoxyacetic acid (MAA) in maternal and embryonic tissues of pregnant Sprague-Dawley rats either exposed to 10 MHz RF radiation or sham conditions. Additionally, adduct formation for both plasma and embryonic protein was tested as a possible biomarker for the observed 2ME/RF teratogenicity. Rats were administered [ethanol-1,2-(14)C]-2ME (150 mg/kg, 161 &mgr;Ci/rat average) by gavage on gestation day 13 immediately before RF radiation sufficient to elevate body temperature to 42 degrees C for 30 min. Concurrent sham- and RF-exposed rats were sacrificed at 3, 6, 24 or 48 h for harvest of maternal blood, urine, embryos and extra-embryonic fluid. Tissues were either digested for determination of radioactivity or deproteinized with TCA and analyzed by HPLC for quantification of 2ME metabolites. Results show the presence of 2ME and seven metabolites, with the major metabolite, MAA, peaking at 6 h in the tissues tested. MAA, the proximal teratogen, was detectable in maternal serum, urine, embryo and extraembryonic fluid 48 h after dosing. Clearance of total body 14C was significantly reduced for the RF-exposed animals (P<0.05) for the 24-48 h period, but MAA values for serum, embryos and extraembryonic fluid were similar for both sham- and RF-exposed rats. Additionally, no difference was noted for 2ME metabolite profiles in urine or tissue for sham- or RF-exposed rats, thus eliminating an effect of RF radiation on MAA production as a possible explanation for the reported RF-2ME synergism. Subsequently, serum and embryo protein-bound adducts were evaluated by analysis of covalently bound radioactivity. Serum protein binding was significantly higher for sham than RF rats at 3- and 6-h - highest for sham rats at 6 h (519+/-95 &mgr;g as parent 2ME/g of protein) whereas RF serum values were highest at 24 h (266+/-79 &mgr;g/g protein). Embryonic protein binding was significantly higher for sham rats at 6 h, but binding was highest for both groups at 24 h (sham=229+/-71

&mgr;g/g, RF=185+/-48 &mgr;g/g). Formation of protein adducts after 2ME is thought to be related to levels of methoxyacetaldehyde, a reactive intermediate in the formation of MAA. These results suggest that no direct relationship exists for covalent binding in the embryo which would explain RF-2ME synergistic malformations. In comparison with urinary metabolites, the relatively slow elimination of adducted serum 2ME indicates that analysis of protein-bound concentrations could be a potential tool for long- term biomonitoring of worker exposure.

Chemeris NK, Gapeyev AB, Sirota NP, Gudkova OY, Kornienko NV, Tankanag AV, Konovalov IV, Buzoverya ME, Suvorov VG, Logunov VA. DNA damage in frog erythrocytes after in vitro exposure to a high peak-power pulsed electromagnetic field. Mutat Res. 558(1-2):27-34, 2004.

Till the present time, the genotoxic effects of high peak-power pulsed electromagnetic fields (HPPP EMF) on cultured cells have not been studied. We investigated possible genotoxic effects of HPPP EMF (8.8GHz, 180ns pulse width, peak power 65kW, repetition rate 50Hz) on erythrocytes of the frog Xenopus laevis. We used the alkaline comet assay, which is a highly sensitive method to assess DNA single-strand breaks and alkali-labile lesions. Blood samples were exposed to HPPP EMF for 40min in rectangular wave guide. The specific absorption rate (SAR) calculated from temperature kinetics was about 1.6kW/kg (peak SAR was about 300MW/kg). The temperature rise in the blood samples at steady state was [Formula: see text] degrees C. The data show that the increase in DNA damage after exposure of erythrocytes to HPPP EMF was induced by the rise in temperature in the exposed cell suspension. This was confirmed in experiments in which cells were incubated for 40min under the corresponding temperature conditions. The results allow us to conclude that HPPP EMF-exposure at the given modality did not cause any a-thermal genotoxic effect on frog erythrocytes in vitro.

Chen C, Ma Q, Liu C, Deng P, Zhu G, Zhang L, He M, Lu Y, Duan W, Pei L, Li M, Yu Z, Zhou Z. Exposure to 1800 MHz radiofrequency radiation impairs neurite outgrowth of embryonic neural stem cells. Sci Rep. 2014 May 29;4:5103. doi: 10.1038/srep05103.

A radiofrequency electromagnetic field (RF-EMF) of 1800 MHz is widely used in mobile communications. However, the effects of RF-EMFs on cell biology are unclear. Embryonic neural stem cells (eNSCs) play a critical role in brain development. Thus, detecting the effects of RF-EMF on eNSCs is important for exploring the effects of RF-EMF on brain development. Here, we exposed eNSCs to 1800 MHz RF-EMF at specific absorption rate (SAR) values of 1, 2, and 4 W/kg for 1, 2, and 3 days. We found that 1800 MHz RF-EMF exposure did not influence eNSC apoptosis, proliferation, cell cycle or the mRNA expressions of related genes. RF-EMF exposure also did not alter the ratio of eNSC differentiated neurons and astrocytes. However, neurite outgrowth of eNSC differentiated neurons was inhibited after 4 W/kg RF-EMF exposure for 3 days. Additionally, the mRNA and protein expression of the proneural genes Ngn1 and NeuroD, which are crucial for neurite outgrowth, were decreased after RF-EMF exposure. The expression of their inhibitor Hes1 was upregulated by RF-EMF exposure. These results together suggested that 1800 MHz RF-EMF exposure impairs neurite outgrowth of eNSCs. More attention should be given to the potential adverse effects of RF-EMF exposure on brain development.

Chen G, Lu D, Chiang H, Leszczynski D, Xu Z. Using model organism Saccharomyces cerevisiae to evaluate the effects of ELF-MF and RF-EMF exposure on global gene expression. Bioelectromagnetics. 33(7):550-560, 2012.

The potential health hazard of exposure to electromagnetic fields (EMF) continues to cause public concern. However, the possibility of biological and health effects of exposure to EMF remains controversial and their biophysical mechanisms are unknown. In the present study, we used Saccharomyces cerevisiae to identify genes responding to extremely low frequency magnetic fields (ELF-MF) and to radiofrequency EMF (RF-EMF) exposures. The yeast cells were exposed for 6 h to either 0.4 mT 50 Hz ELF-MF or 1800 MHz RF-EMF at a specific absorption rate of 4.7 W/kg. Gene expression was analyzed by microarray screening and confirmed using real-time reverse transcription-polymerase chain reaction (RT-PCR). We were unable to confirm microarray-detected changes in three of the ELF-MF responsive candidate genes using RT-PCR ($P > 0.05$). On the other hand, out of the 40 potential RF-EMF responsive genes, only the expressions of structural maintenance of chromosomes 3 (SMC3) and aquaporin 2 (AQY2 (m)) were confirmed, while three other genes, that is, halotolerance protein 9 (HAL9), yet another kinase 1 (YAK1) and one function-unknown gene (open reading frame: YJL171C), showed opposite changes in expression compared to the microarray data ($P < 0.05$). In conclusion, the results of this study suggest that the yeast cells did not alter gene expression in response to 50 Hz ELF-MF and that the response to RF-EMF is limited to only a very small number of genes. The possible biological consequences of the gene expression changes induced by RF-EMF await further investigation.

Chen L, Qin F, Chen Y, Sun J, Tong J.[Chronotoxicity of 1800 MHz microwave radiation on sex hormones and spermatogenesis in male mice]. Wei Sheng Yan Jiu. 43(1):110-115, 2014.[Article in Chinese]

OBJECTIVE: To study the chronotoxicity of 1800 MHz micrwave radiation on the male reproductive system. METHODS: Sixty healthy male C57 mice with circadian rhythm in a 12:12 h light-dark photoperiod were divided into false radiation group (Sham) and microwave radiation (MR) group exposed to 1800 MHz RF at 208 microW/cm2 power (SAR: 0 .2221 W/kg) density at different zeitgeber times of a day (ZT01:00, ZT05:00, ZT09 : 00, ZT13: 00, ZT17 : 00, ZT21 : 00) for continuous 32 days with 2 h/d. The testicular sperm head was counted with a microscope, and serum testosterone (T) and estradiol (E2) levels were measured by ELISA method. RESULTS: Compared with the sham group,microwave radiation induced reduced level in testicular sperm head count and serum testosterone, while the level of serum estradiol increased. Also, the circadian rhythms of testicular sperm head count and estradiol disappeared after the microwave radiation. CONCLUSION: 1800 MH2 microwave radiation may disturb the level as well as circadian rhythmicity of the reproductive functions in male mice.

Chen Q, Xu G, Lang L, Yang A, Li S, Yang L, Li C, Huang H, Li T. ECG changes in factory workers exposed to 27.2 MHz radiofrequency radiation. Bioelectromagnetics. 2012 Dec 31. doi: 10.1002/bem.21771. [Epub ahead of print]

To research the effect of 27.2 MHz radiofrequency radiation on electrocardiograms (ECG), 225 female workers operating radiofrequency machines at a shoe factory were chosen as the exposure group and 100 female workers without exposure from the same factory were selected as the control group. The 6 min electric field strength that the female workers were exposed to was 64.0 ± 25.2 V/m (mean ± SD), which exceeded 61 V/m, the International Commission on Non-Ionizing Radiation Protection reference root mean square levels for occupational exposure. A statistical difference was observed between the exposed group and the control group in terms of the rate of sinus bradycardia ($\chi(2) = 11.48$, $P = 0.003$). When several known risk factors for cardiovascular disease were considered, including smoking, age, alcohol ingestion habit, and so on, the exposure duration was not an effective factor for ECG changes, sinus arrhythmia, or sinus bradycardia according to $\alpha = 0.05$, while $P = 0.052$ for sinus arrhythmia was very close to 0.05. We did not find any statistical difference in heart rate, duration of the QRS wave (ventricular depolarization), or corrected QT intervals (between the start of the Q wave and end of the T wave) between the exposed and control groups. Occupational exposure to radiofrequency radiation was not found to be a cause of ECG changes after consideration of the confounding factors.

Chen WH, Lau CP, Leung SK, Ho DS, Lee IS, Interference of cellular phones with implanted permanent pacemakers. Clin Cardiol 19(11):881-886, 1996.

BACKGROUND AND HYPOTHESIS: Occasional reports have suggested that cellular phones may interfere with permanent pacemakers. Our investigation sought to determine systematically the effects of commercially available cellular phones on the performances of different pacing modes and sensing lead configurations of permanent implanted pacemakers. METHODS: We conducted the study in 29 patients implanted with single- or dual-chamber bipolar rate-adaptive permanent pacemakers (a total of nine different models and six different sensors: minute ventilation, activity sensing using either accelerometer or piezoelectric crystal, QT and oxygen saturation sensing) from four different manufacturers. Three different cellular phones with analog or digital coding with maximum power from 0.6 to 2 W were used to assess the effect of pacemaker interference. Each cellular phone was positioned at (1) above the pacemaker pocket, (2) the ear level ipsilateral to the pacemaker pocket, and (3) the contralateral ear level. Surface electrocardiograms, intracardiac electrograms, and marker channels were recorded where possible during the following maneuvers at each position: (1) calls made by a stationary phone to cellular phone, and (2) calls made from the cellular phone to a stationary phone. A total of eight different pacing modes [DDD(R), VDD(R), AAI(R) and VVI(R)] in both unipolar and bipolar sensing configurations was tested. RESULTS: Interference was demonstrated during cellular phone operation in 74 of 2,418 (3.1%) episodes in eight patients. Three types of interference were observed: inhibition of pacing output, rapid ventricular tracking in DDD(R) or VDD(R) mode, and asynchronous pacing. All were observed only with the cellular phone positioned above the pacemaker pocket. Interference occurred prior to and after the termination of the ringing tone of the cellular phone in 57% of cases. Cellular phones with either digital or analog technology could cause interference. Unipolar atrial lead was most susceptible to interference (relative frequency of interference: unipolar 1.8%, bipolar 0.4%, $p < 0.05$; atrial 2.9%, ventricular 1%, $p < 0.05$). There was no sensor-driven rate acceleration during all tests. In all patients, reprogramming of the sensitivity level successfully prevented cellular phone interference. CONCLUSIONS: Commercially available cellular phones can cause reversible interference to implanted single- or dual-chamber permanent pacemakers. The effect is maximal with high atrial unipolar sensitivity, especially in single pass VDD(R) systems. Both digital and analog cellular phones can lead to interference. Pacemaker interference can occur prior to a warning sign (ringing tone) of the phone and may have significant implications in patient safety.

Chen YB, Li J, Qi Y, Miao X, Zhou Y, Ren D, Guo GZ. The effects of electromagnetic pulses (EMP) on the bioactivity of insulin and a preliminary study of mechanism. Int J Radiat Biol. 86(1):22-26, 2010.

PURPOSE: To investigate the effects of electromagneticpulse (EMP) exposure on the bioactivity of insulin and a preliminary mechanism for these effects.MATERIALS AND METHODS: A tapered parallel plate Gigahertz Transverse Electromagnetic (GTEM) cell with a flared rectangular coaxial transmission line was used to expose the insulin solution to EMP. Concurrent sham-exposed insulin solutions were used as a control. The effect of EMP-exposed insulin on fasting blood glucose levels of type I diabetes model mice, the effect of EMP on binding affinity between insulin and its receptor and the effect of EMP on insulin's fluorescence intensity were detected, respectively.RESULTS: (i) After EMP exposure, compared with sham-exposed insulin, the bioactivity of insulin in decreasing fasting blood glucose levels in type I diabetes model mice was reduced significantly ($p = 0.023$). (ii) Compared with sham-exposed insulin group, the percentage fluorescein isothiocyannate (FITC) labelling of HL-7702 cells was significantly reduced in the EMP-exposed insulin group (22.7-13.8%, respectively). (iii) Compared with sham-exposed insulin, the fluorescence intensity was significantly reduced in EMP-exposed insulin ($p < 0.001$).CONCLUSIONS: EMP exposure significantly decreased the bioactivity of insulin to reduce the blood glucose levels in type I diabetic mice. This could be due to a decreased binding affinity between insulin and its receptor. This mechanism could involve an alteration of insulin's' conformation caused by EMP exposure.

Chen YB, Li J, Liu JY, Zeng LH, Wan Y, Li YR, Ren D, Guo GZ.Effect of Electromagnetic Pulses (EMP) on associative learning in mice and a preliminary study of mechanism. Int J Radiat Biol. 87(12):1147-1154, 2011.

PURPOSE: To investigate the effects of electromagnetic pulses (EMP) on associative learning in mice and test a preliminary mechanism for these effects. MATERIALS AND METHODS: A tapered parallel plate gigahertz transverse electromagnetic (GTEM) cell with a flared rectangular coaxial transmission line was used to expose male BALB/c mice to EMP (peak-intensity 400 kV/m, rise-time 10 ns, pulse-width 350 ns, 0.5 Hz and total 200 pulses). Concurrent sham-exposed mice were used as a control. Associative learning, oxidative stress in the brain, serum chemistry and the protective action of tocopherol monoglucoside (TMG) in mice were measured, respectively. RESULTS: (1)

Twelve hour and 1 day post EMP exposure associative learning was reduced significantly compared with sham control ($p<0.05$) but recovered at 2 d post EMP exposure. (2) Compared with the sham control, lipid peroxidation of brain tissue and chemiluminescence (CL) intensity increased significantly ($p<0.05$), while the activity of the antioxidant enzymes Superoxide Dismutase [SOD], Glutathione [GSH], Glutathione Peroxidase [GSH-Px], Catalase [CAT]) decreased significantly ($p<0.05$) at 3 h, 6 h, 12 h and 1 d post EMP exposure. All these parameters recovered at 2 d post EMP exposure. (3) No significant differences between the sham control group and EMP exposed group were observed in serum cholesterol and triglycerides. (4) Pretreatment of mice with TMG showed protective effects to EMP exposure. CONCLUSIONS: EMP exposure significantly decreased associative learning in mice and TMG acted as an effective protective agent from EMP exposure. This mechanism could involve an increase of oxidative stress in brain by EMP exposure.

Chen ZJ, He JL. [Mutagenic, carcinogenic and teratogenic effects induced by radiofrequency electromagnetic field of mobile phone.] Zhejiang Da Xue Xue Bao Yi Xue Ban. 37(1):97-102, 2008. [Article in Chinese].

OBJECTIVE: The extensive use of mobile phones causes increasing public concern on health effects of exposure to radiofrequency (RF) electromagnetic fields. Conflicting results are found in publications on the mutagenic, carcinogenic and teratogenic effects of RF electromagnetic fields. The overwhelming findings do not support the assumption that RF exposure may induce mutagenic, carcinogenic or teratogenic effects. However, health effects from low level RF exposure need to be further studied.

Chia SE, Chia HP, Tan JS, Prevalence of headache among handheld cellular telephone users in singapore: A community study. Environ Health Perspect 108(11):1059-1062, 2000.

We carried out a cross-sectional community study in Singapore to determine the prevalence of specific central nervous system (CNS) symptoms among hand-held cellular telephone (HP) users compared to nonusers and to study the association of risk factors and CNS symptoms among HP users. A total of 808 men and women between 12 and 70 years of age, who lived in one community, were selected using one-stage cluster random sampling and responses to a structured questionnaire. The prevalence of HP users was 44.8%. Headache was the most prevalent symptom among HP users compared to non-HP users, with an adjusted prevalence rate ratio of 1.31 [95% confidence interval, 1.00-1.70]. There is a significant increase in the prevalence of headache with increasing duration of usage (in minutes per day). Prevalence of headache was reduced by more than 20% among those who used hand-free equipment for their cellular telephones as compared to those who never use the equipment. The use of HPs is not associated with a significant increase of CNS symptoms other than headache.

Chiabrera A, Bianco B, Moggia E, Kaufman JJ, Zeeman-Stark modeling of the RF EMF interaction with ligand binding. Bioelectromagnetics 21(4):312-324, 2000.

The influence of radiofrequency electromagnetic exposure on ligand binding to hydrophobic receptor proteins is a plausible early event of the interaction mechanism. A comprehensive quantum Zeeman-Stark model has been developed which takes into account the energy losses of the ligand ion due to its collisions inside the receptor crevice, the attracting nonlinear endogenous force due to the potential energy of the ion in the binding site, the out of equilibrium state of the ligand-receptor system due to the basal cell metabolism, and the thermal noise. The biophysical "output" is the change of the ligand binding probability that, in some instances, may be affected by a suitable low intensity exogenous electromagnetic "input" exposure, e.g., if the depth of the potential energy well of a putative receptor protein matches the energy of the radiofrequency photon. These results point toward both the possibility of the electromagnetic control of biochemical processes and the need for a new database of safety standards.

Chiang H, Microwave and ELF electromagnetic field effects on intercellular communication, Proceedings of the 20th Annual International Conference of the IEEE Engineering in Medicine and Biology Society 20:2798-2801, 1998.

Gap junctional intercellular communication (GJIC) plays an essential role in regulation of cell growth, differentiation and wound healing. Microwave irradiation may down-regulate GJIC and the effect is strongly influenced by modulation frequency. Many studies have demonstrated that GJIC could be suppressed by ELF magnetic field (MF) and the suppression is related to the intensity of magnetic flux density and the exposure duration. Pulsed MF is more effective than sinusoidal MF in inhibiting GJIC. Inhibiting GJIC by electromagnetic field in some cases could be beneficial or detrimental. The mechanism of GJIC inhibition by ELF MF has also been studied and found that the inhibition may be mainly due to hyperphosphorylation of gap junctional connexins by PKC rather than its transcriptional or translational disregulation.

Chiladakis JA, Davlouros P, Agelopoulos G, Manolis AS. In-vivo testing of digital cellular telephones in patients with implantable cardioverter-defibrillators. Eur Heart J 22(15):1337-1342, 2001.

Aims To investigate the susceptibility of implantable cardioverter defibrillators to electromagnetic interference generated by digital cellular telephones, functioning in both international transmission technologies: the Global System for Mobile Communication (GSM) and the Digital Cellular System (DCS 1800).Methods and Results In 36 patients with transvenous implantable cardioverter defibrillators from two manufacturers (Medtronic and Guidant/CPI), cellular telephones with different levels of minimal and maximal power output were tested in the transmitting and receiving mode. Evaluation was performed in activated implantable defibrillators during spontaneous cardiac activity and continuous VVI or DDD pacing to assess possible electromagnetic interference. In two patients, appropriateness of ventricular fibrillation detection and therapy was judged during telephone testing. There was no damage, reprogramming, inappropriate shock therapy or pacing inhibition during the tests. In seven pre-pectoral Medtronic implantable defibrillators, transient electromagnetic interference caused 19 erroneous sensing events, when the operating phone was held in close vicinity to the programmer head. These 'pseudo-oversensing' events, which did not result in logging of arrhythmia episodes in the device counter, were interpreted as an adverse interaction between the telephone and the programming device.Conclusion Digital cellular telephones do not represent a risk to Medtronic and Guidant/CPI recipients of the specific implantable defibrillator models herein tested.

Chiu CT, Chang YH, Chen CC, Ko MC, Li CY. Mobile phone use and health symptoms in children. J Formos Med Assoc. 2014 Aug 9. pii: S0929-6646(14)00207-1. doi: 10.1016/j.jfma.2014.07.002. [Epub ahead of print]

BACKGROUND/PURPOSE: To investigate the mobile phone (MP) use for talking in relation to health symptoms among 2042 children aged 11-15 years in Taiwan. METHODS: A nationwide, cross-sectional study, using the computer assisted telephone interview (CATI) technique, was conducted in 2009 to collect information on children's utilization of MPs and the perceived health symptoms reported by their parents. RESULTS: The overall prevalence of MP use in the past month was estimated at 63.2% [95% confidence interval (CI) = 61.1-65.3%]. MP use was associated with a significantly increased adjusted odds ratio (AOR) for headaches and migraine (1.42, 95% CI = 1.12-1.81) and skin itches (1.84, 95% CI = 1.47-2.29). Children who regularly used MPs were also considered to have a health status worse than it was 1 year ago (β = 0.27, 95% CI = 0.17-0.37). CONCLUSION: Although the cross-sectional design precludes the causal inference for the observed association, our study tended to suggest a need for more cautious use of MPs in children, because children are expected to experience a longer lifetime exposure to radiofrequency electromagnetic fields (RF-EMF) from MPs.

Choi KH, Ha M, Ha EH, Park H, Kim Y, Hong YC, Lee AK, Hwa Kwon J, Choi HD, Kim N, Kim S, Park C. Neurodevelopment for the first three years following prenatal mobile phone **use, radio frequency radiation and lead exposure. Environ Res. 156:810-817, 2017.**

BACKGROUND: Studies examining prenatal exposure to **mobile phone** use and its effect on child neurodevelopment show different results, according to child's developmental stages. OBJECTIVES: To examine neurodevelopment in children up to 36 months of age, following prenatal **mobile phone** use and radiofrequency radiation (RFR) exposure, in relation to prenatal lead exposure.METHODS: We analyzed 1198 mother-child pairs from a prospective cohort study (the Mothers and Children's Environmental Health Study). Questionnaires were provided to pregnant women at ≤20 weeks of gestation to assess **mobile phone** call frequency and duration. A personal exposure meter (PEM) was used to measure RFR exposure for 24h in 210 pregnant women. Maternal blood lead level (BLL) was measured during pregnancy. Child neurodevelopment was assessed using the Korean version of the Bayley Scales of Infant Development-Revised at 6, 12, 24, and 36 months of age. Logistic regression analysis applied to groups classified by trajectory analysis showing neurodevelopmental patterns over time.RESULTS: The psychomotor development index (PDI) and the mental development index (MDI) at 6, 12, 24, and 36 months of age were not significantly associated with maternal **mobile phone** use during pregnancy. However, among children exposed to high maternal BLL in utero, there was a significantly increased risk of having a low PDI up to 36 months of age, in relation to an increasing average calling time (p-trend=0.008). There was also a risk of having decreasing MDI up to 36 months of age, in relation to an increasing average calling time or frequency during pregnancy (p-trend=0.05 and 0.007 for time and frequency, respectively). There was no significant association between child neurodevelopment and prenatal RFR exposure measured by PEM in all subjects or in groups stratified by maternal BLL during pregnancy.CONCLUSIONS: We found no association between prenatal exposure to RFR and child neurodevelopment during the first three years of life; however, a potential combined effect of prenatal exposure to lead and **mobile phone** use was suggested.

Choi SB, Kwon MK, Chung JW, Park JS, Chung K, Kim DW. Effects of short-term radiation emitted by WCDMA mobile phones on teenagers and adults. BMC Public Health 14:438, 2014. doi:10.1186/1471-2458-14-438. Published: 10 May 2014

Background. With the rapid increasing use of third generation (3 G) mobile phones, social concerns have arisen concerning the possible health effects of radio frequency-electromagnetic fields (RF-EMFs) emitted by wideband code division multiple access (WCDMA) mobile phones in humans. The number of people, who complain of various symptoms such as headache, dizziness, and fatigue, has also increased. Recently, the importance of researches on teenagers has been on the rise. However, very few provocation studies have examined the health effects of WCDMA mobile phone radiation on teenagers. Methods. In this double-blind study, two volunteer groups of 26 adults and 26 teenagers were simultaneously investigated by measuring physiological changes in heart rate, respiration rate, and heart rate variability for autonomic nervous system (ANS), eight subjective symptoms, and perception of RF-EMFs during sham and real exposure sessions to verify its effects on adults and teenagers. Experiments were conducted using a dummy phone containing a WCDMA module (average power, 250 mW at 1950 MHz; specific absorption rate, 1.57 W/kg) within a headset placed on the head for 32 min. Results. Short-term WCDMA RF-EMFs generated no significant changes in ANS, subjective symptoms or the percentages of those who believed they were being exposed in either group. Conclusions. Considering the analyzed physiological data, the subjective symptoms surveyed, and the percentages of those who believed they were being exposed, 32 min of RF radiation emitted by WCDMA mobile phones demonstrated no effects in either adult or teenager subjects.

Choi Y-J, Choi Y-S. Effects of Electromagnetic Radiation from Smartphones on Learning Ability and Hippocampal Progenitor Cell Proliferation in Mice. Osong Public Health and Research Perspectives. 7(1):12-17. February 2016. doi:10.1016/j.phrp.2015.12.009

Objectives Nonionizing radiation is emitted from electronic devices, such as smartphones. In this study, we intended to elucidate the effect of electromagnetic radiation from smartphones on spatial working memory and progenitor cell proliferation in the hippocampus. Methods Both male and female mice were randomly separated into two groups (radiated and control) and the radiated group was exposed to electromagnetic radiation for 9 weeks and 11 weeks for male and female mice, respectively. Spatial working memory was examined with a Y maze, and proliferation of hippocampal progenitor cells were examined by 5-bromo-2′-deoxyuridine administration and immunohistochemical detection. Results When spatial working memory on a Y maze was examined in the 9th week, there was no significant difference in the spontaneous alternation score on the Y maze between the two groups. In addition, there was no significant difference in hippocampal progenitor cell proliferation. However, immunoreactivity to glial fibrillary acidic protein was increased in exposed animals. Next, to test the effect of recovery following chronic radiation exposure, the remaining female mice were further exposed to electromagnetic radiation for 2 more weeks (total 11 weeks), and spontaneous alternation was tested 4 weeks later. In this experiment, although there was no significant difference in the spontaneous alternation scores, the number of arm entry was significantly increased. Conclusion These data indicate that although chronic electromagnetic radiation does not affect spatial working memory and hippocampal progenitor cell proliferation it can mediate astrocyte activation in the hippocampus and delayed hyperactivity-like behavior.

Chou CK, Guy AW, Kunz LL, Johnson RB, Crowley JJ, Krupp JH, Long-term, low-level microwave irradiation of rats. Bioelectromagnetics 13(6):469-496, 1992.

Our goal was to investigate effects of long-term exposure to pulsed microwave radiation. The major emphasis was to expose a large sample of experimental animals throughout their lifetimes and to monitor them for effects on general health and longevity. An exposure facility was developed that enabled 200 rats to be maintained under specific-pathogen-free (SPF) conditions while housed individually in circularly-polarized waveguides. The exposure facility consisted of two rooms, each containing 50 active waveguides and 50 waveguides for sham (control) exposures. The experimental rats were exposed to 2,450-MHz pulsed microwaves at 800 pps with a 10-microseconds pulse width. The pulsed microwaves were square-wave modulated at 8-Hz. Whole body calorimetry, thermographic analysis, and power-meter analysis indicated that microwaves delivered at 0.144 W to each exposure waveguide resulted in an average specific absorption rate (SAR) that ranged from 0.4 W/kg for a 200-g rat to 0.15 W/kg for an 800-g rat. Two hundred male, Sprague-Dawley rats were assigned in equal numbers to radiation-exposure and sham-exposure conditions. Exposure began at 8 weeks of age and continued daily, 21.5 h/day, for 25 months. Animals were bled at regular intervals and blood samples were analyzed for serum chemistries, hematological values, protein electrophoretic patterns, thyroxine, and plasma corticosterone levels. In addition to daily measures of body mass, food and water consumption by all animals, O2 consumption and CO2 production were periodically measured in a sub-sample (N = 18) of each group. Activity was assessed in an open-field apparatus at regular intervals throughout the study. After 13 months, 10 rats from each group were euthanatized to test for immunological competence and to permit whole-body analysis, as well as gross and histopathological examinations. At the end of 25 months, the survivors (11 sham-exposed and 12 radiation-exposed rats) were euthanatized for similar analyses. The other 157 animals were examined histopathologically when they died spontaneously or were terminated in extremis.

Chou CK, McDougall JA, Can KW, Absence of radiofrequency heating from

auditory implants during magnetic resonance imaging. Bioelectromagnetics 16(5):307-316, 1995.

The possibility of tissue heating due to an auditory brainstem implant (ABI) or a modified cochlear implant (CI) during magnetic resonance imaging (MRI) of the head was tested on a full-sized human phantom using a realistic phantom head consisting of simulated skull, brain, and muscle. Dielectric properties of the brain, muscle, and bone materials were similar to those of human tissues at 64 MHz. The body consisted of homogeneous phantom muscle enclosed in a human-shaped fiberglass shell. Thermographic and fiber-optic temperature measurements were conducted to reveal any heating. Thermograms of sagittal, frontal, and horizontal planes of the head with the ABI and CI electrodes were taken immediately before and after a 26 min MRI scan. The MRI sequence was set at 94 excitations and 25 ms echo time to induce maximum radiofrequency heating, as suggested by the General Electric Company. The difference of these two thermograms gives the heating results. In two uncut phantom heads. Teflon tubes were placed along the implanted ABI and CI, and temperature data were recorded via fiber-optic probes before, during, and after the MRI. Results showed no observable heating associated with the ABI and the modified CI during worst-case MRI of the head.

Christ A, Chavannes N, Nikoloski N, Gerber HU, Pokovic K, Kuster N. A numerical and experimental comparison of human head phantoms for compliance testing of mobile telephone equipment. Bioelectromagnetics. 26(2):125-137, 2005.

A new human head phantom has been proposed by CENELEC/IEEE, based on a large scale anthropometric survey. This phantom is compared to a homogeneous Generic Head Phantom and three high resolution anatomical head models with respect to specific absorption rate (SAR) assessment. The head phantoms are exposed to the radiation of a generic mobile phone (GMP) with different antenna types and a commercial mobile phone. The phones are placed in the standardized testing positions and operate at 900 and 1800 MHz. The average peak SAR is evaluated using both experimental (DASY3 near field scanner) and numerical (FDTD simulations) techniques. The numerical and experimental results compare well and confirm that the applied SAR assessment methods constitute a conservative approach.

Christ A, Kuster N. Differences in RF energy absorption in the heads of adults and children. Bioelectromagnetics. Suppl 7:S31-44. 2005.

There has been a long and controversial debate on possible differences in electromagnetic (EM) energy absorption between adults and children during cell phone usage. Some published studies report higher specific absorption rate (SAR) in children and explain this based on smaller head size. More recently, age dependent changes of the dielectric tissue parameters have again ignited the discussion. This study intends to give a comprehensive review of the current state of knowledge about the parameters and mechanisms affecting the exposure of the mobile phone user with special focus on the exposure of children. Discussed are the absorption mechanism, tissue parameters, the effect of the pinna, and the uncertainties associated with head models based on spheroids, scaled adult heads, and magnetic resonance imaging (MRI) data of children. The conclusions of the review do not support the assumption that the energy exposure increases due to smaller heads, but identifies open issues regarding the dielectric tissue parameters and the thickness of the pinna.

Christ A, Samaras T, Klingenböck A, Kuster N. Characterization of the electromagnetic near-field absorption in layered biological tissue in the frequency range from 30 MHz to 6000 MHz Phys. Med. Biol.51: 4951-4965, 2006.

Abstract. Currently, standards for the compliance testing of wireless devices are being extended to cover a wider frequency band and different usage patterns of mobile phones as well as of novel body-worn and handheld devices. As a consequence, not only the head but also strongly varying tissue distributions of the body are exposed to electromagnetic radiation. Several authors have reported changes in the SAR absorption of body tissue due to the presence of a low permittivity fat layer. This paper identifies two different effects which can lead to increased SAR in layered tissue in comparison to the SAR assessed using homogeneous tissue simulating liquid: (1) for larger distances between the tissue and the antenna, standing wave effects occur depending on the frequency and fat layer thickness. (2) In the very close near-field (distances approximately λ/40), reactive E-field components lead to high local absorption in the skin. The latter effect occurs at lower frequencies and depends on the antenna type. Modification of the parameters of the homogeneous liquids cannot compensate for these effects. However, a conservative exposure estimate can be obtained by applying a multiplication factor between 1 and 3 to the values assessed using current experimental dosimetric techniques.

Christ A, Gosselin MC, Christopoulou M, Kühn S, Kuster N. Age-dependent tissue-specific exposure of cell phone users. Phys Med Biol. 55(7):1767-1783, 2010.

The peak spatial specific absorption rate (SAR) assessed with the standardized specific anthropometric mannequin head phantom has been shown to yield a conservative exposure estimate for both adults and children using mobile phones. There are, however, questions remaining concerning the impact of age-dependent dielectric tissue properties and age-dependent proportions of the skull, face and ear on the global and local absorption, in particular in the brain tissues. In this study, we compare the absorption in various parts of the cortex for different magnetic resonance imaging-based head phantoms of adults and children exposed to different models of mobile phones. The results show that the locally induced fields in children can be significantly higher (>3 dB) in subregions of the brain (cortex, hippocampus and hypothalamus) and the eye due to the closer proximity of the phone to these tissues. The increase is even larger for bone marrow (>10 dB) as a result of its significantly high conductivity. Tissues such as the pineal gland show no increase since their distances to the phone are not a function of age. This study, however, confirms previous findings saying that there are no age-dependent changes of the peak spatial SAR when averaged over the entire head.

Christensen HC , Schüz J, Kosteljanetz M, Poulsen HS, Thomsen J, Johansen J. Cellular telephone use and risk of acoustic neuroma Am J Epidemiol 159:277-283, 2004.

Despite limited evidence, cellular telephones have been claimedto cause cancer, especially in the brain. In this Danish study,the authors examined the possible association between use ofcellular telephones and development of acoustic neuroma. Between2000 and 2002, they ascertained 106 incident cases and matchedthese persons with 212 randomly sampled, population-based controlson age and sex. The data obtained included information on useof cellular telephones from personal interviews, data from medicalrecords, and the results of radiologic examinations. The authorsobtained information on socioeconomic factors from StatisticsDenmark. The overall estimated relative risk of acoustic neuromawas 0.90 (95% confidence interval: 0.51, 1.57). Use of a cellphone for 10 years or more did not increase acoustic neuromarisk over that of short-term users. Furthermore, tumors didnot occur more frequently on the side of the head on which thetelephone was typically used, and the size of the tumor didnot correlate with the pattern of cell phone use. The resultsof this prospective, population-based, nationwide study, whichincluded a large number of long-term users of cellular telephones,do not support an association between cell phone use and riskof acoustic neuroma.

Christensen, HC; Schüz, J; Kosteljanetz, M; Poulsen, HS; Boice, JD. Jr; McLaughlin, JK; Johansen, C. Cellular telephones and risk for brain tumors: A population-based, incident case-control study. Neurology 64: 1189-1195, 2005.

Objective: To evaluate a possible association of glioma or meningioma with use of cellular telephones, using a nationwide population-based case-control study of incident cases of meningioma and glioma. Methods: The authors ascertained all incident cases of glioma and meningioma diagnosed in Denmark between September 1, 2000, and August 31, 2002. They enrolled 252 persons with glioma and 175 persons with meningioma aged 20 to 69. The authors also enrolled 822 randomly sampled, population-based controls matched for age and sex. Information was obtained from personal interviews, medical records containing diagnoses, and the results of radiologic examinations. For a small number of cases and controls, the authors obtained the numbers of incoming and outgoing calls. They evaluated the memory of the respondents with the Mini-Mental State Examination and obtained data on socioeconomic factors from Statistics Denmark.Results: There were no material socioeconomic differences between cases and controls or participants and non-participants. Use of cellular telephone was associated with a low risk for high-grade glioma (OR, 0.58; 95% CI, 0.37 to 0.90). The risk estimates were closer to unity for low-grade glioma (1.08; 0.58 to 2.00) and meningioma (1.00; 0.54 to 1.28).Conclusion: The results do not support an association between use of cellular telephones and risk for glioma or meningioma.

Ciaravino V, Meltz ML, Erwin DN, Absence of a synergistic effect between moderate-power radio-frequency electromagnetic radiation and adriamycin on cell-cycle progression and sister-chromatid exchange. Bioelectromagnetics 12(5):289-298, 1991.

In our laboratories we are conducting investigations of potential interactions between radio-frequency electromagnetic radiation (RFR) and chemicals that are toxic by different mechanisms to mammalian cells. The RFR is being tested at frequencies in the microwave range and at different power levels. We report here on the 1) ability of simultaneous RFR exposures to alter the distribution of cells in first and second mitoses from that after treatment by adriamycin alone, and 2) on the ability of simultaneous RFR exposure to alter the extent of sister chromatid exchanges (SCEs) induced by adriamycin alone. This chemical was selected because of its reported mechanism of action and because it is of interest in the treatment of cancer. In our studies, Chinese hamster ovary (CHO) cells were exposed for 2 h simultaneously to adriamycin and pulsed RFR at a frequency of 2,450 MHz and a specific absorption rate of 33.8 W/Kg. The maximal temperature (in the tissue-culture medium) was 39.7 +/- 0.2 degrees C. The experiments were controlled for chemical and RFR exposures, as well as for temperature. Verified statistically, the data indicate that the RFR did not affect changes in cell progression caused by adriamycin, and the RFR did not change the number of SCEs that were induced by the adriamycin, which adriamycin is known to affect cells by damaging their membranes and DNA.

Çiğ B, Nazıroğlu M. Investigation of the effects of distance from sources on apoptosis, oxidative stress and cytosolic calcium accumulation via TRPV1 channels induced by mobile phones and Wi-Fi in breast cancer cells. Biochim Biophys Acta. 2015 Feb 19. pii: S0005-2736(15)00053-X. doi: 10.1016/j.bbamem.2015.02.013. [Epub ahead of print]

TRPV1 is a Ca^{2+} permeable channel and gated by noxious heat, oxidative stress and capsaicin (CAP). Some reports have indicated that non-ionized electromagnetic radiation (EMR)-induces heat and oxidative stress effects. We aimed to investigate the effects of distance from sources on calcium signaling, cytosolic ROS production, cell viability, apoptosis, plus caspase-3 and -9 values induced by mobile phones and Wi-Fi in breast cancer cells MCF-7 human breast cancer cell lines were divided into A, B, C and D groups as control, 900, 1800 and 2450MHz groups, respectively. Cells in Group A were used as control and were kept in cell culture conditions without EMR exposure. Groups B, C and D were exposed to the EMR frequencies at different distances (0cm, 1cm, 5cm, 10cm, 20cm and 25cm) for 1h before CAP stimulation. The cytosolic ROS production, Ca^{2+} concentrations, apoptosis, caspase-3 and caspase-9 values were higher in groups B, C and D than in A group at 0cm, 1cm and 5cm distances although cell viability (MTT) values were increased by the distances. There was no statistically significant difference in the values between control, 20 and 25cm. Wi-Fi and mobile phone EMR placed within 10cm of the cells induced excessive oxidative responses and apoptosis via TRPV1-induced cytosolic Ca^{2+} accumulation in the cancer cells. Using cell phones and Wi-Fi sources which are farther away than 10cm may provide useful protection against oxidative stress, apoptosis and overload of intracellular Ca^{2+}. This article is part of a Special Issue entitled: Membrane channels and transporters in cancers.

Cinel C, Boldini A, Russo R, Fox E. Effects of mobile phone electromagnetic fields on an auditory order threshold task. Bioelectromagnetics.28(6):493-496,2007.

The effect of acute exposure to radio frequency electromagnetic fields (RF EMF) generated by mobile phones on an auditory threshold task was investigated. 168

participants performed the task while exposed to RF EMF in one testing session (either global system for mobile communication (GSM) or unmodulated signals) while in a separate session participants were exposed to sham signals. Lateralization effects were tested by exposing participants either on the left side or on the right side of the head. No significant effect of exposure to RF EMF was detected, suggesting that acute exposure to RF EMFs does not affect performance in the order threshold task.

Cinel C, Russo R, Boldini A, Fox E. Exposure to mobile phone electromagnetic fields and subjective symptoms: a double-blind study. Psychosom Med. 70(3):345-348, 2008.

OBJECTIVES: The objective of this study was to examine whether acute exposure to radio frequency electromagnetic fields (REFs) emitted by mobile phone may affect subjective symptoms. METHODS: Three large groups of volunteers (total 496) were exposed to REFs emitted by mobile phones in one session and sham signals in a different session. REF and sham exposure sessions were counterbalanced and double blinded. Participants were exposed to either Global System for Mobile Communication (GSM) or unmodulated signals, and the mobile phone was positioned either on the left or on the right side of the head. Before and after REF and sham exposure participants completed a questionnaire to rate five symptoms. Any changes in the severity of the symptoms after REF exposure were compared with changes after sham exposure. RESULTS: For one group of participants (N = 160), it was found that dizziness was affected by GSM exposure, but this was not consistently found with the other two groups of participants. No other significant effects were found. CONCLUSIONS: We did not find consistent evidence suggesting that exposure to mobile phone REFs affect subjective symptoms.Even though we acknowledge that more research is needed, we believe that our results give an important contribution to the research on mobile phone use and subjective symptoms.

Clark ML, Burch JB, Yost MG, Zhai Y, Bachand AM, Fitzpatrick CT, Ramaprasad J, Cragin LA, Reif JS. Biomonitoring of estrogen and melatonin metabolites among women residing near radio and television broadcasting transmitters.J Occup Environ Med. 49(10):1149-1156, 2007.

OBJECTIVES: Metabolites of estrogen (estrone-3-glucuronide [E1G]) and melatonin (6-hydroxymelatonin sulfate [6-OHMS]) were characterized among women living in a community with increased radiofrequency (RF) exposure from radio and television transmitters. **METHODS:** RF spot measurements, and personal 60-Hz magnetic field and residential parameters were collected. Overnight urine samples were assayed for E1G and 6-OHMS excretion. **RESULTS:** Among premenopausal women, there were no associations between RF or 60-Hz nonionizing radiation and E1G or 6-OHMS excretion. Among postmenopausal women, increased residential RF exposures, transmitter proximity and visibility, and temporally stable 60-Hz exposures were significantly associated with increased E1G excretion. This association was strongest among postmenopausal women with low overnight 6-OHMS levels. **CONCLUSIONS:** RF and temporally stable 60-Hz exposures were associated with increased E1G excretion among postmenopausal women. Women with reduced nocturnal 6-OHMS excretion may represent a sensitive subgroup.

Cleary SF, Liu LM, Merchant RE, In vitro lymphocyte proliferation induced by radio-frequency electromagnetic radiation under isothermal conditions. Bioelectromagnetics 11(1):47-56, 1990.

Whole human blood was exposed or sham-exposed in vitro for 2 h to 27 or 2,450 MHz radio-frequency electromagnetic (RF) radiation under isothermal conditions (i.e., 37 +/- 0.2 degrees C). Immediately after exposure, mononuclear cells were separated from blood by Ficoll density-gradient centrifugation and cultured for 3 days at 37 degrees C with or without mitogenic stimulation by phytohemagglutinin (PHA). Lymphocyte proliferation was assayed at the end of the culture period by 6 h of pulse labeling with 3H-thymidine (3H-TdR). Exposure to radiation at either frequency at specific absorption rates (SARs) below 50 W/kg resulted in a dose-dependent, statistically significant increase of 3H-TdR uptake in PHA-activated or unstimulated lymphocytes. Exposure at 50 W/kg or higher suppressed 3H-TdR uptake relative to that of sham-exposed cells. There were no detectable effects of RF radiation on lymphocyte morphology or viability. Notwithstanding the characteristic temperature dependence of lymphocyte activation in vitro, the isothermal exposure conditions of this study warrant the conclusion that the biphasic, dose-dependent effects of the radiation on lymphocyte proliferation were not dependent on heating.

Cleary, SF, Cao, G, Liu, LM, Egle, PM, Shelton, KR, Stress proteins are not induced in mammalian cells exposed to radiofrequency or microwave radiation. Bioelectromagnetics 18(7):499-505, 1997.

The induction of stress proteins in HeLa and CHO cells was investigated following a 2 h exposure to radiofrequency (RF) or microwave radiation. Cells were exposed or sham exposed in vitro under isothermal (37 +/- 0.2 degrees C) conditions. HeLa cells were exposed to 27- or 2450 MHz continuous wave (CW) radiation at a specific absorption rate (SAR) of 25 W/kg. CHO cells were exposed to CW 27 MHz radiation at a SAR of 100 W/kg. Parallel positive control studies included 2 h exposure of HeLa or CHO cells to 40 degrees C or to 45 microM cadmium sulfate. Stress protein induction was assayed 24 h after treatment by electrophoresis of whole-cell extracted protein labeled with [35S]-methionine. Both cell types exhibited well-characterized responses to the positive control stresses. Under these exposure conditions, neither microwave nor RF radiation had a detectable effect on stress protein induction as determined by either comparison of RF-exposed cells with sham-exposed cells or comparison with heat-stressed or Cd++ positive control cells.

Cleary, SF, Du, Z, Cao, G, Liu, LM, McCrady, C, Effect of isothermal radiofrequency radiation on cytolytic T lymphocytes. FASEB J 10(8):913-919. 1996.

Previous in vitro studies provide evidence that RF electromagnetic radiation modulates proliferation of human glioma, lymphocytes, and other cell types. The mechanism of RF radiation cell proliferation modulation, as well as mechanisms for effects on other cell physiologic endpoints, are not well understood. To obtain insight regarding interaction mechanisms, we investigated effects of RF radiation exposure on interleukin 2 (IL-2) -dependent proliferation of cytolytic T lymphocytes (CTLL-2). After exposure to RF radiation in the presence or absence of IL-2 cells were cultured at various physiological concentrations of IL-2. Treatment effects on CTLL-2 proliferation were determined by tritiated thymidine incorporation immediately or 24 h after exposure. Exposure to 2450 MHz RIF radiation at specific absorption rates (SARs) of greater than 25 W/kg (induced E-field strength 98.4 V/m) induced a consistent, statistically significant reduction in CTLL-2 proliferation, especially at low IL-2 concentrations. At lower SARs, 2450 MHz exposure increased CTLL-2 proliferation immediately after exposure but reduced 24 h postexposure proliferation. RF radiation effects depended on the mitotic stateof the cells at the time of exposure. Comparison of the effects of temperature elevation and RF radiation indicated significant qualitative and quantitative differences.

Cobb BL, Jauchem JR, Mason PA, Dooley MP, Miller SA, Ziriax JM, Murphy MR, Neural and behavioral teratological evaluation of rats exposed to ultra-wideband electromagnetic fields. Bioelectromagnetics 21(7):524-537, 2000.

Several investigators have reported teratologic effects of electromagnetic field exposure. The majority of these studies have been performed at levels of exposure that could produce substantial heating of the animals. New and unique sources of ultra-wideband (UWB) electromagnetic fields are currently being developed and tested that are capable of generating nonthermalizing, high-peak-power, microwave(MW) pulses with nanosecond (ns) pulse widths, picosecond (ps) rise times, and an UWB of frequencies. Our study was performed to determine if teratological changes occur in rat pups as a result of (i) daily UWB exposures during gestation days 3-18, or (ii) as a result of both prenatal and postnatal (10 days) exposures. Dams were exposed either to (i) UWB irradiation from a Kentech system that emitted a 55 kV/m-peak E field, 300 ps rise time, and a 1.8 ns pulse width, average whole-body specific absorption rate 45 mW/kg; (ii) sham irradiation; or (iii) a positive control, lead (Pb) acetate solution (2000 mug/ml) continuously available in the drinking water. Offspring were examined for ontogeny (litter size, sex-ratios, weights, coat appearance, tooth-eruption, eye-opening, air-righting, and ultrasonic stress vocalizations). Male pups were tested on various performance measures (locomotor, water-maze learning, and fertilization capabilities). The pups postnatally exposed were examined for hippocampal morphology and operant behavior. Behavioral, functional, and morphological effects of UWB exposure were unremarkable with these exceptions: (i) The UWB-exposed pups emitted significantly more stress vocalizations than the sham-exposed pups; (ii) the medial-to-lateral length of the hippocampus was significantly longer in the UWB-exposed pups than in the sham-exposed animals; (iii) male offspring exposed in utero to UWB mated significantly less frequently than sham-exposed males, but when they did mate there was no difference in fertilization and offspring numbers from the sham group. There does not appear to be a unifying physiological or behavioral relationship among the significant differences observed, and our findings could be due to the expected spurious results derived when a large number of statistical comparisons are made. Significant effects found between our positive-controls and other groups on numerous measures indicates that the techniques used were sensitive enough to detect teratological effects.

Cobb BL, Jauchem JR, Adair ER. Radial arm maze performance of rats following repeated low level microwave radiation exposure. Bioelectromagnetics. 25(1): 49-57, 2004.

We examined the possibility of changes in "working" memory of rats following whole body exposure to microwave (MW) radiation. During each of 10 days, we exposed rats within circularly polarized waveguides for 45 min to 2450 MHz fields at whole body SARs of 0.6 W/kg (2 micros pulses, 500 pps), followed by testing in a 12 arm, radial arm maze (RAM). Rats received a preexposure injection of one of three psychoactive compounds or saline, to determine whether a compound would interact with MW exposure to affect performance in the maze. Error rate, i.e., reentry into arms already visited, and time to criterion data for 10 consecutive days of testing were analyzed by a three way analysis of variance (ANOVA) using main effects of "exposure" and "drug" and a repeated factor of "test day." Our alpha limit for significance was P <.05. Analyzes of error rates revealed no significant exposure effect, no significant drug effect and no significant interaction between the two main factors. There was a significant difference in test days, as expected, with repeated test-trial days, which indicates that learning was accomplished. There was no significant interaction of test day and the other two factors. The results of our analyzes of time to criterion data included no significant exposure effect, a significant drug effect, a significant test day effect, and a significant interaction between drug and test day factors. Post hoc analyzes of the drug factor revealed that rats treated with either physostigmine or nalrexone hydrochloride, took significantly longer to complete the maze task than rats pretreated with saline or with naloxone methodide. We conclude that there is no evidence from the current study that exposure to of MW radiation under parameters examined caused decrements in the ability of rats to learn the spatial memory task.

Cohen JT, Graham JD. A revised economic analysis of restrictions on the use of cell phones while driving. Risk Anal 23(1):5-17, 2003.

Evidence that cell phone use while driving increases the risk of being involved in a motor vehicle crash has led policymakers to consider prohibitions on this practice. However, while restrictions would reduce property loss, injuries, and fatalities, consumers would lose the convenience of using these devices while driving. Quantifying the risks and benefits associated with cell phone use while driving is complicated by substantial uncertainty in the estimates of several important inputs, including the extent to which cell phone use increases a driver's risk of being involved in a crash, the amount of time drivers spend using cell phones (and hence their aggregate contribution to crashes, injuries, and fatalities), and the incremental value to users of being able to make calls while driving. Two prominent studies that have investigated cell phone use while driving have concluded that the practice should not be banned. One finds that the benefits of calls made while driving substantially exceed their costs while the other finds that other interventions could reduce motor vehicle injuries and fatalities (measured in terms of quality adjusted life years) at a lower cost. Another issue is that cell phone use imposes increased (involuntary) risks on other roadway users. This article revises the assumptions used in the two previous analyses to make them consistent and updates them using recent data. The result is a best estimate of zero for the net benefit of cell phone use while driving, a finding that differs substantially from the previous study. Our revised cost-effectiveness estimate for cell phone use while driving moves in the other direction, finding that the cost per quality adjusted life year increases modestly compared to the previous estimate. Both estimates are very uncertain.

Colak C, Parlakpinar H, Ermis N, Tagluk ME, Colak C, Sarihan E, Dilex OF, Turan B, Bakir S, Acet A. Effects of electromagnetic radiation from 3G mobile phone on heart rate, blood pressure and ECG parameters in rats. Toxicol Ind Health.28(7):629-638, 2012.

Effects of electromagnetic energy radiated from mobile phones (MPs) on heart is one of the research interests. The current study was designed to investigate the effects of electromagnetic radiation (EMR) from third-generation (3G) MP on the heart rate (HR), blood pressure (BP) and ECG parameters and also to investigate whether exogenous melatonin can exert any protective effect on these parameters. In this study 36 rats were randomized and evenly categorized into 4 groups: group 1 (3G-EMR exposed); group 2 (3G-EMR exposed + melatonin); group 3 (control) and group 4 (control + melatonin). The rats in groups 1 and 2 were exposed to 3G-specific MP's EMR for 20 days (40 min/day; 20 min active (speech position) and 20 min passive (listening position)). Group 2 was also administered with melatonin for 20 days (5 mg/kg daily during the experimental period). ECG signals were recorded from cannulated carotid artery both before and after the experiment, and BP and HR were calculated on 1st, 3rd and 5th min of recordings. ECG signals were processed and statistically evaluated. In our experience, the obtained results did not show significant differences in the BP, HR and ECG parameters among the groups both before and after the experiment. Melatonin, also, did not exhibit any additional effects, neither beneficial nor hazardous, on the heart hemodynamics of rats. Therefore, the strategy (noncontact) of using a 3G MP could be the reason for ineffectiveness; and use of 3G MP, in this perspective, seems to be safer compared to the ones used in close contact with the head. However, further study is needed for standardization of such an assumption.

Col-Araz N. Evaluation of factors affecting birth weight and preterm birth in southern Turkey. J Pak Med Assoc. 2013 Apr;63(4):459-62.

OBJECTIVE: To identify factors affecting birth weight and pre-term birth, and to find associations with electromagnetic devices such as television, computer and mobile phones. METHODS: The study was conducted in Turkey at Gazintep University, Faculty of Medicine's Outpatient Clinic at the Paediatric Ward. It comprised 500 patients who presented at the clinic from May to December 2009. All participants were administered a questionnaire regarding their pregnancy history. SPSS 13 was used for statistical analysis. RESULTS: In the study, 90 (19%) patients had pre-term birth, and 64 (12.9%) had low birth weight rate Birth weight was positively correlated with maternal age and baseline maternal weight ($r = 0.115$, $p < 0.010$; $r = 0.168$, $p < 0.000$, respectively). Pre-term birth and birth weight less than 2500g were more common in mothers with a history of disease during pregnancy ($p < 0.046$ and $p < 0.008$, respectively). The habit of watching television and using mobile phones and computer by mothers did not demonstrate any relationship with birth weight. Mothers who used mobile phones or computers during pregnancy had more deliveries before 37 weeks ($p < 0.018$, $p < 0.034$;

respectively). Similarly, pregnancy duration was shorter in mothers who used either mobile phone or computers during pregnancy ($p < 0.005$, $p < 0.048$, respectively). CONCLUSION: Mobile phones and computers may have an effect on pre-term birth.

Colletti V, Mandalà M, Manganotti P, Ramat S, Sacchetto L, Colletti L. Intraoperative observation of changes in cochlear nerve action potentials during exposure to electromagnetic fields generated by mobile phones. J Neurol Neurosurg Psychiatry.82(7):766-71, 2010

Background The rapid spread of devices generating electromagnetic fields (EMF) has raised concerns as to the possible effects of this technology on humans. The auditory system is the neural organ most frequently and directly exposed to electromagnetic activity owing to the daily use of mobile phones. In recent publications, a possible correlation between mobile phone usage and central nervous system tumours has been detected. Very recently a deterioration in otoacoustic emissions and in the auditory middle latency responses after intensive and long-term magnetic field exposure in humans has been demonstrated. Methods To determine with objective observations if exposure to mobile phone EMF affects acoustically evoked cochlear nerve compound action potentials, seven patients suffering from Ménière's disease and undergoing retrosigmoid vestibular neurectomy were exposed to the effects of mobile phone placed over the craniotomy for 5 min. Results All patients showed a substantial decrease in amplitude and a significant increase in latency of cochlear nerve compound action potentials during the 5 min of exposure to EMF. These changes lasted for a period of around 5 min after exposure. Discussion The possibility that EMF can produce relatively long-lasting effects on cochlear nerve conduction is discussed and analysed in light of contrasting previous literature obtained under non-surgical conditions. Limitations of this novel approach, including the effects of the anaesthetics, craniotomy and surgical procedure, are presented in detail.

Conover DL, Moss CE, Murray WE, Edwards RM, Cox C, Grajewski B, Werren DM, Smith JM, Foot currents and ankle SARs induced by dielectric heaters. Bioelectromagnetics 13(2):103-110, 1992.

Data are presented on ankle-specific SARs and foot currents as a function of strengths of radio-frequency electromagnetic fields encountered by operators of dielectric heaters. The determination of foot currents was based on near-field exposures in which reactive coupling dominates, and which can result in substantial SARs in exposed workers. The operators were located less than one wavelength from--usually within one meter of--the dielectric heaters, which generated fields at frequencies from 6.5 to 65 MHz. At distances normally assumed by workers, maximal strengths of electric fields ranged from 10(4) to 2.4 x 10(6) V2/m2; maximal strengths of magnetic fields ranged from 5.0 x 10(-3) to 33.3 A2/m2. Currents through both feet to ground were measured while operators stood where they normally worked. Maximal currents ranged from 3 to 617 mA, rms. Nearly 27 percent of the dielectric heaters induced foot currents that exceeded the 200-mA limit that has been proposed for a new ANSI C95.1 standard. Twenty percent of the heaters induced foot currents that exceeded 350 mA. SARs in ankles were calculated from foot currents, and they approximated 5 W/kg at 100 mA, 29 W/kg at 250 mA, and 57 W/kg at 350 mA. The maximal SAR in the ankle was approximately 176 W/kg at 617 mA.

Consiglio W, Driscoll P, Witte M, Berg WP. Effect of cellular telephone conversations and other potential interference on reaction time in a braking response. Accid Anal Prev 35(4):495-500, 2003.

This experiment studied the effect of phone conversations and other potential interference on reaction time (RT) in a braking response. Using a laboratory station which simulated the foot activity in driving, 22 research participants were requested to release the accelerator pedal and depress the brake pedal as quickly as possible following the activation of a red brake lamp. Mean reaction time was determined for five conditions: (a) control, (b) listening to a radio, (c) conversing with a passenger, (d) conversing using a hand-held phone, and (e) conversing using a hands-free phone. Results indicated that conversation, whether conducted in-person or via a cellular phone caused RT to slow, whereas listening to music on the radio did not.

Cook A, Woodward A, Pearce N, Marshall C. Cellular telephone use and time trends for brain, head and neck tumours. N Z Med J. 116(1175):U457, 2003.

AIM: The objective of this study was to determine whether incidence rates of head and neck malignancies in New Zealand have varied since the introduction of cellular telephones in 1987. In particular, we sought to compare trends in tumour rates in anatomical sites that receive high, medium and low levels of cellular telephone radiation (based on dosimetry data). METHODS: We investigated whether trends in tumour incidence rates in New Zealand have varied since the introduction of cellular telephones in 1987. The exposure measure used was the proportion of cellular telephone subscribers within the national population, calculated using the number of subscribers over the study period. RESULTS: The graphs for high, medium and low exposure sites did not display any significant changes in trend patterns for either gender over the years 1986 to 1998. CONCLUSIONS: Incidence rates for malignancies arising in the head and neck, including those sites that hypothetically receive the highest levels of radio frequency radiation during cellular telephone use, have not changed materially since the introduction of cellular telephones to New Zealand. However, ecological studies of this nature are limited in many ways and a stronger study design is clearly needed to establish more exactly any elevation in risk.

Cooke R, Laing S, Swerdlow AJ. A case-control study of risk of leukaemia in relation to mobile phone use. Br J Cancer.103(11):1729-1735,2010.

Background:Mobile phone use is now ubiquitous, and scientific reviews have recommended research into its relation to leukaemia risk, but no large studies have been conducted.Methods:In a case-control study in South East England to investigate the relation of acute and non-lymphocytic leukaemia risk to mobile phone use, 806 cases with leukaemia incident 2003-2009 at ages 18-59 years (50% of those identified as eligible) and 585 non-blood relatives as controls (provided by 392 cases) were interviewed about mobile phone use and other potentially aetiological variables.Results:No association was found between regular mobile phone use and risk of leukaemia (odds ratio (OR)=1.06, 95% confidence interval (CI)=0.76, 1.46). Analyses of risk in relation to years since first use, lifetime years of use, cumulative number of calls and cumulative hours of use produced no significantly raised risks, and there was no evidence of any trends. A non-significantly raised risk was found in people who first used a phone 15 or more years ago (OR=1.87, 95% CI=0.96, 3.63). Separate analyses of analogue and digital phone use and leukaemia subtype produced similar results to those overall.Conclusion:This study suggests that use of mobile phones does not increase leukaemia risk, although the possibility of an effect after long-term use, while biologically unlikely, remains open.

Cooper PJ, Zheng Y. Turning gap acceptance decision-making: the impact of driver distraction. J Safety Res 33(3):321-335, 2002.

PROBLEM: A number of studies have found that use of in-car phones by drivers can interfere with the cognitive processing necessary for making appropriate and timely vehicle control decisions. However, the specific linkage between communication-based distraction and unsafe decision-making has not been sufficiently explored. METHOD: In a closed-course driving experiment, 39 subjects were exposed to approximately 100 gaps each in a circulating traffic stream of eight vehicles on an instrumented test track that was wet about half the time. The subjects were at the controls of an instrumented car, which was oriented in a typical left-turn configuration (traffic-crossing situation in North America) and with parking brake on and the transmission in neutral. The subjects were instructed to press on the accelerator pedal when they felt that a gap was safe to accept. Their performances were monitored and incentives were provided for balancing safe decision-making with expeditious completion of the task. For half of the gap exposures (randomly assigned), each subject was required to listen and respond to a complex verbal message. RESULTS: When not distracted, the subjects' gap acceptance judgment was found to be significantly influenced by their age, the gap size, the speed of the trailing vehicle, the level of "indecision," and the condition of the track surface. However, when distracted, the subjects did not factor pavement surface condition into the decision process. On wet pavement, the subjects were judged to have initiated twice the level of potential collisions when distracted by the messages that they did when not distracted. DISCUSSION: Listening/responding to verbal messages may reduce the capacity of drivers to process adequately all the important information necessary for safe decision-making. The effects of the messages in our study seemed to cause the subjects to misjudge gap size and speed information when operating under the additional disadvantage of adverse pavement condition. SUMMARY: Attention to complex messages while making decisions about turning through gaps in an on-coming vehicle stream was associated with significantly increased unsafe decision making by subjects in our experiment when the additional complexity of wet surface condition was introduced. IMPACT ON INDUSTRY: While the results reflected a somewhat artificial situation where the measure was signaled intention to act rather than the act itself, nevertheless, they do strongly suggest a scenario in which mental distraction could contribute to crash risk. With the rapid proliferation of telematics in the vehicle market, even with the laudable objectives represented by the Intelligent Transportation Systems initiative, there is a danger of the primary task of the driver being subordinated to a perceived need to enhance information flow to/from the external "world." Industry and governments need to work together to ensure that apparently desirable in-vehicle communication improvements do not compromise safety.

Cooper TG, Mann SM, Khalid M, Blackwell RP. Public exposure to radio waves near GSM microcell and picocell base stations. J Radiol Prot. 26:199-211, 2006.

Abstract. Exposures of the general public to radio waves at locations near 20 randomly selected GSM microcell and picocell base stations in the UK have been assessed in the context of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Compliance distances were calculated for the antennas of the base stations from their reported radiated powers. Under pessimistic assumptions that would maximise exposures, the minimum height at which the general public reference level could potentially be exceeded near any of the base station antennas was calculated to be 2.4 m above ground level. The power densities of the broadcast carriers transmitted by the base stations have been measured and scaled to include all other possible carriers. Exposures were generally in the range 0.002–2% of the ICNIRP general public reference level, and the greatest exposure quotient near any of the base stations was 8.6%. Exposures close to microcell base stations were found to be generally greater than those close to macrocell base stations.

Copty AB, Neve-Oz Y, Barak I, Golosovsky M, Davidov D. Evidence for a specific microwave radiation effect on the green fluorescent protein. Biophys J. 91(4):1413-1423, 2006.

We have compared the effect of microwave irradiation and of conventional heating on the fluorescence of solution-based green fluorescent protein. A specialized near-field 8.5 GHz microwave applicator operating at 250 mW input microwave power was used. The solution temperature, the intensity, and the spectrum of the green fluorescent protein fluorescence 1), under microwave irradiation and 2), under conventional heating, were measured. In both cases the fluorescence intensity decreases and the spectrum becomes red-shifted. Although the microwave irradiation heats the solution, the microwave-induced changes in fluorescence cannot be explained by heating alone. Several possible scenarios are discussed.

Cosquer B, Galani R, Kuster N, Cassel JC. Whole-body exposure to 2.45 GHz electromagnetic fields does not alter anxiety responses in rats: a plus-maze study including test validation. Behav Brain Res. 156(1):65-74, 2005.

In a first phase of this investigation, a validation of our elevated plus-maze apparatus was performed in male Sprague-Dawley rats by testing anxiety response at various ambient light intensities (200, 30, 10 and 2.5 lux), as well as the effects of diazepam treatment (0.5 and 1.0 mg/kg, i.p. at 30 lux). Anxiety responses were found to decrease with decreasing light intensity and to be attenuated by diazepam treatment. Subsequently, a separate set of rats was exposed to 2.45 GHz EMFs (2 micros pulse width, 500 pulses per second, whole-body and time averaged of SAR 0.6 W/kg +/-2 dB, brain-averaged SAR of 0.9 W/kg +/-3 dB) for 45 min to assess whether EMF exposure altered anxiety responses in the same apparatus. As we made no a priori hypothesis on whether the effects would be anxiogenic or anxiolytic, part of the rats were tested under an ambient light intensity of 2.5 lux, the other one being tested at 30 lux. The low intensity level set the behavioural baseline for the detection of anxiogenic effects, while the higher one corresponded to the detection of anxiolytic effects. Sham-exposed and naive rats were used as controls. Whatever light intensity was used, EMF exposure failed to induce any significant effect on anxiety responses in the plus maze. The present experiment demonstrates that exposure to EMFs, which was previously found to increase the number of benzodiazepine receptors in the rat cortex [Lai H, Carino MA, Horita A, Guy AW. Single vs. repeated microwave exposure: effects on benzodiazepine receptors in the brain of the rat. Bioelectromagnetics 1992;13(1):57-66], does not alter anxiety responses assessed in the elevated plus maze.

Cosquer B, Kuster N, Cassel JC. Whole-body exposure to 2.45GHz electromagnetic fields does not alter 12-arm radial-maze with reduced access to spatial cues in rats. Behav Brain Res. 161(2):331-334, 2005.

Lai et al. [Lai H, Horita A, Guy AW. Microwave irradiation affects radial-arm maze performance in the rat. Bioelectromagnetics 1994;15(2):95-104] reported that exposure of rats to pulsed 2.45GHz microwaves altered maze performance. Their maze was bordered by 20cm high opaque walls. Using a maze test based on unrestrained access to spatial cues (no walls), we could not replicate this result [Cassel JC, Cosquer B, Galani R, Kuster N. Whole-body exposure to 2.45GHz electromagnetic fields does not alter radial-maze performance in rats. Behav Brain Res 2004;155:37-43]. Here, we attempted another replication using a maze apparatus bordered by 30cm high opaque walls. Performance of exposed rats was normal. These results show that microwave exposure as used herein does not alter spatial working memory, when access to spatial cues is reduced.

Cosquer B, Vasconcelos AP, Frohlich J, Cassel JC. Blood-brain barrier and electromagnetic fields: Effects of scopolamine methylbromide on working memory after whole-body exposure to 2.45GHz microwaves in rats. Behav Brain Res. 161(2):229-237, 2005.

We first verified that our 12-arm radial maze test enabled demonstration of memory deficits in rats treated with the muscarinic antagonist scopolamine hydrobromide (0.5mg/kg, i.p.). We then investigated whether a systemically-injected quaternary-ammonium derivate of this antagonist (scopolamine methylbromide; MBR), which poorly crosses the blood-brain barrier (BBB), altered maze performance after a 45-min exposure to 2.45GHz electromagnetic field (EMF; 2mus pulse width, 500pps, whole-body specific energy absorption rate [SAR] of 2.0W/kg, +/-2dB and brain averaged SAR of 3.0W/kg, +/-3dB); if observed, such an alteration would reflect changes in BBB permeability. The drug was injected before or after exposure. Controls were naive rats (no experience of the exposure device) and sham-exposed rats (experience of the exposure device without microwaves). In a final approach, rats were subjected to i.v. injections of Evans blue, a dye binding serum albumin, before or after EMF exposure. Whether scopolamine MBR was injected before or after exposure, the exposed rats did not perform differently from their naive or sham-exposed counterparts. Thus, EMFs most probably failed to disrupt the BBB. This conclusion was further supported by the absence of Evans blue extravasation into the brain parenchyma of our exposed rats.

Costa FP, de Oliveira AC, Meirelles R, Machado MC, Zanesco T, Surjan R, Chammas MC, de Souza Rocha M, Morgan D, Cantor A, Zimmerman J, Brezovich I,

Kuster N, Barbault A, Pasche B. Treatment of advanced hepatocellular carcinoma with very low levels of amplitude-modulated electromagnetic fields.Br J Cancer. 105(5):640-648, 2011.

BACKGROUND: Therapeutic options for patients with advanced hepatocellular carcinoma (HCC) are limited. There is emerging evidence that the growth of cancer cells may be altered by very low levels of electromagnetic fields modulated at specific frequencies.**METHODS:** A single-group, open-label, phase I/II study was performed to assess the safety and effectiveness of the intrabuccal administration of very low levels of electromagnetic fields amplitude modulated at HCC-specific frequencies in 41 patients with advanced HCC and limited therapeutic options. Three-daily 60-min outpatient treatments were administered until disease progression or death. Imaging studies were performed every 8 weeks. The primary efficacy end point was progression-free survival 6 months. Secondary efficacy end points were progression-free survival and overall survival.**RESULTS:** Treatment was well tolerated and there were no NCI grade 2, 3 or 4 toxicities. In all, 14 patients (34.1%) had stable disease for more than 6 months. Medianprogression-free survival was 4.4 months (95% CI 2.1-5.3) and median overall survival was 6.7 months (95% CI 3.0-10.2). There were three partial and one near complete responses.**CONCLUSION:** Treatment with intrabuccally administered amplitude-modulated electromagnetic fields is safe, well tolerated, and shows evidence of antitumour effects in patients with advanced HCC.

Court-Kowalski S, Finnie JW, Manavis J, Blumbergs PC, Helps SC, Vink R. Effect of long-term (2 years) exposure of mouse brains to global system for mobile communication (GSM) radiofrequency fields on astrocytic immunoreactivity. Bioelectromagnetics. 2015 Feb 20. doi: 10.1002/bem.21891. [Epub ahead of print]

This study was designed to determine whether long-term (2 years) brain exposure to mobile telephone radiofrequency (RF) fields produces any astrocytic activation as these glia react to a wide range of neural perturbations by astrogliosis. Using a purpose-designed exposure system at 900 MHz, mice were given a single, far-field whole body exposure at a specific absorption rate of 4 W/kg on five successive days per week for 104 weeks. Control mice were sham-exposed or freely mobile in a cage to control any stress caused by immobilization in the exposure module. Brains were perfusion-fixed with 4% paraformaldehyde and three coronal levels immunostained for glial fibrillary acidic protein (GFAP). These brain slices were then examined by light microscopy and the amount of this immunomarker quantified using a color deconvolution method. There was no change in astrocytic GFAP immunostaining in brains after long-term exposure to mobile telephony microwaves compared to control (sham-exposed or freely moving caged mice). It was concluded that long-term (2 years) exposure of murine brains to mobile telephone RF fields did not produce any astrocytic reaction (astrogliosis) detectable by GFAP immunostaining

Cox RA, Luxton LM, Cerebral symptoms from mobile telephones. Occup Environ Med 57(6):431, 2000. (letter to the editor)

Mobile phones affect the inner ear in 5-8% of users leading to dizziness, disorientation, nausea, headache and transient confusion.

Crabtree DPE, Herrera BJ, Kang S.The response of human bacteria to static magnetic field and radiofrequency electromagnetic field. J Microbiol. 55(10):809-815,2017.

Cell phones and electronic appliances and devices are inseparable from most people in modern society and the electromagnetic field (EMF) from the devices is a potential health threat. Although the direct health effect of a cell phone and its radiofrequency (RF) EMF to human is still elusive, the effect to unicellular organisms is rather apparent. Human microbiota, including skin microbiota, has been linked to a very significant role in the health of a host human body. It is important to understand the response of human skin microbiota to the RF-EMF from cell phones and personal electronic devices, since this may be one of the potential mechanisms of a human health threat brought about by the disruption of the intimate and balanced host-microbiota relationship. Here, we investigated the response of both laboratory culture strains and isolates of skin bacteria under static magnetic field (SMF) and RF-EMF. The growth patterns of laboratory cultures of Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus epidermidis under SMF were variable per different species. The bacterial isolates of skin microbiota from 4 subjects with different cell phone usage history also showed inconsistent growth responses. These findings led us to hypothesize that cell phone level RF-EMF disrupts human skin microbiota. Thus, the results from the current study lay ground for more comprehensive research on the effect of RF-EMF on human health through the human-microbiota relationship.

Cranfield CG, Wood AW, Anderson V, Menezes KG. Effects of mobile phone type signals on calcium levels within human leukaemic T-cells (Jurkat cells). Int J Radiat Biol 77(12):1207-1217, 2001.

PURPOSE: To test whether exposure to simulated GSM mobile phone signals (915 MHz, 2 W kg(-1)) influences the concentration of calcium or calcium signalling patterns in a human lymphocyte cell line. MATERIALS AND METHODS: The radiofrequency (RF) energy was delivered via a coaxial applicator to a perfused chamber where cells adherent to a thin glass coverslip were imaged by laser scanning confocal microscopy. Cell calcium concentration, estimated from Fluo-3 fluorescence, was monitored over two 10-min periods; control followed by exposed/sham, with exposure status assigned in a blind and randomized fashion. Both continuous wave (CW) and pulsed wave (PW) RF (on both phytohaemagglutanin-activated and unactivated cells) were studied (with an equal number of sham exposures) on 100 cells per category (total 800 cells). RESULTS: No significant changes were noted for the following: regression slope of calcium fluorescence; mean calcium concentration; number of calcium 'spikes' in each 10 min; or mean height of these 'spikes'. The average frequency from Fourier spectra of these periods showed significant alteration in one category only: PW exposure of activated cells. CONCLUSIONS: There is no clear indication that RF emissions from mobile phones are associated with any changes in calcium levels or calcium signalling in lymphocytes.

Cranfield C, Wieser HG, Al Madan J, Dobson J. Preliminary evaluation of nanoscale biogenic magnetite-based ferromagnetic transduction mechanisms for mobile phone bioeffects. IEEE Trans Nanobioscience. 2(1):40-43, 2003.

Ferromagnetic transduction models have been proposed as a potential mechanism for mobile phone bioeffects. These models are based on the coupling of RF and pulsed electromagnetic emissions to biogenic magnetite (Fe3O4) present in the human brain via either ferromagnetic resonance or mechanical activation of cellular ion channels. We have tested these models experimentally for the first time using a bacterial analogue (Magnetospirillum magnetotacticum) which produces intracellular biogenic magnetite similar to that present in the human brain. Experimental evaluation revealed that exposure to mobile phone emissions resulted in a consistent and significantly higher proportion of cell death in exposed cultures versus sham exposure ($p = 0.037$). Though there appears to be a repeatable trend toward higher cell mortality in magnetite-producing bacteria exposed to mobile phone emissions, it is not yet clear that this would extrapolate to a deleterious health effect in humans.

Cranfield CG, Wieser HG, Dobson J. Exposure of magnetic bacteria to simulated mobile phone-type RF radiation has no impact on mortality. IEEE Trans Nanobioscience. 2(3):146-149, 2003.

The interaction of mobile phone RF emissions with biogenic magnetite in the human brain has been proposed as a potential mechanism for mobile phone bioeffects. This is of particular interest in light of the discovery of magnetite in human brain tissue. Previous experiments using magnetite-containing bacteria exposed directly to emissions from a mobile phone have indicated that these emissions might be causing greater levels of cell death in these bacterial populations when compared to sham exposures. A repeat of these experiments examining only the radio frequency (RF) global system for mobile communication (GSM) component of the mobile phone signal in a well-defined waveguide system (REFLEX), shows no significant change in cell mortality compared to sham exposures. A nonmagnetite containing bacterial cell strain (CC-26) with similar genotype and phenotype to the magnetotactic bacteria was used as a control. These also showed no significant change in cell mortality between RF and sham exposed samples. Results indicate that the RF components of mobile phone exposure do not appear to be responsible for previous findings indicating cell mortality as a result of direct mobile phone exposure. A further mobile phone emission component that should be investigated is the 2-Hz magnetic field pulse generated by battery currents during periods of discontinuous transmission.

Crespo-Valero P, Christopoulou M, Zefferer M, Christ A, Achermann P, Nikita KS, Kuster N. Novel methodology to characterize electromagnetic exposure of the brain. Phys Med Biol. 56(2):383-396, 2010.

Abstract. Due to the greatly non-uniform field distribution induced in brain tissues by radio frequency electromagnetic sources, the exposure of anatomical and functional regions of the brain may be a key issue in interpreting laboratory findings and epidemiological studies concerning endpoints related to the central nervous system. This paper introduces the Talairach atlas in characterization of the electromagnetic exposure of the brain. A hierarchical labeling scheme is mapped onto high-resolution human models. This procedure is fully automatic and allows identification of over a thousand different sites all over the brain. The electromagnetic absorption can then be extracted and interpreted in every region or combination of regions in the brain, depending on the characterization goals. The application examples show how this methodology enhances the dosimetry assessment of the brain based on results obtained by either finite difference time domain simulations or measurements delivered by test compliance dosimetry systems. Applications include, among others, the detailed dosimetric analysis of the exposure of the brain during cell phone use, improved design of exposure setups for human studies or medical diagnostic and therapeutic devices using electromagnetic fields or ultrasound.

Croft R, Chandler J, Burgess A, Barry R, Williams J, Clarke A. Acute mobile phone operation affects neural function in humans. Clin Neurophysiol 113(10):1623, 2002.

OBJECTIVES: Mobile phones (MP) are used extensively and yet little is known about the effects they may have on human physiology. There have been conflicting reports regarding the relation between MP use and the electroencephalogram (EEG). The present study suggests that this conflict may be due to methodological differences such as exposure durations, and tests whether exposure to an active MP affects EEG as a function of time.METHODS: Twenty-four subjects participated in a single-blind fully counterbalanced cross-over design, where both resting EEG and phase-locked neural responses to auditory stimuli were measured while a MP was either operating or turned off.RESULTS: MP exposure altered resting EEG, decreasing 1-4Hz activity (right hemisphere sites), and increasing 8-12Hz activity as a function of exposure duration (midline posterior sites). MP exposure also altered early phase-locked neural responses, attenuating the normal response decrement over time in the 4-8Hz band, decreasing the response in the 1230Hz band globally and as a function of time, and increasing midline frontal and lateral posterior responses in the 30-45Hz band.CONCLUSIONS: Active MPs affect neural function in humans and do so as a function of exposure duration. The temporal nature of this effect may contribute to the lack of consistent results reported in the literature.

Croft RJ, Hamblin DL, Spong J, Wood AW, McKenzie RJ, Stough C. The effect of mobile phone electromagnetic fields on the alpha rhythm of human electroencephalogram. Bioelectromagnetics.29(1):1-10,2008.

Mobile phones (MP) emit low-level electromagnetic fields that have been reported to affect neural function in humans; however, demonstrations of such effects have not been conclusive. The purpose of the present study was to test one of the strongest findings in the literature; that of increased "alpha" power in response to MP-type radiation. Healthy participants (N = 120) were tested using a double-blind counterbalanced crossover design, with each receiving a 30-min Active and a 30-min Sham Exposure 1 week apart, while electroencephalogram (EEG) data were recorded. Resting alpha power (8-12 Hz) was then derived as a function of time, for periods both during and following exposure. Non-parametric analyses were employed as data could not be normalized. Previous reports of an overall alpha power enhancement during the MP exposure were confirmed (relative to Sham), with this effect larger at ipsilateral than contralateral sites over posterior regions. No overall change to alpha power was observed following exposure cessation; however, there was less alpha power contralateral to the exposure source during this period (relative to ipsilateral). Employing a strong methodology, the current findings support previous research that has reported an effect of MP exposure on EEG alpha power.

Croft RJ, Leung S, McKenzie RJ, Loughran SP, Iskra S, Hamblin DL, Cooper NR. Effects of 2G and 3G mobile phones on human alpha rhythms: Resting EEG in adolescents, young adults, and the elderly. Bioelectromagnetics.31(6):434-444,2010.

The present study was conducted to determine whether adolescents and/or the elderly are more sensitive to mobile phone (MP)-related bioeffects than young adults, and to determine this for both 2nd generation (2G) GSM, and 3rd generation (3G) W-CDMA exposures. To test this, resting alpha activity (8-12 Hz band of the electroencephalogram) was assessed because numerous studies have now reported it to be enhanced by MP exposure. Forty-one 13-15 year olds, forty-two 19-40 year olds, and twenty 55-70 year olds were tested using a double-blind crossover design, where each participant received Sham, 2G and 3G exposures, separated by at least 4 days. Alpha activity, during exposure relative to baseline, was recorded and compared between conditions. Consistent with previous research, the young adults' alpha was greater in the 2G compared to Sham condition, however, no effect was seen in the adolescent or the elderly groups, and no effect of 3G exposures was found in any group. The results provide further support for an effect of 2G exposures on resting alpha activity in young adults, but fail to support a similar enhancement in adolescents or the elderly, or in any age group as a function of 3G exposure.

Crouzier D, Debouzy JC, Bourbon F, Collin A, Perrin A, Testylier G. Neurophysiologic effects at low level 1.8 GHz radiofrequency field exposure: a multiparametric approach on freely moving rats. Pathol Biol (Paris).55(3-4):134-142, 2007.

Deleterious effects on healthcare and particularly disruption of the cholinergic system have been reported after exposure to radiofrequency field at low power density. This work presents a 72 hours multiparametric study, where cholinergic system was investigated using a neurochemical, electrophysiological and physiological approaches. Free moving rats were exposed 24 hours to RF GSM signal at 1.8 GHz at low power density (1.2 and 9 W/m(2)). Acetylcholine (ACh) release in the hippocampus was simultaneously monitored using the microdialysis technique, electroencephalogram (EEG), electromyogram (EMG) and subcutaneous temperature. A spectral analysis of EEG was also performed and sleep stages were determined. After experimental time, the animals were sacrificed and a NMR study was performed on lipid brain extract. No significant parameters modification was observed under RF exposure. The only significant difference was the lack of increase in time spent in REM sleep, the third day, for the 1.2 W/m(2) group. This observation appeared difficult to explain and could not be reasonably related with RF exposure.