



Presentation to the Honorable Governor of North Carolina Roy Cooper,
Legislative Counsel Jess Englert & Deputy Legislative Director Justin Clayton

HB 310, Wireless Radiation and Adverse Health Effects

July 6, 2017

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Resources

- [International Policy Actions on Wireless Radiation Click for PDF](#)
- [Key Research Studies on Microwave Radiation and Health](#)
- [Research Studies on Cell Phone Towers](#)
- [Medical Organization Recommendations on Electromagnetic Fields](#)
- [Telecom and Insurance Companies Warn of Liability and Risk 2017 10K filings.](#)
- [Insurance Reports, White Papers and Legal Cases.](#)
- [Myth Fact on the National Toxicology Program Study](#)
- [Myth Fact on Cell Phones and Health PDF](#)

Powerpoint Slide Presentation

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References for Slides

Slide #5

["List of US States With Legislation \(Proposed and Passed\) Regarding The Streamlining of Wireless Facilities in Right of Way." *Environmental Health Trust*, July 2017.](#)

Slide #8

Federal Communications Commission Radio Frequency Limits

[Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields](#)

[OET Bulletin No. 56: Questions and Answers About Biological Effects Potential Hazards of Radio frequency Electromagnetic Fields \(Fourth Edition, August 1999\)](#)

[ANSI C95.1-1982 Exposure-Limit Standard](#)

[IEEE C95.1-1991 Exposure-Limit Standard](#)

[NCRP 1986 Report No. 086 - Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields \(1986\)](#)

Slide #9

Alster, Norm. [“Captured Agency: How the Federal Communications Commission is Dominated by the Industries It Presumably Regulates.”](#) Harvard University, Edmond J. Safra Center for Ethics.

Slide # 10 Summary of a few of the effects found after EMF exposure at low non thermal levels of exposure. (Please note that there are many more effects but this was a short example.”

Barnes, Frank, and Ben Greenebaum. [“Some Effects of Weak Magnetic Fields on Biological Systems: RF fields can change radical concentrations and cancer cell growth rates.”](#) IEEE Power Electronics Magazine, vol. 3, no. 1, 2016, pp. 60-8.

Carlberg, M. and L. Hardell. [“Decreased Survival of Glioma Patients with Astrocytoma Grade IV \(Glioblastoma Multiforme\) Associated with Long-Term Use of Mobile and Cordless Phones.”](#) International Journal of Environmental Research and Public Health, vol. 11, no. 10, 2014, pp. 10790-805.

Houston B., et al. [“The effects of radiofrequency electromagnetic radiation on sperm function.”](#) Reproduction, 2016.

Yüksel, M., M. Nazıroğlu and M.O. Özkaya. [“Long-term exposure to electromagnetic radiation from mobile phones and Wi-Fi devices decreases plasma prolactin, progesterone, and estrogen levels but increases uterine oxidative stress in pregnant rats and their offspring.”](#) Endocrine, vol. 52, no. 2, 2016, pp. 352-62.

Adams, J., et al. [“Effect of mobile telephones on sperm quality: A systematic review and meta-analysis.”](#) Environment International, vol. 80, 2014, pp. 106-12.

Pall, Martin L. [“Microwave frequency electromagnetic fields \(EMFs\) produce widespread neuropsychiatric effects including depression.”](#) Journal of Chemical Neuroanatomy vol. 75, pt. B, 2016, pp. 43-51.

Aldad TS, et al. [“Fetal Radiofrequency Radiation Exposure From 800-1900 Mhz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice.”](#) Scientific Reports, vol. 2, no. 312, 2012.

Schmid MR, et al. [“Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields.”](#) Journal of Sleep Research, vol. 21, no. 1, 2012, pp. 50-8.

Regel SJ, et al. "[Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance.](#)" Journal of Sleep Research, vol. 16, no. 3, 2007, pp. 253-8.

Ruediger, H.W. "[Genotoxic effects of radiofrequency electromagnetic fields.](#)" Pathophysiology, vol. 16, no. 2-3, 2009, pp. 89-102.

Mina D et al. "[Immune responses of a wall lizard to whole-body exposure to radiofrequency electromagnetic radiation.](#)" International Journal of Radiation Biology, vol. 92, no. 3, 2016, pp. 162-8.

Tang, J., et al. "[Exposure to 900 MHz electromagnetic fields activates the mkp-1/ERK pathway and causes blood-brain barrier damage and cognitive impairment in rats.](#)" Brain Research, vol. 1601, 2015, pp. 92-101.

Kostoff, Ronald N. and Clifford G.Y. Lau. "[Combined biological and health effects of electromagnetic fields and other agents in the published literature.](#)" Technological Forecasting and Social Change, vol. 80, no. 7, 2013, pp. 1331-49.

Leszczynski, D., et al. "[Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: molecular mechanism for cancer- and blood-brain barrier-related effects.](#)" Differentiation, vol. 70, no. 2-3, 2002, pp. 120-9.

This list is a sampling of the thousands of studies that have found effects at low intensities. To see more please review the [RF color charts of the Bioinitiative](#) to review peer reviewed published studies in terms of exposure levels. The RF Color Charts summarize studies that report biological effects and adverse health effects relevant for cell towers, WI-FI, 'smart' wireless utility meters, wireless laptops, baby monitors, cell phones and cordless phones.

Slide #11

["IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans."](#)
International Agency for Research on Cancer, World Health Organization, no 208, 31 May 2011.

International Agency for Research on Cancer Working Group on the Evaluation of Carcinogenic Risks to Humans. "[Non-ionizing radiation, Part 2: Radiofrequency electromagnetic fields.](#)"
International Agency for Research on Cancer (IARC), vol. 102, pt. 2, 2013.

Momoli, F., et al. "[Probabilistic multiple-bias modelling applied to the Canadian data from the INTERPHONE study of mobile phone use and risk of glioma, meningioma, acoustic neuroma, and parotid gland tumors.](#)" *American Journal of Epidemiology*, 2017.

French CERENAT study 2014: Coureau, G., et al. [“Mobile phone use and brain tumours in the CERENAT case-control study.”](#) *Occupational and Environmental Medicine*, vol. 71, no. 7, 2014, pp. 514-22.

Hardell 2017: Carlberg, Micheal and Lennart Hardell. [“Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation.”](#) *BioMed Research International*, vol. 2017, 2017.

Slide #12

Wyde, Michael. [“NTP Toxicology and Carcinogenicity Studies of Cell Phone Radiofrequency Radiation.”](#) Powerpoint Slides, 2016.

Slide #13

Shahin, S. et al. [“2.45-GHz Microwave Irradiation Adversely Affects Reproductive Function in Male Mouse, Mus Musculus by Inducing Oxidative and Nitrosative Stress.”](#) *Free Radical Research*, vol. 48, no. 5, 2014, pp. 511–25.

Slide #14

Odaci, Ersan, Orhan Bas, and Suleyman Kaplan. [“Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study.”](#) *Brain Research*, no. 1238, 2008, pp. 224-229.

Slide #15

Ferreira, Juliana Borges, and Álvaro Augusto Almeida de Salles. [“Specific Absorption Rate \(SAR\) in the head of Tablet users.”](#) *7th Latin American Workshop On Communications*, 2015.

Fernandez-Rodriguez, C.E., A.A.A. De Salles and Devra Lee Davis. [“Dosimetric Simulations of Brain Absorption of Mobile Phone Radiation–The Relationship Between psSAR and Age.”](#) *IEEE Access*, vol.3, 2015, pp.2425-30.

Ferreira, Juliana Borges, Alvaro Augusto Almeida de Salles and Claudio Enrique Fernandez-Rodriguez. [“SAR simulations of EMF exposure due to tablet operation close to the user’s body.”](#) *Microwave and Optoelectronics Conference*, 2015.

Gandhi, Om. [Yes the Children are more exposed to radio-frequency energy from mobile telephones than adults.](#) *IEEE Spectrum*, vol. 3, 2015, pp. 985-8.

Morris, Robert D., Lloyd L. Morgan, and Devra L. Davis. [“Children Absorb Higher Doses of Radio Frequency Electromagnetic Radiation From Mobile Phones Than Adults.”](#) *IEEE Access*, vol. 3, 2015, pp. 2379-87.

Slide #16 Image of Far Field Radiation exposure to Virtual Family.

[“Sound Exposure and Risk Assessment of Wireless Network Devices \(SEAWIND\).”](#) European SEAWIND aimed to provide a comprehensive assessment of the incident field exposure in typical living scenarios such as in homes, offices and classrooms by installed wireless local area networks (WLAN or WiFi) or wireless metropolitan area networks (WMAN or WiMAX), body-mounted and body-worn wireless personal area networks (WPAN) and WLAN devices, and specific wireless applications in industry, e.g., novel RFID logistic applications; (2) to numerically determine the induced fields in the human body using a set of models representing the human population; and (3) to screen potential biological sensitivities at the molecular, developmental and functional levels in cells. A comparison to other exposures such as cellular mobile devices, base stations, TV, Radio, etc was included.

The image is Figure 4: Far field exposure of the Virtual Family (Duke, Ella, Thelonious) from page 6 of Seawind’s [Project Final Report \(Partners & Figures\)](#). In order to see the full SEAWIND Report please go to the [Project page](#) and click on [Download application/zip](#) (36063830)

“Far field” means that the transmitting antenna is *at a distance*. In comparison, “near field” exposure is when the device is being used by the person near the body, such a cellphone laptop. This study has images of near field exposure as well as farfield exposure and uses highly sophisticated modeling to simulate SAR. .

Slide #17

["Wireless Radiation and Health." Israel Institute for Advanced Studies, Environmental Health Trust, 23-26 January 2017.](#)

RECENT MILLIMETER WAVE BIOEFFECT STUDIES

Feldman, Yuri and Paul Ben-Ishai. [“Potential Risks to Human Health Originating from Future Sub-MM Communication Systems.” Abstract, 2017.](#)

Feldman, Yuri, et al. [“Human skin as arrays of helical antennas in the millimeter and submillimeter wave range.” Physical Review Letters, vol. 100, no. 12, 2008.](#)

Hayut, Itai, et al. [“Circular polarization induced by the three-dimensional chiral structure of human sweat ducts.” Physical Review, vol. 89, no. 4, 2014.](#)

Hayut, Itai, et al. [“The Helical Structure of Sweat Ducts: Their Influence on the Electromagnetic Reflection Spectrum of the Skin.” IEEE Transactions on Terahertz Science and Technology, vol. 3, no. 2, 2013, pp. 207-15.](#)

Professor Yuri Feldman – [Research Study Summaries, The Hebrew University of Jerusalem Department of Applied Physics, Dielectric Spectroscopy Laboratory](#)

Slide #18

[Image from US Military Youtube video on Active Denial System and History Channel Report on Active Denial System](#)

REFERENCES ON DEFENSE USE OF MILLIMETER WAVES

[US Department of Defense Non-Lethal Weapons Program FAQs](#)

[A Narrative Summary and Independent Assessment of the Active Denial System The Human Effects Advisory Panel](#)

Slide #19

DeLisle, Jean-Jacques. [“Millimeter Waves Enhance Military Projects.”](#) *Microwaves & RF*, 11 Aug. 2014.

Slide #20

Russell, Cindy. [“A 5G Wireless Future: Will It Give Us a Smart Nation or Contribute to an Unhealthy One?”](#) Santa Clara Bulletin, 2017.

Slide #21

[“INTERNATIONAL POLICY BRIEFING: Cautionary Policy on Radiofrequency Radiation Actions by Governments, Health Authorities and Schools Worldwide.”](#) *Environmental Health Trust*, 2017.

Slide #30

Radiofrequency Radiation & Sleep

Schmid MR, et al. [“Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields.”](#) *Journal of Sleep Research*, vol. 21, no. 1, 2012, pp. 50-8.

Hillert, L., et al. [“The Effects of 884 MHz GSM Wireless Communication Signals on Self-reported Symptom and Sleep \(EEG\)- An Experimental Provocation Study.”](#) *Bioelectromagnetics*, vol. 3, no. 7, 2007, pp. 1148-50.

Regel SJ, et al. [“Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance.”](#) *Journal of Sleep Research*, vol. 16, no. 3, 2007, pp. 253-8.

Mann and J. Röschke. [“Effects of Pulsed High-Frequency Electromagnetic Fields on Human Sleep.”](#) *Neuropsychobiology*, vol. 33, 1996, pp. 41-47.

[Additional Research Studies on Cell Towers and Radio frequency Exposure](#)

Cell Tower Research Studies

Roda, Claudia and Susan Perry. "Mobile phone infrastructure regulation in Europe: Scientific challenges and human rights protection." *Environmental Science & Policy* 37 (2014): 204-14.

- This law article was published in *Environmental Science & Policy* by human rights experts. It argues that cell tower placement is a human rights issue for children.

Waldmann-Selsam, Cornelia, et al. "Radiofrequency radiation injures trees around mobile phone base stations." *Science of The Total Environment* 572 (2016): 554-69.

- "A detailed long-term (2006-2015) field monitoring study was performed in the cities of Bamberg and Hallstadt (Germany). During monitoring, observations and photographic recordings of unusual or unexplainable tree damage were taken, alongside the measurement of electromagnetic radiation.

Yakymenko, I., et al. "Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems." *Experimental Oncology* 33.2 (2011): 62-70.

- We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.

Gandhi, Gursatej, Gurpreet Kaur, and Uzma Nisar. "A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station."

Electromagnetic Biology and Medicine 34.4 (2015): 344-54.

- This cross-sectional case control study on genetic damage in individuals living near cell towers found genetic damage parameters of DNA were significantly elevated. The authors state, "The genetic damage evident in the participants of this study needs to be addressed against future disease-risk, which in addition to neurodegenerative disorders, may lead to cancer."

Abdel-Rassoul, G., et al. "Neurobehavioral effects among inhabitants around mobile phone base stations." *Neurotoxicology* 28.2 (2006): 434-40.

- "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

Dode, Adilza C., et al. "Mortality by neoplasia and cellular telephone base stations." *Science of The Total Environment* 409.19 (2011): 3649-65.

- A clearly elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell phone transmission towers.
- This 10 year study on cell phone antennas was released by the Municipal Health Department in Belo Horizonte and several universities in Brazil. Shortly after this study was published, the city prosecutor sued several cell phone companies and requested that almost half of the cities antennae be removed. Many were.

Khurana, Vini C., et al. "Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations." *Int. J Occup. Envir Health* 16.3 (2010): 263-7.

- 10 epidemiological studies that assessed for putative health effects of mobile phone base stations. Seven of these studies explored the association between base station proximity and neurobehavioral effects and three investigated cancer. We found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations.
- None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations. We believe that comprehensive epidemiological studies of long-term mobile phone base station exposure are urgently required to more definitively understand its health impact.

Levitt, Blake B. and Henry Lai. "Biological Effects from Exposure to Electromagnetic Radiation Emitted by Cell Tower Base Stations and Other Antenna Arrays." *Environmental Reviews* 18.1 (2010): 369-85.

- Over 100 citations, approximately 80% of which showed biological effects near towers. "Both anecdotal reports and some epidemiology studies have found headaches, skin rashes, sleep disturbances, depression, decreased libido, increased rates of suicide, concentration problems, dizziness, memory changes, increased risk of cancer, tremors, and other neurophysiological effects in populations near base stations. Built case for 'setbacks' and need for new exposure guidelines reflecting multiple and cumulative exposures

Gulati, S., et al. "Effect of GSTM1 and GSTT1 Polymorphisms on Genetic Damage in Humans Populations Exposed to Radiation From Mobile Towers." *Arch Environ Contam Toxicol* 70.3 (2015): 615-25.

- In our study, 116 persons exposed to radiation from mobile towers and 106 control subjects were genotyped for polymorphisms in the GSTM1 and GSTT1 genes by

multiplex polymerase chain reaction method. DNA damage in peripheral blood lymphocytes was determined using alkaline comet assay in terms of tail moment (TM) value and micronucleus assay in buccal cells (BMN). Our results indicated that TM value and BMN frequency were higher in an exposed population compared with a control group and the difference is significant. In our study, we found that different health symptoms, such as depression, memory status, insomnia, and hair loss, were significantly associated with exposure to EMR. Damaging effects of nonionizing radiation result from the generation of reactive oxygen species (ROS) and subsequent radical formation and from direct damage to cellular macromolecules including DNA.

Hutter, H.P., et al. "Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations." *Occup Environ Med.* 63.5 (2006): 307-13.

- Found a significant relationship between some cognitive symptoms and measured power density; highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels. There was no significant effect on sleep quality.

Eskander, E.F., Selim F. Estefan, and Ahmed A. Abd-Rabou. "How does long term exposure to base stations and mobile phones affect human hormone profiles?" *Clinical Biochemistry* 45.1-2 (2011): 157-61.

- Showed significant decrease in volunteers' ACTH, cortisol, thyroid hormones, prolactin for young females, and testosterone levels from RF exposures from both mobiles and cell towers.

Abdel-Rassoul, G. et al. "Neurobehavioral effects among inhabitants around mobile phone base stations." *Neurotoxicology* 28.2 (2007): 434-40.

- Residents living beneath and opposite a long established mobile phone mast reported significantly higher occurrences of headaches, memory changes, dizziness, tremors, depressive symptoms and sleep disturbance than a control group.

Oberfeld, G., H. Schimke, and G. Bernatzky. ["Cell phone base stations change brain currents and cause unwellness."](#) *Salzburg Univ. & Land Salzburg* (2005).

- All subjects reported various symptoms during exposure including buzzing in the head, heart palpitations, unwellness, lightheadedness, anxiety, breathlessness, respiratory problems, nervousness, agitation, headache, tinnitus, heat sensation, and depression.

Top Experimental and Epidemiological Studies on Wireless Radiation Cancer and Cancer Promotion:

Glioma Epidemiology

Yang, M., et al. [“Mobile phone use and glioma risk: A systematic review and meta-analysis.”](#) *PLoS One*, vol. 12, no. 5, 2017.

Meta-analysis found significant positive association between long-term mobile phone use (minimum, 10 years) and glioma. And there was a significant positive association between long-term ipsilateral mobile phone use and the risk of glioma. Long-term mobile phone use was associated with 2.22 times greater odds of low-grade glioma occurrence.

Carlberg, Michael and Lennart Hardell. [“Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation.”](#) *BioMed Research International*, vol. 2017, 2017.

When considered vis a vis deductive public health principles, the combined evidence from epidemiology and laboratory studies indicate that meningioma and glioma in the temporal lobe can be considered to be caused by cumulative RF radiation exposure. Experimental findings that RF increases production of reactive oxygen species suggest a potential mechanism.

Prasad, M., et al. [“Mobile phone use and risk of brain tumours: a systematic review of association between study quality, source of funding, and research outcomes.”](#) *Neurological Sciences*, 2017.

Studies with higher quality are more likely to find higher risk of brain tumour, while lower quality studies tend to indicate lower risk/protection

Grell, Kathrine, et al. [“The Intracranial Distribution of Gliomas in Relation to Exposure From Mobile Phones: Analyses From the INTERPHONE Study.”](#) *American Journal of Epidemiology*, vol. 184, no. 11 2016, pp. 818-28.

Similar to earlier results, we found a statistically significant association between the intracranial distribution of gliomas and the self-reported location of the phone. When we accounted for the preferred side of the head not being exclusively used for all mobile phone calls, the results were similar.

Hardell, Lennart and Michael Carlberg. [“Mobile phone and cordless phone use and the risk for glioma—Analysis of pooled case-control studies in Sweden, 1997–2003 and 2007–2009.”](#) *Pathophysiology*, vol. 22, no. 1, 2015, pp. 1-13.

Mobile phone and cordless phone use increased the risk of glioma, with highest risk in the >15–20 years latency group. Highest ORs overall were found for ipsilateral mobile or cordless phone use, while the highest risk was found for glioma in the temporal lobe. First use of mobile or cordless phone before the age of 20 gave higher OR for glioma than in later age groups.

Carlberg, Michael and Lennart Hardell. [“Decreased survival of glioma patients with astrocytoma grade IV \(glioblastoma multiforme\) associated with long-term use of mobile and cordless phones.”](#) *International Journal of Environmental Research and Public Health*, vol. 11, no. 10, 2014, pp. 10790-805.

Elevated HR (decreased survival) for the most malignant glioma type, astrocytoma grade IV, was found for long-term use of mobile and cordless phones. Highest HR was found for cases with first use before the age of 20 years.

Coureau, Gaëlle, et al. ["Mobile phone use and brain tumours in the CERENAT case-control study."](#) *Occupational and Environmental Medicine*, vol. 71, no. 7, 2014, pp. 514-22.

No association with brain tumours was observed when comparing regular mobile phone users with non-users, however, the positive association was statistically significant in the heaviest users when considering life-long cumulative duration and number of calls for gliomas. Risks were higher for gliomas, temporal tumours, occupational and urban mobile phone use.

Absorbed Exposures to Anatomical Regions of the Brain and Increased Brain Cancer Incidence Rates

Zada, Gabriel, et al. ["Incidence trends in the anatomic location of primary malignant brain tumors in the United States: 1992–2006."](#) *World Neurosurgery*, vol. 77, no. 3, 2012, pp. 518-24.

Data from 3 major cancer registries demonstrate increased incidences of glioblastoma multiforme in the frontal lobe, temporal lobe, and cerebellum, despite decreased incidences in other brain regions. Although this may represent an effect of diagnostic bias, the incidence of both large and small tumors increased in these regions.

Cardis, Elisabeth, et al. ["Risk of brain tumours in relation to estimated RF dose from mobile phones: results from five Interphone countries."](#) *Occupational and Environmental Medicine*, vol. 68, no. 9, 2011, pp. 631-40.

Authors found suggestions of an increased risk of glioma in long-term mobile phone users with high RF exposure and of similar, but apparently much smaller, increases in meningioma risk.

Schwann Cell Cancers

Moon et al. ["Association between vestibular schwannomas and mobile phone use."](#) *Tumour Biology*, vol. 35, no. 1, 2014, pp. 581-7 .

Acoustic neuromas (vestibular schwannomas) occur more frequently on used ear of mobile phones and tumor volume showed a strong correlation with amount of mobile phone use.

Benson, V.S., et al. ["Mobile phone use and risk of brain neoplasms and other cancers: prospective study."](#) *International Journal of Epidemiology*, vol. 42, no. 3, 2013, pp. 792-802.

Acoustic neuromas were 2 1/2 times more likely in long term users compared to never users (10+ years: RR = 2.46, 95% CI = 1.07-5.64, P = 0.03), with the risk increasing with duration of use (trend among users, P = 0.03).

Hardell, et al. [“Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997-2003 and 2007-2009 and use of mobile and cordless phones.”](#) *International Journal of Oncology*, vol. 43, no. 4, 2013, pp. 1036-44.

This study confirmed previous results demonstrating an association between mobile and cordless phone use and acoustic neuroma.

Hardell, L., M. Carlberg and Mild K. Hansson. [“Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma.”](#) *Pathophysiology*, vol. 20, no. 2, 2012, pp. 85-110.

Regarding acoustic neuroma, ipsilateral mobile phone use in the latency group ≥ 10 years gave OR=1.81, 95% CI=0.73-4.45. For ipsilateral cumulative use ≥ 1640 h OR=2.55, 95% CI=1.50-4.40 was obtained. Also use of cordless phones increased the risk for glioma and acoustic neuroma in the Hardell group studies.

Interphone Study Group. [“Acoustic neuroma risk in relation to mobile telephone use: results of the INTERPHONE international case-control study.”](#) *Cancer Epidemiology*, vol. 35, no. 5, 2011, pp. 453-64.

In general, ORs were not greater in subjects who reported usual phone use on the same side of the head as their tumour than in those who reported it on the opposite side, but it was greater in those in the 10th decile of cumulative hours of use.

Hardell et al. [“Mobile phones, cordless phones and the risk for brain tumours.”](#) *International Journal of Oncology*, vol. 35, no. 1, 2009, pp. 5-17.

For acoustic neuroma, the highest OR was found for ipsilateral use and >10 year latency, for mobile phone OR=3.0, 95% CI=1.4-6.2 and cordless phone OR=2.3, 95% CI=0.6-8.8.

Schoemaker et al. [“Mobile phone use and risk of acoustic neuroma: results of the Interphone case-control study in five North European countries.”](#) *British Journal of Cancer*, vol. 93, no. 7, 2005, pp. 842-8.

Risk of a tumour on the same side of the head as reported phone use was raised for use for 10 years or longer (OR = 1.8, 95% CI: 1.1-3.1). The study suggests that there is no substantial risk of acoustic neuroma in the first decade after starting mobile phone use. However, an increase in risk after longer term use or after a longer lag period could not be ruled out.

Lonn et al. [“Mobile phone use and the risk of acoustic neuroma.”](#) *Epidemiology*, vol.15, no. 6, 2004, pp. 653-9

The overall odds ratio for acoustic neuroma associated with regular mobile phone use was 1.0 (95% confidence interval = 0.6-1.5). Ten years after the start of mobile phone use the estimates relative risk increased to 1.9 (0.9-4.1); when restricting to tumors on the same side of the head as the phone was normally used, the relative risk was 3.9 (1.6-9.5).

Thyroid Cancer

Lim et al. [“Trends in Thyroid Cancer Incidence and Mortality in the United States, 1974-2013.”](#) *JAMA*, vol. 317, no. 13, 2017, pp. 1338-48.

Among patients in the United States diagnosed with thyroid cancer from 1974-2013, the overall incidence of thyroid cancer increased 3% annually, with increases in the incidence rate and thyroid cancer mortality rate for advanced-stage papillary thyroid cancer. These findings are consistent with a true increase in the occurrence of thyroid cancer in the United States.

Carlberg, Michael, et al. [“Increasing incidence of thyroid cancer in the Nordic countries with main focus on Swedish data.”](#) BMC Cancer, vol. 16, no. 426, 2016.

The main finding of this register based study was an increasing incidence of thyroid cancer in Sweden during the whole study period 1970–2013 in both women and men, although not statistically significant in men. In both genders the incidence increased during the more recent study period, from 2001 in women and from 2005 in men.

Parotid Gland Cancers

Sadetzki, Siegal, et al. ["Cellular Phone Use and Risk of Benign and Malignant Parotid Gland Tumors--A Nationwide Case-Control Study."](#) *American Journal of Epidemiology*, vol. 167, no. 4, 2007, pp. 457-67.

Our results suggest a relation between long-term and heavy cellular phone use and parotid gland tumors. This association was seen in analyses restricted to regular users, analyses of laterality of phone use, and analyses of area of main use.

Cancer and Cancer Promotion - Epidemiology

Momoli, F., et al. [“Probabilistic multiple-bias modelling applied to the Canadian data from the INTERPHONE study of mobile phone use and risk of glioma, meningioma, acoustic neuroma, and parotid gland tumors.”](#) *American Journal of Epidemiology*, 2017.

Since the [13-nation Interphone study](#) was published in 2010, several methods papers have been published that reanalyze the data to correct for biases in the original paper. The authors of this study found that the risk estimate for glioma among the highest quartile of cell phone users increased after adjustment. Risk estimates for other types of head tumors did not change.

Siqueira, Elisa Carvalho, et al. [“Cell phone use is associated with an inflammatory cytokine profile of parotid gland saliva.”](#) *Journal of Oral Pathology & Medicine*, vol. 45, no. 9, 2016, pp. 682-6.

Cell phone exposure was associated with an increased level of IL-1 β (a pro-inflammatory cytokine) and decreased IL-10 level (anti-inflammatory cytokine) in the exposed parotid gland saliva .

Sadetzki, Siegal, et al. ["The MOBI-Kids Study Protocol: Challenges in Assessing Childhood and Adolescent Exposure to Electromagnetic Fields from Wireless Telecommunication Technologies and Possible Association with Brain Tumor Risk."](#) *Frontiers in Public Health*, vol. 2, no. 124, 2014, pp. 1-10.

MOBI-Kids, a multinational case–control study, investigates the potential effects of childhood and adolescent exposure to EMF from mobile communications technologies on brain tumor risk

in 14 countries. This manuscript discusses the design of MOBI-Kids and describes the challenges and approaches chosen to address them.

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. ["IARC monographs on the evaluation of carcinogenic risks to humans. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields."](#) *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans/World Health Organization, International Agency for Research on Cancer* vol. 102, 2013.

Breast Cancer Case Series Report

West JG, Kapoor NS, Liao S, Chen JW, Bailey L, Nagourney RA. (2013). [Multifocal Breast Cancer in Young Women with Prolonged Contact between Their Breasts and Their Cellular Phones.](#) *Case Reports in Medicine*. Volume 2013, Article ID 354682.

Researchers report a four case series of women-ages from 21 to 39-with multifocal invasive breast cancer, all which regularly carried their cell phones against their breast for up to 10 hours/day for several years, had no family history of breast cancer, tested negative for BRCA1 and BRCA2, and have highly similar case pathology and morphology.

Damage to Male Reproduction

Houston, B.J., et al. ["The effects of radiofrequency electromagnetic radiation on sperm function."](#) *Reproduction*, vol. 152, no. 2, 2016, pp. R263-76.

Documented impacts of RF-EMR on the male reproductive system include decreased sperm motility, elevated levels of reactive oxygen species, increased DNA damage, and decreased antioxidant levels.

Adams, Jessica A., et al. ["Effect of mobile telephones on sperm quality: A systematic review and meta-analysis."](#) *Environmental International*, vol. 70, 2014, pp. 106-12.

Following a systematic review and meta-analysis to determine whether exposure to RF-EMR emitted from mobile phones affects human sperm quality, researchers found that exposure to mobile phone was associated with reduced sperm motility and overall quality.

De Iuliis, Geoffrey N., et al. ["Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro."](#) *PloS one*, vol. 4, no. 7, 2009.

RF-EMR in both the power density and frequency range of mobile phones (1.8 GHz covering a SAR range from 0.4 to 27.5 W/kg) were shown to enhance mitochondrial reactive oxygen species generation, decrease the motility and vitality, stimulating DNA base adduct formation and ultimately cause DNA fragmentation within the human spermatozoa

Atasoy, Halil I., et al. ["Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices."](#) *Journal of Pediatric Urology*, vol. 9, no. 2, 2013, pp. 223-9.

Researchers 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 ($p < 0.05$) and effects on enzyme activity.

Avendano, Conrado, et al. ["Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation."](#) *Fertility and Sterility*, vol. 97, no. 1, 2012, pp. 39-45.

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.

Sepehrimanesh, Masood and Devra Lee Davis. ["Proteomic impacts of electromagnetic fields on the male reproductive system."](#) *Comparative Clinical Pathology*, vol. 26, no. 2, 2017, pp. 309-13.

This paper reviews proteomic experimental and clinical evidence that EMF acts as a male-mediated teratogen and contributor to infertility.

Neurodevelopment and Neurological

Volkow, Nora D., et al. ["Effects of cell phone radiofrequency signal exposure on brain glucose metabolism."](#) *JAMA*, vol. 305, no. 8, 2011, pp. 808-13.

Researchers concluded that compared to individuals with no exposure, 50-minute cell phone exposure was associated with increased brain glucose metabolism in the region closest to the antenna.

Bas, O., et al. ["Chronic prenatal exposure to the 900 megahertz electromagnetic field induces pyramidal cell loss in the hippocampus of newborn rats."](#) *Toxicology and Industrial Health*, vol. 25, no. 6, 2009, pp. 377-84.

It was found that 900 megahertz of electromagnetic field significantly reduced the total pyramidal cell number in the cornu ammonis of the electromagnetic field group ($P < 0.001$).

Deshmukh, Pravin Suryakantrao, et al. ["Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation."](#) *International Journal of Toxicology*, vol. 34, no. 3, 2015, pp. 284-90.

Rats exposed to low-intensity microwave radiation showed declined cognitive function, elevated HSP70 level, and DNA damage within the brain, compared to control animals.

Herbert, Martha R., and Cindy Sage. ["Autism and EMF? Plausibility of a pathophysiological link—Part I."](#) *Pathophysiology*, vol. 20, no. 3, 2013, pp. 191-209.

Authors review pathophysiological damage to core cellular processes that are associated both with autism spectrum conditions and with biological effects of EMF/RFR exposures that contribute to chronically disrupted homeostasis

Herbert, Martha R., and Cindy Sage. "[Autism and EMF? Plausibility of a pathophysiological link part II.](#)" *Pathophysiology*, vol. 20, no. 3, 2013, pp. 211-34.

Authors document how behaviors in autism spectrum conditions may emerge from alterations of electrophysiological oscillatory synchronization, how EMF/RFR could contribute to these by de-tuning the organism, and policy implications of these vulnerabilities.

Odaci, E., O. Bas, and S. Kaplan. "[Effects of prenatal exposure to a 900MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study.](#)" *Brain Research*, no. 1238, 2008, pp. 224-9.

The results showed that prenatal EMF exposure caused a decrease in the number of granule cells in the dentate gyrus of the rats ($P<0.01$), suggesting that prenatal exposure to a 900 MHz EMF affects the development of the dentate gyrus granule cells in the rat hippocampus.

Sonmez, O.F., et al. "[Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field.](#)" *Brain Research*, no. 1356, 2010, pp. 95-101.

Results showed that the total number of Purkinje cells in the cerebellum of the EMFG was significantly lower than those of CG ($p<0.004$) and SG ($p<0.002$), suggesting that long duration exposure to 900 MHz EMF leads to decreases of Purkinje cell numbers in the female rat cerebellum.

Tang, Jun, et al. "[Exposure to 900MHz electromagnetic fields activates the mkp-1/ERK pathway and causes blood-brain barrier damage and cognitive impairment in rats.](#)" *Brain Research*, no. 1601, 2015, pp. 92-101.

Results demonstrate that exposure to 900 MHz EMF radiation for 28 days can significantly impair spatial memory and damage BBB permeability in rat by activating the mkp-1/ERK pathway.

EXPERIMENTAL FINDINGS

The NTP Study Shows Cancer and Cancer Promotion

Wyde, Michael, et al. "[Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats \(Whole Body Exposure\).](#)" *bioRxiv*, no. 055699, 2016. ([National Toxicology Program Video Presentation](#) that includes genotoxicity results June 2016)

Exposures to cell phone equivalent RFR began for rats in-utero and during adolescence for mice, continuing through young adulthood (subchronic) or for 2 years (chronic). Researchers observed increased incidence of gliomas as well as schwannomas in both sexes, as well as significantly more rare, pre-cancerous changes in the glial cells of the brain in both sexes, while not a single

one of the unexposed control animals developed these same abnormal brain cells. Male rats exposed to all levels of CDMA developed exceptional numbers of damaged, pre-cancerous brain cells (glial hyperplasia). Body weights at birth and throughout lactation in rat pups exposed in utero tended to be lower than controls. Comet assay summaries revealed statistically significant evidence of DNA damage from nonthermal exposure in mice and rats within the frontal cortex (male & female rats, male male), hippocampus (male rats), liver (male rats, female mice), and blood (male rats, female mice). The increased types of tumors found in NTP's research rats parallel the types of increased tumors found in human long term users of cell phones.

Lerchl, Alexander, et al. ["Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans."](#) *Biochemical and Biophysical Research Communications*, vol. 459, no. 4, 2015, pp. 585-90.

Numbers of tumors of the lungs and livers in exposed animals were significantly higher than in sham-exposed controls. In addition, lymphomas were also found to be significantly elevated by exposure.

Experimental Study of Pregnancy with Prenatal Exposure Affects Brain and Behavior

Aldad, Tamir S., et al. ["Fetal radiofrequency radiation exposure from 800-1900 Mhz-rated cellular telephones affects neurodevelopment and behavior in mice."](#) *Scientific Reports*, vol. 2, no. 312, 2012.

In a study examining the association between prenatal cell phone use and hyperactivity in children, researchers found that mice exposed *in-utero* were hyperactive and had impaired memory, and in addition, recordings of excitatory postsynaptic currents revealed that these behavioral changes were due to altered neuronal developmental programming.

Kim, Ju Hwan, et al. ["Long-term exposure to 835 MHz RF-EMF induces hyperactivity, autophagy and demyelination in the cortical neurons of mice."](#) *Scientific Reports*, vol. 7, 2017.

The neuronal effects of 835 MHz RF-EMF on the cerebral cortex of the mouse brain at 4.0 W/kg for 5 hours/day for 12 weeks included induction of autophagy genes, production of proteins, accumulation of autolysosome, demyelination in cortical neurons and hyperactivity-like behavior.

Environmental Exposures Can Enhance Damage from EMFs

Kostoff, Ronald N., and Clifford GY Lau. ["Combined biological and health effects of electromagnetic fields and other agents in the published literature."](#) *Technological Forecasting and Social Change* vol. 80, no. 7, 2013, no. 1331-49.

The present study examined the scope of the combined effects; i.e., identified effects on biological systems from combined exposure to electromagnetic fields/radiation and at least one other agent, concluding that EMF health impacts increase substantially when EMFs function as co-promoters and thus inclusion of co-promoters is essential for modeling real-world effects.

Byun, Yoon-Hwan, et al. ["Mobile phone use, blood lead levels, and attention deficit hyperactivity symptoms in children: a longitudinal study."](#) *PLoS One*, vol. 8, no. 3, 2013.

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.

EMF Can Interfere with Cognition

Papageorgiou, Charalabos C., et al. ["Effects of wi-fi signals on the p300 component of event-related potentials during an auditory hayling task."](#) *Journal of Integrative Neuroscience*, vol. 10, no. 2, 2011, pp. 189-202.

The present study focused on the possible gender-related effects of Wi-Fi electromagnetic fields (EMF) on the attention and working memory operations of the brain, concluding that Wi-Fi exposure may exert gender-related alterations on neural activity associated with the amount of attentional resources engaged during a linguistic test.

Ntzouni, Maria P, et al. ["Transient and cumulative memory impairments induced by GSM 1.8 GHz cell phone signal in a mouse model."](#) *Electromagnetic Biology and Medicine*, vol. 32, no. 1, 2013, pp. 95-120.

The data suggest that visual information processing mechanisms in hippocampus, perirhinal and entorhinal cortex are gradually malfunctioning upon long-term daily exposure, a phenotype that persists for at least 2 weeks after interruption of radiation, returning to normal memory performance levels 4 weeks later.

Theoretical and Experimental Evidence that RF Induces Specific Mechanisms

Barnes, Frank, and Ben Greenebaum. ["Some Effects of Weak Magnetic Fields on Biological Systems: RF fields can change radical concentrations and cancer cell growth rates."](#) *IEEE Power Electronics Magazine*, vol. 3, no. 1, 2016, pp. 60-8.

Authors describe historical and recent concerns raised about the possible biological effects of nonionizing radiation of many different types on humans or other organisms, detailing these effects and possible mechanisms behind their induction of cellular damage.

Belyaev, Igor Y., et al. ["Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/γ-H2AX DNA repair foci in human lymphocytes."](#) *Bioelectromagnetics*, vol. 30, no. 2, 2009, pp. 129-41.

Researchers described frequency-dependent effects of mobile phone microwaves on human lymphocytes from persons reporting hypersensitivity to electromagnetic fields and healthy persons, concluding that microwaves from universal global telecommunications system (UMTS) mobile phones affect chromatin and inhibit formation of DNA double-strand breaks in human lymphocytes from both hypersensitive and healthy persons.

Yakymenko, Igor, et al. ["Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation."](#) *Electromagnetic Biology and Medicine*, vol. 35, no. 2, 2016, pp. 186-202.

In conclusion, our analysis demonstrates that low-intensity RFR is an expressive oxidative agent for living cells with a high pathogenic potential and that the oxidative stress induced by RFR exposure should be recognized as one of the primary mechanisms of the biological activity of this kind of radiation.

Pall, M. [Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects](#). *Journal of Cellular and Molecular Medicine*, vol. 17, no. 8, 2013 pp. 958-965

This article reviews a substantially supported set of targets, voltage-gated calcium channels, whose stimulation produces non-thermal EMF responses by humans/higher animals with downstream effects involving Ca^{2+} /calmodulin-dependent nitric oxide increases, which may explain therapeutic and pathophysiological effects of electromagnetic fields.

Hinrikus, Hiie, et al. ["Mechanism of low-level microwave radiation effect on nervous system."](#) *Electromagnetic Biology and Medicine*, 2016.

Results support the proposed model of excitation by low-level microwave radiation based on the influence of water polarization on hydrogen bonding forces between water molecules, caused by this the enhancement of diffusion and consequences on neurotransmitters transit time and neuron resting potential.

Leszczynski, Dariusz, et al. ["Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: Molecular mechanism for cancer-and blood-brain barrier-related effects."](#) *Differentiation*, vol. 70, no. 2-3, 2002, pp. 120-9.

Results obtained demonstrate that 1-hour non-thermal exposure of EA.hy926 cells changes the phosphorylation status of numerous, yet largely unidentified, proteins.

Marková, Eva, Lars OG Malmgren, and Igor Y. Belyaev. ["Microwaves from mobile phones inhibit 53BP1 focus formation in human stem cells more strongly than in differentiated cells: possible mechanistic link to cancer risk."](#) *Environ Health Perspect*, vol. 118, no. 3, 2010, pp. 394-9.

Microwaves from mobile phones inhibited formation of 53BP1 foci in human primary fibroblasts and mesenchymal stem cells. These data parallel our previous findings for human lymphocytes.

Pall, Martin L. ["Microwave frequency electromagnetic fields \(EMFs\) produce widespread neuropsychiatric effects including depression."](#) *Journal of Chemical Neuroanatomy*, vol. 75, pt. B, 2016, pp. 43-51.

Results show microwave EMFs activate voltage-gated Ca^{2+} channels (VGCCs) concentrated in the brain, and VGCC activity causes widespread neuropsychiatric effects in humans (genetic studies).

ELF-EMF Studies of Note

Soffritti, Morando, et al. ["Synergism between sinusoidal-50 Hz magnetic field and formaldehyde in triggering carcinogenic effects in male Sprague–Dawley rats."](#) *American Journal of Industrial Medicine*, vol. 59, no. 7, 2016, pp. 509-21.

Soffritti, Morando, et al. [“Life-span exposure to sinusoidal-50 Hz magnetic field and acute low-dose \$\gamma\$ radiation induce carcinogenic effects in Sprague-Dawley rats.”](#) *International Journal of Radiation Biology*, vol. 92, no. 4, 2016, pp. 202-14.

Compared to untreated controls, exposure to MF and formaldehyde causes in males a statistically significant increased incidence of malignant tumors ($P \leq 0.01$), thyroid C-cell carcinomas ($P \leq 0.01$), and hemolymphoreticular neoplasias ($P \leq 0.05$). No statistically significant differences were observed among female groups.

Exposure Assessment Shows Greater Absorption into Younger Smaller Brains

Fernández-Rodríguez, Claudio Enrique, Alvaro Augusto Almeida De Salles, and Devra Lee Davis. ["Dosimetric Simulations of Brain Absorption of Mobile Phone Radiation—The Relationship Between psSAR and Age."](#) *IEEE Access* vol. 3, 2015, pp. 2425-30.

If the peak spatial SAR (psSAR) is modeled in the entire head, as current testing standards recommend, the results for adults and children are equivalent, however the present study uses anatomically based evaluations which rely on Finite-difference time-domain simulations of different tissues within the brain, which confirm that the psSAR in a child's brain is higher than in an adult's brain and thus higher doses are likely to have more severe implications in the young brain.

Gandhi, Om P., et al. ["Exposure limits: the underestimation of absorbed cell phone radiation, especially in children."](#) *Electromagnetic Biology and Medicine*, vol. 31, no. 1, 2012, pp. 34-51. *Includes detailed history of FDA/FCC test standard evolution*

Researchers indicate that the existing cell phone certification process is outdated and greatly underestimates the SAR for typical phone users, especially children, and thus call for a new certification process that incorporates different modes of use, head size, tissue properties, and anatomically based models.

Bakker, J. F., et al. ["Assessment of Induced SAR in children Exposed to Electromagnetic Plane Waves Between 10 MHz and 5.6 GHz."](#) *Physics in Medicine and Biology*, vol. 55, no. 11, 2010, pp. 3115-30.

Researchers found that the basic restriction on the SAR(wb) is occasionally exceeded for children, up to a maximum of 45% in small children. The maximum SAR(10g) values, usually found at body protrusions, remain under the limit for all scenarios studied.

Ferreira, Juliana Borges, and Álvaro Augusto Almeida de Salles. ["Specific Absorption Rate \(SAR\) in the head of Tablet users."](#) *7th Latin American Workshop On Communications*, 2015

The psSAR simulations in heterogeneous models (adult and child) show higher levels in the children model. The possible reasons for the higher SAR estimated in the child head model compared with adult model can be due to different reasons (e.g. thinner skull, higher dielectric parameters, smaller dimensions, etc.).

Findlay, R. P., and P. J. Dimbylow. "SAR in a child voxel phantom from exposure to wireless computer networks (Wi-Fi)." *Physics in Medicine and Biology*, vol. 55, no. 15, 2010, pp. N405-11.

For a typical Wi-Fi exposure scenario using an inverted F antenna operating at 100 mW, a duty factor of 0.1 and an antenna-body separation of 34 cm, the maximum peak localized SAR was found to be 3.99 mW kg⁻¹ in the torso region. At 2.4 GHz, using a power of 100 mW and a duty factor of 1, the highest localized SAR value in the head was calculated as 5.7 mW kg⁻¹.

Gultekin, David H., and Lothar Moeller. "NMR imaging of cell phone radiation absorption in brain tissue." *Proceedings of the National Academy of Sciences*, vol. 110, no. 1, 2013, pp. 58-63.

A method is described for measuring absorbed electromagnetic energy radiated from cell phone antennae into ex vivo brain tissue.

Morris, Robert D., Lloyd L. Morgan, and Devra L. Davis. "Children Absorb Higher Doses of Radio Frequency Electromagnetic Radiation From Mobile Phones Than Adults." *IEEE Access*, vol. 3, 2015, pp. 2379-87.

Authors discuss the differences between exposure and tissue absorption and re-examine the results presented by Foster and Chou. Based upon the review, authors suggest an alternative interpretation of the published literature.

Verloock, Leen, et al. "Assessment of Radio Frequency Exposures in Schools, Homes, and Public Places in Belgium." *Health Physics*, vol. 107, no. 6, 2014, pp. 503-13.

Exposure to RF electromagnetic fields (EMF) was assessed in three "sensitive" microenvironments namely, schools, homes, and public places located in urban environments and compared to exposure in offices.