

September 6, 2022

To: Spectrum Auctions, Innovation, Science and Economic Development  
[spectrumauctions-encheresduspectre@ised-isde.gc.ca](mailto:spectrumauctions-encheresduspectre@ised-isde.gc.ca)

Re: **Canada Gazette, Part I, Volume 156, Number 25, June 18, 2022, Notice No. SPB-001-22:**  
**Consultation on a Policy and Licensing Framework for Spectrum in the 26, 28 and 38 GHz Bands**

**Joint Statement to Industry, Science and Economic Development Canada (ISED)**  
**On behalf of Canadian experts and citizens' Groups urgently calling for a moratorium**  
**on the release of the extremely high frequency millimetre wave spectrum (mmWaves)**  
*including the 26/28 and 38 GHz bands*

On behalf of signatories, we are pleased to submit the following statement and supporting information to the *Consultation on a Policy and Licensing Framework for Spectrum in the 26, 28 and 38 GHz Bands*.

The signatories to this statement include highly respected Canadian science-based organizations representing thousands of individuals, as well as experienced and internationally respected topic experts in sciences (physics, biology), human health (medicine, epidemiology, and environmental health), and electrical engineering and technology.

Most of this information is hosted online. Please redact the detailed table of containing personal information for signatories, for public posting. A summary table is provided for public viewing.

Respectfully Submitted,

Meg Sears PhD  
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<https://preventcancernow.ca/des-experts-et-des-groupes-sopposent-a-la-liberation-du-spectre-des-ondes-mm-et-demandent-un-moratoire-de-la-5g/>

#### **Six raisons pour un moratoire sur la libération du spectre des ondes millimétriques (ondes mm)**

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**JOINT STATEMENT TO**  
**Industry, Science and Economic Development Canada (ISED)**

September 6, 2022

*Canada Gazette*, Part I, Volume 156, Number 25, June 18, 2022, Notice No. SPB-001-22:  
**Consultation on a Policy and Licensing Framework for Spectrum in the 26, 28 and 38 GHz Bands**

**Most Canadians are presently exposed to “wireless” radiation (radiofrequency electromagnetic radiation, RF-EMR) levels a quintillion times higher than the natural background.**<sup>1</sup> Experts warn that this poses a serious risk to our health and to the environment. In operation, millimetre waves would be emitted by antennas installed on cell towers and hundreds of thousands of complex “small cells” across Canada (e.g. on/in buildings, utility poles and other structures); many in very close proximity to people and wildlife. In addition, millions of 5G wireless devices such as cell phones would further contribute to exposures.

**WE, CANADIAN EXPERTS AND CITIZENS' GROUPS,**  
**urgently call for a MORATORIUM on the release of**  
**the extremely high frequency millimetre wave spectrum (mmWaves),**  
including the 26/28 GHz bands

**UNTIL**

**Industry, Science and Economic Development Canada (ISED), Health Canada,**  
**and Environment and Climate Change Canada (ECCC) complete the following:**

1. **Comprehensive studies, with hazard and risk analyses of known and potential adverse health effects (human and environmental)**, including non-thermal biological effects, of exposures to radiofrequency electromagnetic radiation (RF-EMR), including millimetre waves.<sup>2</sup>
2. **Health Canada develops demonstrably safe exposure limits for RF-EMR, to incorporate the non-thermal effects**, basing limits on a health-protective precautionary interpretation of the findings (i.e., a reasonable certainty of “no harm”, especially for pregnant women, children, the elderly, people who are ill, and people who are electrosensitive).
3. **ECCC establishes legally binding exposure limits to protect the environment, including wildlife – all flora and fauna – against harm from RF-EMR.**
4. **ISED establishes procedures that are fully transparent and effective to:**
  - **monitor and report RF-EMR emissions**, as measured from existing equipment and modelled for proposals;
  - **map environmental exposure levels** (existing and proposed) for all areas across Canada;
  - **ensure industry compliance** with more stringent regulatory requirements for infrastructure and devices;
  - **ensure that no frequency bands are released that could place lives at risk by interfering with critical Earth observation data** (e.g., that would reduce weather forecasting accuracy).
5. **ISED establishes a meaningful, comprehensive and transparent process for municipalities and citizens to have a decisive say over whether and where cellular network antennas are installed**, on both towers and non-tower structures (e.g., lamp posts, hydro poles and buildings).<sup>3</sup>

CONTACT INFORMATION: [info@preventcancernow.ca](mailto:info@preventcancernow.ca)

<sup>1</sup> Planetary Electromagnetic Pollution: It Is Time to Assess Its Impact. *The Lancet*. (2018): 512–14.  
[https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196\(18\)30221-3/fulltext](https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196(18)30221-3/fulltext).

<sup>2</sup> This study, by a truly independent panel with appropriate expertise, requires rigorous scientific methods, transparency, full public consultation from initial scoping throughout the process, and health-protective precautionary interpretation of findings.

<sup>3</sup> Informed public participatory consultation and local decision-making, giving full consideration of environmental, health and security issues, and of hazards, risks and costs of wireless expansion compared to alternatives (e.g., use of fibre/cable), must replace the broad powers currently vested in the Minister of ISED.

## SIGNATORIES AS OF SEPTEMBER 6, 2022



Prevent Cancer Now  
[preventcancernow.ca](http://preventcancernow.ca)



Canadians for Safe Technology /  
Canadiens pour une technologie sécuritaire  
[c4st.org](http://c4st.org)



Friends of the Earth  
Les Ami(e)s de la Terre

Friends of The Earth Canada  
Les Ami(e)s de la Terre  
[foecanada.org](http://foecanada.org)



Canadian Educators  
for Safe Technology

Canadian Educators for Safe  
Technology



Electromagnetic Pollution Illnesses  
Canada Foundation  
[iexistworld.org](http://iexistworld.org)



Electrosensitive Society  
[electrosensitivesociety.com](http://electrosensitivesociety.com)



Rassemblement ElectroSensibilité  
Québec  
[electrosensibilitequebec.com](http://electrosensibilitequebec.com)



Association québécoise de lutte contre  
la pollution atmosphérique (AQLPA)  
[aqlpa.com](http://aqlpa.com)

**EHA-MB**  
Environmental Health  
Association of  
Manitoba

Environmental Health Association  
of Manitoba  
[ehamanitoba.weebly.com](http://ehamanitoba.weebly.com)

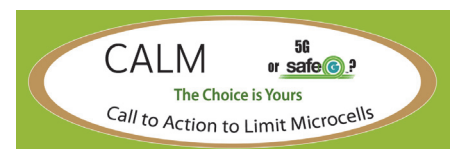


Stoppons la 5G Vivons sans danG  
[stopponsla5g.ca](http://stopponsla5g.ca)



Well Earth  
Collaborative

Well Earth Collaborative  
[wellearthcollaborative.com](http://wellearthcollaborative.com)



CALM (Call to Action to Limit  
Microcells)  
[thecalm.ca](http://thecalm.ca)



Albertans for Safe Technology

**Citizens**  
FOR  
**Safer Tech**

Citizens for Safer Tech  
[stopsmartmetersbc.com](http://stopsmartmetersbc.com)



Manitobans for Safe Technology  
[m4st.ca](http://m4st.ca)

## SIGNATORIES (CONTINUED)

### Citizens Against the Proliferation of Cell Antennas in the Eastern Townships

Citoyens contre la prolifération  
des antennes cellulaires dans  
les Cantons-de-l'Est (Québec)  
[thecelltowers.org](http://thecelltowers.org)



Safe Living Technologies  
[safelivingtechnologies.com](http://safelivingtechnologies.com)

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# SIX REASONS FOR A MORATORIUM

## ON THE RELEASE OF THE MILLIMETRE WAVE SPECTRUM (mmWAVES):

### **Reason #1: There has been no research on the long-term health effects of mmWaves.**

There has been no research on the health effects of long-term exposure to ensure that mmWaves and the new 5G technologies are safe. To quote a U.S. Senator: “So there really is no research ongoing. We’re kind of flying blind here, as far as health and safety is concerned.”<sup>4</sup>

Health Canada itself has admitted that it could not find any human studies that assessed potential health impacts (e.g., cancer, or effects on the eyes, child development, reproduction, cognition, the immune system) of exposure to RF-EMR in the 6–300 GHz frequency range that will be used for 5G technology, including the mmWave frequencies.<sup>5</sup>

### **Reason #2: There is strong scientific evidence that radiation from current (pre-5G) wireless technologies causes serious adverse effects (5G will worsen the existing problem).**

- Hundreds of high-quality peer-reviewed studies show that exposure to radiofrequency electromagnetic radiation (RF-EMR) from present-day wireless technologies causes serious adverse health effects (e.g., DNA damage, cancer, sperm damage, neurological effects, and more).<sup>6</sup>
- 5G will use those same frequencies, plus it will employ new technologies and add the higher-frequency millimetre wave (mmWave) bands.
- Children and other susceptible/vulnerable populations are more seriously impacted.
- Scientists specialized in the field have been warning governments that this type of radiation is harmful. Close to 50 appeals calling for standards that are more protective from RF-EMR have been endorsed by hundreds of researchers and physicians.

#### **Some people experience more immediate, and sometimes debilitating, health effects: Electrohypersensitivity (EHS)**

- As with other environmental exposures, some people are more immediately susceptible and overtly affected by wireless radiation. Common symptoms include, among many others: headaches, cognitive difficulties, cardiovascular difficulties and sleep problems.
- Surveys conducted estimate that 3% to 13% or more of the population experience symptoms of EHS.<sup>7</sup>
- Many are being misdiagnosed or undiagnosed because the medical community is not well-informed about the symptoms and underlying causes.

#### **Wildlife, including birds and pollinators, and plants are also detrimentally affected.**

- Research has demonstrated adverse effects of radiofrequency radiation on wildlife, such as birds, amphibians, insects, fish, mammals and plants. Studies show that RF-EMR can impact the navigation abilities of birds and bees; and cause nest and site abandonment, plumage deterioration, locomotion problems, reduced survivorship, and death in wild nesting birds.<sup>8,9</sup>

<sup>4</sup> US Senator Richard Blumenthal, US Senate Hearing on the Future of 5G Wireless Technology, Feb 6, 2019.

<https://www.youtube.com/watch?v=ekNC0J3xx1w>

<sup>5</sup> Health Canada, Analysis of recommended localized human exposure limits for radiofrequency fields in the frequency range, 6 GHz to 300 GHz. p. 32. <https://bit.ly/3plphB3>

<sup>6</sup> Hundreds of recent scientific reports show harms from “wireless” radiofrequency radiation.

<https://preventcancer.ca/hundreds-of-recent-scientific-reports-show-harms-from-radiofrequency-radiation/>

<sup>7</sup> Clegg, F. M., Sears, M., Friesen, M., Scarato, T., Metzinger, R., Russell, C., Stadtner, A., & Miller, A. B. (June 2020). Building science and radiofrequency radiation: What makes smart and healthy buildings, *Building and Environment*, 176(106324), <https://doi.org/10.1016/j.buildenv.2019.106324>

<sup>8</sup> Manville, Albert. A Briefing Memorandum: What We Know, Can Infer, and Don’t Yet Know about Impacts from Thermal and Non-thermal Non-ionizing Radiation to Birds and Other Wildlife. Submitted to the FCC in 2016. (Albert M. Manville, II, Ph.D., C.W.B.; Principal, Wildlife and Habitat Conservation Solutions, LLC; Adjunct Professor, Johns Hopkins University’s Krieger School of Arts and Sciences, DC Campus; and former U.S. Fish and Wildlife Service agency lead on avian-structural impacts — including from radiation)



### **Reason #3: Health Canada's exposure guidelines<sup>10</sup> (Safety Code 6) do not protect Canadians.**

These guidelines are:

- **based on a 6-minute exposure** for far-field exposures (i.e., more than 8 inches from the body) such as from cell tower antenna emissions;
- **based on a disproven assumption** that tissue must be heated to be harmed (only “thermal” effects are covered). Health Canada dismisses all studies that do not conform with this assumption. Also, Health Canada recently reported that according to IEEE (one of its main reference organizations), *“there is only limited experimental human data related to human tissue heating by RF energy for frequencies above 6 GHz.”*<sup>11</sup> The mmWaves ISED plans to release are in the 26, 28 and 38 GHz bands.
- **not based on the most current scientific evidence** demonstrating harm, such as DNA damage at levels far below Safety Code 6 maximum limits.

#### **Furthermore,**

- **Health Canada relies on biased organizations when setting its guidelines** – in particular the International Commission on Non-Ionizing Radiation Protection, a self-appointed group that has come under criticism for conflicts of interest.<sup>12, 13, 14, 15, 16</sup>
- **Health Canada does not consult Canadians.**  
For example: Until recently, all devices used close to the body at frequencies below 6 GHz had to respect the *SAR limit*, while those used further from the body had to respect *power density limits*, 2 to 10 W/m<sup>2</sup>. Since the new 5G devices that are to be used close to the body would use frequencies above 6 GHz including mmWaves (in addition to presently used frequencies), Health Canada chose to **double the power density limit** to 20 W/m<sup>2</sup> for these devices, without consulting Canadians and without long-term experimental data.<sup>17, 18</sup>

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<sup>9</sup> Protect Birds, Bees and Trees: Include Anthropogenic Radiofrequency Electromagnetic Radiation in *Canadian Environmental Protection Act* Amendments. White Paper. (April 2022) by Prevent Cancer Now and Canadians for Safe Technology: <https://preventcancer.ca/wp-content/uploads/2022/04/RF-EMRinCEPA-WhitePaper-inclAmendments-PCNC4ST-UPDATED2022April7.pdf>

<sup>10</sup> Safety Code 6 – *Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz*. <https://www.canada.ca/en/health-canada/services/publications/health-risks-safety/limits-human-exposure-radiofrequency-electromagnetic-energy-range-3-300.html>

<sup>11</sup> Health Canada, Analysis of recommended localized human exposure limits for radiofrequency fields in the frequency range, 6 GHz to 300 GHz. <https://bit.ly/3plphB3>

<sup>12</sup> The International Commission on Non-Ionizing Radiation Protection: Conflicts of interest, corporate capture and the push for 5G. Report commissioned, coordinated and published by Members of the European Parliament – Michèle Rivasi (Europe Écologie) and Klaus Buchner (Ökologisch-Demokratische Partei), and financed by the Greens/EfA group in the European Parliament. Brussels, June 2020. [https://www.michele-rivasi.eu/wp-content/uploads/2020/06/ICNIRP-report-FINAL-JUNE-2020\\_EN.pdf](https://www.michele-rivasi.eu/wp-content/uploads/2020/06/ICNIRP-report-FINAL-JUNE-2020_EN.pdf)

<sup>13</sup> Hardell, Lennart. “World Health Organization, radiofrequency radiation and health - a hard nut to crack (Review).” *International Journal of Oncology*, vol. 51, 2 (2017): 405-413. doi:10.3892/ijo.2017.4046 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5504984/>

<sup>14</sup> Pascual, Gabriel Doménech. “Not Entirely Reliable: Private Scientific Organizations and Risk Regulation – The Case of Electromagnetic Fields.” *European Journal of Risk Regulation* (Cambridge University Press), Volume 4, Issue 1 (2013): 29-42. <https://www.uv.es/gadopas/2013.Not.Entirely.Reliable.pdf>

<sup>15</sup> “There is something utterly wrong with the ICNIRP membership”, Between a Rock and a Hard Place, Science Blog on Mobile Phone Radiation and Health by Dariusz Leszczynski. September 8, 2020. <https://betweenrockandhardplace.wordpress.com/2020/09/08/leszczynski-there-is-something-utterly-wrong-with-the-icnirp-membership/>

<sup>16</sup> “The Lies Must Stop: Disband ICNIRP -- Facts Matter, Now More Than Ever”, *Microwave News*, April 9, 2020. <https://microwavenews.com/news-center/time-clean-house>

<sup>17</sup> January 2021. Notice: Localized human exposure limits for radiofrequency fields in the range of 6 GHz to 300 GHz <https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/types-sources/radiofrequency-fields/notice-localized-human-exposure-limits-range-6-ghz-300-ghz.html>

<sup>18</sup> Health Canada, Analysis of recommended localized human exposure limits for radiofrequency fields in the frequency range, 6 GHz to 300 GHz. <https://bit.ly/3plphB3>

#### **Reason #4: ISED is neither monitoring exposures nor enforcing industry compliance with emissions standards.**

- ISED states that it is the responsibility of the companies to ensure that they comply, including considering "combined effects of nearby installations." ISED claims it "routinely audits the tower sites."
- However, ISED relies on [Spectrum Licences Site Data](#)<sup>19</sup> that is built on data that licensees upload themselves. This data is error-ridden.<sup>20</sup>
- Data collection and analyses are not standardized, and lack transparency and accountability. For example, it is unknown how ISED monitors for or assesses "combined effects."
- Nine out of 10 cell phones on the market in Canada exceed Safety Code 6 guidelines in real use, and yet ISED is taking no action. These devices remain on the market, and in use.<sup>21</sup>
- The *Radiation Emitting Devices Act* does not mention radiofrequency radiation, nor telecommunications devices, in the law nor regulation.<sup>22</sup>

#### **Reason #5: Introducing mmWave bands to facilitate the deployment of 5G wireless networks and technologies will also:**

- **increase risks to individual and business privacy, and cybersecurity.**<sup>23, 24</sup>
  - Wireless networks are less secure and more vulnerable to hacking, than wired systems.
  - 5G networks will allow massive amounts of data to be transmitted wirelessly, providing more opportunities to intercept, collect, process, and use personal, financial, strategic or other data, for illegitimate or nefarious purposes.
- **interfere with critical satellite data, resulting in an estimated 30% reduction in weather forecast accuracy, and decreased capability to monitor the climate**, according to NASA and the US National Oceanic and Atmospheric Administration.<sup>25, 26</sup> It is reported to be degrading weather forecasts already in Europe.<sup>27</sup>

"Critically, virtually every sector of the Nation's economy is weather-sensitive and any degradation of Earth observation data for scientific and operational uses can be expected to have significant negative financial and safety impacts.

If forecasts of hurricanes, floods, and other natural disasters were degraded, lives and property would be at risk. The profitability of (...) industries, ranging from agriculture and energy to manufacturing and transportation, would also be adversely affected if forecasts become less accurate." – W.P. Mahoney, Associate Director, National Center for Atmospheric Research<sup>28</sup>

<sup>19</sup> [http://sms-sgs.ic.gc.ca/eic/site/sms-sgs-prod.nsf/eng/h\\_00010.html](http://sms-sgs.ic.gc.ca/eic/site/sms-sgs-prod.nsf/eng/h_00010.html)

<sup>20</sup> A C4ST volunteer, tracking the data since 2016, has discovered hundreds of thousands of duplicate records and other anomalies. When errors are pointed out, they are eventually corrected. However, the Spectrum Management Operations Branch Officer explained in an email that: "The Spectrum Licences Site Data is built upon the data that spectrum licensees upload. ISED regulates them, but the companies are responsible for updating the data."

<sup>21</sup> <https://tinyurl.com/2dc5vwa6>

<sup>22</sup> Radiation Emitting Devices Act (R.S.C., 1985, c. R-1): <https://laws-lois.justice.gc.ca/eng/acts/R-1/>; Radiation Emitting Devices Regulations: [https://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,\\_c.\\_1370/index.html](https://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._1370/index.html)

<sup>23</sup> Schneier, B. (2019, September 25). Essays: Every Part of the Supply Chain Can Be Attacked - Schneier on Security. *The New York Times*, Sept 25, 2019 [https://www.schneier.com/essays/archives/2019/09/every\\_part\\_of\\_the\\_supply\\_chain\\_can\\_be\\_attacked.html](https://www.schneier.com/essays/archives/2019/09/every_part_of_the_supply_chain_can_be_attacked.html)

<sup>24</sup> The Electronic Frontier Foundation (<https://www.eff.org/>) offers some in-depth analysis of privacy and security issues. EFF is an independent non-profit that has been working to protect online privacy for nearly thirty years.

<sup>25</sup> <https://www.washingtonpost.com/weather/2019/05/23/head-noaa-says-g-deployment-could-set-weather-forecasts-back-years-wireless-industry-denies-it/>

<sup>26</sup> Spectrum Needs for Observations in Earth and Space Sciences. US House of Representatives Committee on Science, Space, & Technology, Hearing, July 20, 2021. <https://science.house.gov/hearings/spectrum-needs-for-observations-in-earth-and-space-sciences>

<sup>27</sup> Radio Frequency Interference: an NWP perspective on the RFI 2022 workshop. March 14, 2022.

<https://www.ecmwf.int/en/about/media-centre/science-blog/2022/radio-frequency-interference-nwp-perspective-rfi-2022>

<sup>28</sup> Congressional testimony of William Paul Mahoney III, Associate Director, National Center for Atmospheric Research. 2021. <https://science.house.gov/imo/media/doc/Mahoney%20Testimony.pdf>

- **contribute significantly to climate change and pollution.**
  - Wireless technologies consume at least 10 times more power than wired technologies.<sup>29</sup> A 5G base station is expected to consume roughly three times more power than a 4G base station. Furthermore, 5G will require far more base stations.<sup>30</sup>
  - 5G will cause a substantial increase of e-waste since devices currently used will become obsolete. E-waste contains toxic and difficult-to-recycle components; only 20% of e-waste is recycled today,<sup>31</sup> and that is often subpar.
  - The exponential growth of wireless technologies is associated with large increases in greenhouse gases, both from the “life cycle” of devices and their use. *Greenhouse gas emissions associated with smart phones alone jumped 730% in absolute terms in just 10 years.*<sup>32</sup>
- **increase the economic burden as a consequence of** higher health care costs;<sup>33</sup> lost productivity; security and privacy breaches;<sup>34, 35</sup> agricultural harm; damage caused by the degradation of weather forecast accuracy; and environmental damage.<sup>36</sup> All of the described risks, which have never been evaluated nor considered, will translate into tangible costs to Canadian society.<sup>37</sup>

## **Reason #6: Releasing the mmWave spectrum and encouraging the deployment of 5G technologies contravenes principles of *Canada's Digital Charter*.**

ISED's Policy Objectives for the current consultation (section 3) include following the 10 principles of *Canada's Digital Charter*.<sup>38</sup>

- These principles include universal access, a level playing field for business, safety and security, and protection of privacy. **All of these principles would be better served by ensuring that all Canadians have access to fibre optic connections (FTTP) not connected to wireless.** Fibre-optic connections are safe, 100 times faster and more reliable, much less vulnerable to security and privacy breaches, more dependable/resilient in a disaster, and consume one-tenth of the energy.<sup>39</sup>
- The goal of *Canada's Digital Charter* is to establish “a **people-centred and inclusive digital economy built on trust.**” ISED's regulations prevent citizens from opposing a cell tower on the basis of health or environmental concerns. They also do not require public notification for small cell antennas nor for low earth orbit satellites. **It is not “people-centred and inclusive” nor does it “build trust” to install antennas close to people's homes and workplaces, without their knowledge or consent.**

<sup>29</sup> Baliga, J., Ayre, R., Hinton, K., & Tucker, R. (2011). Energy Consumption in Wired and Wireless Access Networks. *IEEE Communications Magazine*, June 2011, p. 76 <https://ieeexplore.ieee.org/document/5783987>

<https://people.eng.unimelb.edu.au/rtucker/publications/files/energy-wired-wireless.pdf>

<sup>30</sup> Koziol, Michael. (2019). 5G's Waveform Is a Battery Vampire. *IEEE Spectrum*, July 24, 2019. <https://spectrum.ieee.org/5gs-waveform-is-a-battery-vampire>

<sup>31</sup> International Telecommunication Union (2020). <https://www.itu.int/en/mediacentre/backgrounders/Pages/e-waste.aspx>

<sup>32</sup> Belkhir, L. & Elmelig, A. (2018). Assessing ICT global emissions footprint: Trends to 2040 & Recommendations. Elsevier, *Journal of Cleaner Production*, 177, 448-463.

<sup>33</sup> Press Conference - Ontario Doctors Warn of Rising Health Care Costs after 5G Roll Out [https://www.youtube.com/watch?time\\_continue=4&v=S16Ql6-w9l8](https://www.youtube.com/watch?time_continue=4&v=S16Ql6-w9l8)

<sup>34</sup> Schneier, B. (2019, September 25). Essays: Every Part of the Supply Chain Can Be Attacked - Schneier on Security. [https://www.schneier.com/essays/archives/2019/09/every\\_part\\_of\\_the\\_su.html](https://www.schneier.com/essays/archives/2019/09/every_part_of_the_su.html)

<sup>35</sup> The Threat Lab. (2019, June 26). The History of Cellular Network Security Doesn't Bode Well for 5G. <https://www.eff.org/deeplinks/2019/06/history-cellular-network-security-doesnt-bode-well-5g>

<sup>36</sup> The Minister of Environment and Climate Change Canada (ECCC), in his response to an Environmental Petition to the Auditor General (October 2021), confirmed that: ECCC “is not examining energy and resources implications to sustainability and climate change from the use of various alternative technologies for telecommunications.” Petition 456. (2021). Concerns regarding the Government of Canada's rigour and transparency in evaluating the science regarding localized exposures to 5G technologies in its update of Safety Code 6. [https://www.oag-bvg.gc.ca/internet/English/pet\\_456\\_e\\_43873.html](https://www.oag-bvg.gc.ca/internet/English/pet_456_e_43873.html); Petition and government responses available at: <https://preventcancer.ca/wp-content/uploads/2022/02/5G-Petition-and-Government-Response.pdf>

<sup>37</sup> Patel, N. (2019, May 23). Wait, why the hell is the ‘race to 5G’ even a race? <https://www.theverge.com/2019/5/23/18637213/5g-race-us-leadership-china-fcc-lte>

<sup>38</sup> Canada's Digital Charter: Trust in a digital world. [https://www.ic.gc.ca/eic/site/062.nsf/eng/h\\_00108.html](https://www.ic.gc.ca/eic/site/062.nsf/eng/h_00108.html)

<sup>39</sup> Schoechle, Timothy. (2018). Re-Inventing Wires: The Future of Landlines and Networks. *National Institute for Science, Law & Public Policy Washington, DC*, 156. <https://bit.ly/3crWnfv>



## WHAT HAPPENED AT THE 2017 CONSULTATION

### Regarding “Release” of Millimetre Wave Frequencies for 5G?

[preventcancer.ca/2017-consultation-on-5g-millimetre-wave-spectrum-what-happened-then/](http://preventcancer.ca/2017-consultation-on-5g-millimetre-wave-spectrum-what-happened-then/)

The [2022 consultation on the 26, 28 and 38 GHz Bands](#) arises from the [2019 Decision on Releasing Millimetre Wave Spectrum to Support 5G](#) following a 2017 Consultation on Releasing Millimetre Wave Spectrum.

The [2017 public consultation responses](#) included 246 letters from Canadian citizens and from non-industry organizations representing close to 100,000 Canadians, who opposed the release of the mmWave spectrum. The vast majority cited health concerns.

ISED’s reasons for ignoring health concerns were laid out in Section 10 of its decision and can be summed up as follows:

- Health Canada is responsible for carrying out research, monitoring the scientific literature, and developing guidelines for human exposure to radiofrequency electromagnetic radiation. According to ISED, Health Canada’s recommended human exposure limits (Safety Code 6), which cover the frequencies that will be used by 5G mmWave technology, are “based on the most current scientific literature on radio-frequency exposure and are designed to provide protection for all age groups, including infants and children, on a continuous basis.”
- ISED has adopted Safety Code 6, and “ensures that all radiocommunication installations and devices are installed and operated in a manner that complies with Safety Code 6 limits.”

#### Nine NGOs opposed the release of the mmWave spectrum for health reasons

<ul style="list-style-type: none"><li>• Canadians for Safe Technology</li><li>• Prevent Cancer Now</li><li>• Rassemblement Électro Sensibilité Québec</li><li>• Electromagnetic Pollution Illnesses Canada Foundation</li><li>• Environmental Health Association Manitoba</li></ul>	<b>20,000 + Canadians</b> <i>(Estimated total — based on <a href="#">Appeal</a> signatories)</i>
Fédération des employés et employés de services publics	<b>60,000 Canadians</b>
Learning Disabilities Association Canada	<b>10,000 Canadians</b>
Breast Cancer Action Manitoba	?
Global Union Against Radiation Deployment from Space	International Organization

- **237 individuals wrote NOT IN FAVOUR of the release of the spectrum, most citing health concerns.**

- **The Canadian Astronomical Society (CASCA), Canadian Space Agency (CSA) advised caution regarding possible frequency interference.**

See reply comments: <https://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf11350.html>

#### IN FAVOUR: Industry:

5G Americas, Bell Mobility (Bell), British Columbia Broadband Association (BCBA), BSO Coalition (BSO), Cambridge Broadband Networks Ltd (CBNL), Ciel Satellite LP and Affiliates (Ciel), Cogeco Communications Inc. (Cogeco), Dynamic Spectrum Alliance (DSA), Ericsson Canada (Ericsson), Facebook Inc. (Facebook), Global mobile Suppliers Association (GSA), Huawei Technologies Canada (Huawei), IEEE LAN/MAN Standards Committee (IEEE), Intel Corporation (Intel), Intelsat Corporation (Intelsat), Microsoft, MobilExchange Spectrum Inc. (MobilExchange), Nokia, Québecor Média (Québecor), Radio Advisory Board of Canada (RABC), Rogers Communications Canada Inc. (Rogers), Samsung Electronics Canada Inc. (Samsung), Saskatchewan Telecommunications (SaskTel), Shaw Communications Inc. (Shaw), Siklu Communication (Siklu), Starry Inc. (Starry), Telesat Canada (Telesat), TELUS Communications Company (TELUS), TeraGo Networks (TeraGo), ViaSat Inc. (ViaSat), Wi-Fi Alliance, Xplornet Communications Inc. (Xplornet).

## HUNDREDS OF RECENT SCIENTIFIC REPORTS SHOW HARMS FROM “WIRELESS” RADIOFREQUENCY RADIATION

[preventcancer.ca/hundreds-of-recent-scientific-reports-show-harms-from-radiofrequency-radiation/](https://preventcancer.ca/hundreds-of-recent-scientific-reports-show-harms-from-radiofrequency-radiation/)

This [spreadsheet](#) lists citations and abstracts/extracts of hundreds of peer-reviewed scientific publications published since Health Canada’s most recent review of radiofrequency electromagnetic radiation (RF-EMR), and the [Parliamentary Health Committee’s 2015 report](#).

Excessive heating and resulting changes in behaviour are the adverse effects largely referenced by Health Canada. Nevertheless, independent scientists continue to report serious acute and chronic effects in humans as well as diverse biota, in the absence of excessive temperature increases.

### What will you find in this collection?

Top international journals, publishing landmark studies from world-leading institutions, on biological effects of levels of RF-EMR exposure below the maximum limits in Health Canada’s [Safety Code 6](#) human exposure guidelines.

- Reports, replications and reviews of carcinogenicity findings for cell phone and even WiFi level exposures.
- Clinical studies of individuals who are more overtly sensitive to RF-EMF, and laboratory studies of mechanisms of harms.
- How RF-EMR harms flora and fauna, such as interfering with insects’ and birds’ navigation — an important factor along with pesticides and extreme weather causing biodiversity crises. For a summary of environmental concerns, see our [White Paper](#) “Protect the Birds, Bees and Trees.”

Table: Numbers of peer-reviewed publications reporting potentially adverse effects of radiofrequency radiation exposure at levels permitted and encountered in Canada.

Year	2022	2021	2020	2019	2018	2017	Total
All research studies — Primary research, reviews and meta-analyses	8	35	52	37	56	104	292

NOTE: This collection is the result of volunteer scientists following the scientific literature over the years. This work was not funded, and does not represent a systematic review. We welcome feedback, additions and corrections: please email [info@preventcancer.ca](mailto:info@preventcancer.ca).

Original posting: August 22, 2022; 292 unique publications.

## Scientific reports regarding health and environmental effects of radiofrequency radiation

2017 – mid-2022, available online September 6, 2022

<https://preventcancer.org.ca/radiofrequency-radiation-emr-publications-summaries/>

### 2022

Balmori, A. 2022

#### **Corneal opacity in Northern Bald Ibises (*Geronticus eremita*) equipped with radio transmitters.**

Electromagnetic Biology and Medicine, 41(2), 174–176.

This note is intended to try to shed light on the discoveries made entitled “Biologging is suspect to cause corneal opacity in two populations of wild living Northern Bald Ibises (*Geronticus eremita*)”. In this article, researchers participating in a reintroduction program for this endangered species in Europe document the unilateral corneal opacity that took place after birds were equipped with solar radio transmitters fixed on their upper-back position. The authors propose several possible effects caused by the device to explain the problem, and they conclude that the most parsimonious explanation for the symptomatology is a repetitive slight temperature rise in the corneal tissue due to electromagnetic radiation by the Global System for Mobile Communications (GSM) module of the device. The proposal of this communication is that these effects do not necessarily have to be thermal, but they can be non-thermal and thus more subtle and insidious. These effects may be caused by electromagnetic radiation at low levels but in long-term exposure.

<https://doi.org/10.1080/15368378.2022.2046046>

#### **Balmori, A. 2022 Evidence for a health risk by RF on humans living around mobile phone base stations: From radiofrequency sickness to cancer.** Environmental Research, 113851.

The objective of this work was to perform a complete review of the existing scientific literature to update the knowledge on the effects of base station antennas on humans. Studies performed in real urban conditions, with mobile phone base stations situated close to apartments, were selected. Overall results of this review show three types of effects by base station antennas on the health of people: radiofrequency sickness (RS), cancer (C) and changes in biochemical parameters (CBP). Considering all the studies reviewed globally ( $n = 38$ ), 73.6% (28/38) showed effects: 73.9% (17/23) for radiofrequency sickness, 76.9% (10/13) for cancer and 75.0% (6/8) for changes in biochemical parameters. Furthermore, studies that did not meet the strict conditions to be included in this review provided important supplementary evidence. The existence of similar effects from studies by different sources (but with RF of similar characteristics), such as radar, radio and television antennas, wireless smart meters and laboratory studies, reinforce the conclusions of this review. Of special importance are the studies performed on animals or trees near base station antennas that cannot be aware of their proximity and to which psychosomatic effects can never be attributed.

<https://doi.org/10.1016/j.envres.2022.113851>

Deniz, Ö. G., & Kaplan, S. 2022

#### **The effects of different herbals on the rat hippocampus exposed to electromagnetic field for one hour during the prenatal period.** Journal of Chemical Neuroanatomy, 119, 102043.

The purpose of this study was to highlight the possible effects on the hippocampus of the electromagnetic field (EMF) emitted by mobile phones, and to investigate whether these potential effects can be reduced using various antioxidant substances. Twenty-seven female Wistar albino rats were divided into nine equal groups, each containing three pregnant rats aged 8-10 weeks and weighing 200-250 gr. The EMF groups were exposed to 900 Megahertz (MHz) EMF for 1 h (hr) a day for 21 days. No EMF exposure was applied to the Cont and also the groups given only *Garcinia kola* (GK), *Momordica charantia* (MC), and thymoquinone (TQ). The Sham group was kept in the polycarbonate EMF exposure system, but was not exposed to EMF. Four weeks after birth, rat pups were subjected to behavioural tests. Brain tissue samples were evaluated using histological, stereological, functional, and immunohistochemical methods. The numbers of pyramidal neurons in the rat cornu ammonis (CA) were determined using the optical fractionator method. Superoxide dismutase (SOD) and catalase (CAT) enzyme activities in the blood samples were also evaluated. The analysis data indicated that total pyramidal neuron numbers were decreased significantly in the CA of the EMF (1 hr) group ( $p < 0.01$ ). Our results also showed that the protective effect of MC was more potent than that of the other antioxidant substances ( $p < 0.01$ ). A 900 MHz EMF can cause deleterious changes in the brain. It can also be suggested that GK, MC and TQ are capable of reducing these adverse effects.

<https://doi.org/10.1016/j.jchemneu.2021.102043>

Er, H., Tas, G. G., Soygur, B., Ozen, S., & Sati, L. 2022

#### **Acute and Chronic Exposure to 900 MHz Radio Frequency Radiation Activates p38/JNK-mediated MAPK Pathway in Rat Testis** Reproductive Sciences (Thousand Oaks, Calif.)

The use of electronic devices such as mobile phones has had a long stretch of rapid growth all over the world. Therefore, exposure to radio frequency radiation (RFR) has increased enormously. Here, we aimed to assess the balance between cell death

and proliferation and also investigate the involvement of the JNK/p38 MAPK signaling pathway in the testis of rats exposed to 900 MHz RFR in acute and chronic periods (2 h/day, 5 days/week) for 1 or 10 weeks, respectively. The expression of proliferating cell nuclear antigen (PCNA), Bcl-xL, cleaved caspase-3, phosphorylated-JNK (p-JNK), and phosphorylated-p38 (p-p38) was analyzed in line with histopathology and TUNEL analysis in rat testis. There were no histopathological differences between sham and RFR groups in the acute and chronic groups. PCNA expression was not altered between groups in both periods. However, alterations for cleaved caspase-3 and Bcl-xL were observed depending on the exposure period. TUNEL analysis showed a significant increase in the RFR group in the acute period, whereas no difference in the chronic groups for the apoptotic index was reported. In addition, both p-p38 and p-JNK protein expressions increased significantly in RFR groups in both periods. Our study indicated that 900 MHz RFR might result in alterations during acute period exposure for several parameters, but this can be ameliorated in the chronic period in rat testis. Here, we also report the involvement of the p38/JNK-mediated MAPK pathway after exposure to 900 MHz RFR. Hence, this information might shed light in future studies toward detailed molecular mechanisms in male reproduction and infertility  
<https://doi.org/10.1007/s43032-022-00844-y>

Hinrikus, H., Koppel, T., Lass J., Orru, H., Roosipuu, P., Bachmann, M. 2022

**Possible health effects on the human brain by various generations of mobile telecommunication: a review based estimation of 5G impact.** *Int. J Radiation biology*, 98:7.

**Purpose** The deployment of new 5G NR technology has significantly raised public concerns in possible negative effects on human health by radiofrequency electromagnetic fields (RF EMF). The current review is aimed to clarify the differences between possible health effects caused by the various generations of telecommunication technology, especially discussing and projecting possible health effects by 5G. The review of experimental studies on the human brain over the last fifteen years and the discussion on physical mechanisms and factors determining the dependence of the RF EMF effects on frequency and signal structure have been performed to discover and explain the possible distinctions between health effects by different telecommunication generations. **Conclusions** The human experimental studies on RF EMF effects on the human brain by 2G, 3G and 4G at frequencies from 450 to 2500 MHz were available for analyses. The search for publications indicated no human experimental studies by 5G nor at the RF EMF frequencies higher than 2500 MHz. The results of the current review demonstrate no consistent relationship between the character of RF EMF effects and parameters of exposure by different generations (2G, 3G, and 4G) of telecommunication technology. At the RF EMF frequencies lower than 10 GHz, the impact of 5G NR FR1 should have no principal differences compared to the previous generations. The radio frequencies used in 5G are even higher and the penetration depths of the fields are smaller; therefore, the effect is rather lower than at previous generations. At the RF EMF frequencies higher than 10 GHz, the mechanism of the effects might differ and the impact of 5G NR FR2 becomes unpredictable. Existing knowledge about the mechanism of RF EMF effects at millimeter waves lacks sufficient experimental data and theoretical models for reliable conclusions. The insufficient knowledge about the possible health effects at millimeter waves and the lack of in vivo experimental studies on 5G NR underline an urgent need for the theoretical and experimental investigations of health effects by 5G NR, especially by 5G NR FR2.

<https://www.tandfonline.com/doi/full/10.1080/09553002.2022.2026516>

Lai, H., & Levitt, B. B. 2022

**The roles of intensity, exposure duration, and modulation on the biological effects of radiofrequency radiation and exposure guidelines.** *Electromagnetic Biology and Medicine*, 0(0), 1–26.

In this paper, we review the literature on three important exposure metrics that are inadequately represented in most major radiofrequency radiation (RFR) exposure guidelines today: intensity, exposure duration, and signal modulation. Exposure intensity produces unpredictable effects as demonstrated by nonlinear effects. This is most likely caused by the biological system's ability to adjust and compensate but could lead to eventual biologic breakdown after prolonged exposure. A review of 112 low-intensity studies reveals that biological effects of RFR could occur at a median specific absorption rate of 0.0165 W/kg. Intensity and exposure duration interact since the dose of energy absorbed is the product of intensity and time. The result is that RFR behaves like a biological "stressor" capable of affecting numerous living systems. In addition to intensity and duration, man-made RFR is generally modulated to allow information to be encrypted. The effects of modulation on biological functions are not well understood. Four types of modulation outcomes are discussed. In addition, it is invalid to make direct comparisons between thermal energy and radiofrequency electromagnetic energy. Research data indicate that electromagnetic energy is more biologically potent in causing effects than thermal changes. The two likely function through different mechanisms. As such, any current RFR exposure guidelines based on acute continuous-wave exposure are inadequate for health protection.

<https://doi.org/10.1080/15368378.2022.2065683>

Rao, M., Sarabandi, K., Soukar, J., Kotov, N. A., & VanEpps, J. S. 2022

**Experimental Evidence of Radio Frequency Radiation from Staphylococcus aureus Biofilms.**

*IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, 1–9.

This paper reports the first successful detection of electromagnetic (EM) radiation from *Staphylococcus aureus* biofilms in the gigahertz (GHz) frequency range. Two novel sensing systems are deployed for the measurement. A very sensitive wideband near-zone radiative system specifically designed for this application is first used to search for signals in the 1–50 GHz frequency region. Notable radiation is observed in the 3–4 GHz band. Exposure to lethal doses of Zinc oxide nanopyrramids (ZnO-NPY) is used to verify that the signals are indeed produced by living cells rather than material thermal emission. Afterwards, a spiral antenna system is exploited to further examine the band of interest in the near-field region. Radiation from 3 identical biofilm samples is monitored and recorded over 70 days. Two distinct frequency bands, namely the 3.18 GHz and the 3.45 GHz bands, are identified as potential “communication bands”. Furthermore, long-term and short-term cycles of the total radiation intensity within the band are observed over the course of the experiment. This work confirms the presence of EM radiation within bacterial communities, which is a key requirement to demonstrate EM signaling among bacterial cells. The insight could lead to breakthroughs in demystifying how cells communicate as well as advancement of important technologies in biology and communication systems.

<https://doi.org/10.1109/JERM.2022.3168618>

Toribio, D., Joseph, W., & Thielens, A. 2022

**Near Field Radio Frequency Electromagnetic Field Exposure of a Western Honey Bee.** IEEE Transactions on Antennas and Propagation, 70(2), 1320–1327

It has been suggested that the wireless network evolution to smaller carrier wavelengths (from 2G to 5G) increases radio frequency electromagnetic field (RF-EMF) absorption in western honey bees (*Apis mellifera*). It is unknown whether the radiation performance of antennas is stable when an insect appears in their vicinity. In this research, the absorbed power in a worker honey bee and the influence of the bee's presence on antennas' radiation performance are investigated for the newly used frequencies in 5G networks from 6 to 240 GHz. To these aims, numerical simulations using the finite-difference time-domain (FDTD) method were performed, in which a bee model, obtained by micro-CT scanning, was employed. These simulations showed that, in the near field, the absorbed power can increase by a factor of 53 from 6 to 240 GHz. This is a factor of 7 higher than the increase reported in the far-field in previous studies. Furthermore, the simulations revealed that antennas' radiation efficiency can decrease by up to –40% when a bee appears in the near field. Likewise, it was found that the gain pattern depends on the separation distance between the bee and the antenna with a stronger dependency for higher frequencies.

<https://doi.org/10.1109/TAP.2021.3111286>

## 2021

Alkis, M. E., Akdag, M. Z., & Dasdag, S. 2021

**Effects of Low-Intensity Microwave Radiation on Oxidant-Antioxidant Parameters and DNA Damage in the Liver of Rats.** Bioelectromagnetics, 42(1), 76–85

The continuously increasing usage of cell phones has raised concerns about the adverse effects of microwave radiation (MWR) emitted by cell phones on health. Several in vitro and in vivo studies have claimed that MWR may cause various kinds of damage in tissues. The aim of this study is to examine the possible effects of exposure to low-intensity MWR on DNA and oxidative damage in the livers of rats. Eighteen Sprague-Dawley male rats were divided into three equal groups randomly (n = 6). Group 1 (Sham-control): rats were kept under conditions the same as those of other groups, except for MWR exposure. Group 2: rats exposed to 1800 MHz (SAR: 0.62 W/kg) at  $0.127 \pm 0.04$  mW/cm<sup>2</sup> power density, and Group 3: rats exposed to 2,100 MHz (SAR: 0.2 W/kg) at  $0.038 \pm 0.03$  mW/cm<sup>2</sup> power density. Microwave application groups were exposed to MWR 2 h/day for 7 months. At the end of the exposure period, the rats were sacrificed and DNA damage, malondialdehyde (MDA), 8-hydroxydeoxyguanosine (8-OHdG), and total oxidant-antioxidant parameter analyses were conducted in their liver tissue samples. It was found that 1800 and 2100 MHz low-intensity MWR caused a significant increase in MDA, 8-OHdG, total oxidant status, oxidative stress index, and comet assay tail intensity ( $P < 0.05$ ), while total antioxidant status levels ( $P < 0.05$ ) decreased. The results of our study showed that whole-body exposure to 1800 and 2100 MHz low-intensity MWR emitted by cell phones can induce oxidative stress by altering oxidant-antioxidant parameters and lead to DNA strand breaks and oxidative DNA damage in the liver of rats

<https://doi.org/10.1002/bem.22315>

Balmori, A. 2021 **Electromagnetic Pollution as a Possible Explanation for the Decline of House Sparrows in Interaction with Other Factors** Birds, 2(3), 329–337

In recent decades, there has been a decline of the House Sparrow (*Passer domesticus*), mainly in European cities, and several hypotheses have been proposed that attempt to determine the causes of this rapid decline. Previous studies indicated that house sparrows were significantly negatively associated with increasing electromagnetic radiation and sparrows disappeared from areas most polluted. In addition, there are many studies on the impact of radiation on other bird and non-bird species, as well as numerous laboratory studies that demonstrated detrimental effects at electric field strength levels that can be found in cities today. Electromagnetic radiation is the most plausible factor for multiple reasons, including that this is the only one that affects the other hypotheses proposed so far. It is a type of pollution that affects productivity, fertility, decreases insects (chicken feed), causes loss of habitat, decreases immunity and can promote disease.



Additionally, the recent sparrow decline matches the deployment of mobile telephony networks. Further, there are known mechanisms of action for non-thermal effects of electromagnetic radiation that may affect sparrows causing their decline. Thus, electromagnetic radiation must be seriously considered as a factor for house sparrows' decline, probably in synergy with the other factors previously proposed. <https://doi.org/10.3390/birds2030024>

Balmori, A. 2021 **Electromagnetic radiation as an emerging driver factor for the decline of insects.**

Science of The Total Environment, 767, 144913

The biodiversity of insects is threatened worldwide. Numerous studies have reported the serious decline in insects that has occurred in recent decades. The same is happening with the important group of pollinators, with an essential utility for pollination of crops. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and ecosystem services. Many authors point out that reductions in insect abundance must be attributed mainly to agricultural practices and pesticide use. On the other hand, evidence for the effects of non-thermal microwave radiation on insects has been known for at least 50 years. The review carried out in this study shows that electromagnetic radiation should be considered seriously as a complementary driver for the dramatic decline in insects, acting in synergy with agricultural intensification, pesticides, invasive species and climate change. The extent that anthropogenic electromagnetic radiation represents a significant threat to insect pollinators is unresolved and plausible. For these reasons, and taking into account the benefits they provide to nature and humankind, the precautionary principle should be applied before any new deployment (such 5G) is considered.

<https://doi.org/10.1016/j.scitotenv.2020.144913>

Borre, E. D., Joseph, W., Aminzadeh, R., Müller, P., Boone, M. N., Josipovic, I., ... Thielens, A. 2021

**Radio-frequency exposure of the yellow fever mosquito (*A. aegypti*) from 2 to 240 GHz.**

PLOS Computational Biology, 17(10), e1009460

Fifth generation networks (5G) will be associated with a partial shift to higher carrier frequencies, including wavelengths of insects. This may lead to higher absorption of radio frequency (RF) electromagnetic fields (EMF) by insects and could cause dielectric heating. The yellow fever mosquito (*Aedes aegypti*), a vector for diseases such as yellow and dengue fever, favors warm climates. Being exposed to higher frequency RF EMFs causing possible dielectric heating, could have an influence on behavior, physiology and morphology, and could be a possible factor for introduction of the species in regions where the yellow fever mosquito normally does not appear. In this study, the influence of far field RF exposure on *A. aegypti* was examined between 2 and 240 GHz. Using Finite Difference Time Domain (FDTD) simulations, the distribution of the electric field in and around the insect and the absorbed RF power were found for six different mosquito models (three male, three female). The 3D models were created from micro-CT scans of real mosquitoes. The dielectric properties used in the simulation were measured from a mixture of homogenized *A. aegypti*. For a given incident RF power, the absorption increases with increasing frequency between 2 and 90 GHz with a maximum between 90 and 240 GHz. The absorption was maximal in the region where the wavelength matches the size of the mosquito. For a same incident field strength, the power absorption by the mosquito is 16 times higher at 60 GHz than at 6 GHz. The higher absorption of RF power by future technologies can result in dielectric heating and potentially influence the biology of this mosquito.

<https://doi.org/10.1371/journal.pcbi.1009460>

Chen, F., Wang, P., Lan, J., Hu, M., Zheng, J., Li, Y., ... Zhou, D. 2021

**Wireless phone use and adult meningioma risk: a systematic review and Meta-analysis.**

British Journal of Neurosurgery, 35(4), 444–450

Introduction: Several studies explored the effects of exposure to radiofrequency-electromagnetic field (RF-EMF) and extremely low frequency (ELF) EMF emitted from mobile phones on meningioma among adults. However, the results could not reach an agreement. This meta-analysis was conducted to confirm the relationship between adult meningioma risk and the use of a wireless phone. Methods: Pertinent studies were identified by searching PubMed and Embase up to August 2018. The random- or fixed-effects model was used to combine the results depending on the heterogeneity of the analysis. The publication bias was evaluated using Egger's regression asymmetry test. The subgroup analysis was performed by time since the first use of wireless phone and laterality (ipsilateral/contralateral). Results: Eight studies were enrolled in this meta-analysis. The pooled results suggested that the ever use of wireless phone led to a borderline decreased adult meningioma risk [odds ratio (OR) 0.90; 95% confidence interval (CI) 0.83-0.99] with no heterogeneity ( $I^2 = 5.3\%$ ;  $p = 0.391$ ). A decreased risk of meningioma was seen in short-term (OR = 0.85; 95% CI = 0.77-0.94) users. Neither decreased nor increased risk of meningioma was observed in mid-term (OR = 0.93, 95% CI = 0.75-1.16) and long-term (OR = 1.05, 95% CI = 0.93-1.19) users. Neither ipsilateral (OR = 1.05, 95% CI = 0.90-1.22) nor contralateral (OR = 0.86, 95% CI = 0.62-1.18) wireless phone use was associated with the risk of meningioma. Conclusions: This meta-analysis suggested a relationship between decreased meningioma risk and wireless phone use. However, the findings need further validation.

<https://doi.org/10.1080/02688697.2020.1856784>

Chowdhury, A., Singh, Y., Das, U., Waghmare, D., Dasgupta, R., & Majumder, S. K. 2021

**Effects of mobile phone emissions on human red blood cells.** Journal of Biophotonics, 14(8), e202100047

Raman spectroscopy was performed on GSM 900 and 1800 MHz mobile phone signal exposed red blood cells (RBCs). The observed changes in the Raman spectra of mobile signal exposed RBCs compared to unexposed control suggest reduced hemoglobin-oxygen affinity for the exposed cells. The possible mechanism may involve activation of the voltage gated membrane Ca<sup>2+</sup> channels by the mobile phone emissions resulting in an increase in the levels of adenosine triphosphate (ATP) and 2,3-diphosphoglycerate (2,3-DPG) in cells via altered metabolic activities. Further studies carried out with fluorescent Ca<sup>2+</sup> indicator confirmed increased intracellular Ca<sup>2+</sup> level in the exposed cells. Since intracellular ATP level influences the shape and mechanics of RBCs, exposed cells were studied using diffraction phase microscopy and optical tweezers. Detectable changes in shape and mechanical properties were observed due to mobile signal exposure.

<https://doi.org/10.1002/jbio.202100047>

Dauda Usman, J., Umar Isyaku, M., & Fasanmade, A. A. 2021

**Evaluation of heart rate variability, blood pressure and lipid profile alterations from dual transceiver mobile phone radiation exposure.** Journal of Basic and Clinical Physiology and Pharmacology, 32(5), 951–957

**OBJECTIVES:** Electromagnetic fields have been reported to alter electrical activities in the brain and heart. However, there is paucity of information on the potential functional alterations that magnetic fields from mobile phone could cause to the heart. This study investigated heart rate variability (HRV), blood pressure (BP) and lipid profile in Wistar rats exposed to electromagnetic field radiation from a dual transceiver mobile phone (DTrMP). **METHODS:** Twenty-one male albino Wistar rats (140-180 g) were randomly assigned to two major groups positioned 5 m apart as follows: control: no phone (n=7) and treatment group (n=14) continuously exposed to electromagnetic field from Tecno T312 DTrMP 900/1800 MHz set in silence mode. Experimental treatment consisted in 10 min calls/day, directed to this device for a period of six weeks. Seven animals from the treatment group were allowed to recover for a period of two weeks after exposure. HRV, systolic, diastolic and mean arterial BP were noninvasively investigated, while serum lipid profile and heart tissue nitric oxide (NO) activities were determined using standard procedures. **RESULTS:** There was significant (p<0.05) increase in systolic, diastolic, mean arterial BP and a decrease in HRV. Serum high density lipoproteins decreased, while total cholesterol, atherogenic indices, and heart NO levels increased significantly in the radiation exposed animals. The alterations observed in exposed animals remained unchanged even after the recovery period. **CONCLUSIONS:** These results suggest that exposure to electromagnetic radiation from dual transceiver mobile phones could be a risk factor to increase in blood pressure.

<https://doi.org/10.1515/jbcpp-2020-0047>

Gunes, M., Ates, K., Yalcin, B., Akkurt, S., Ozen, S., & Kaya, B. 2021 **An Evaluation of the Genotoxic Effects of Electromagnetic Radiation at 900 MHz, 1800 MHz, and 2100 MHz Frequencies with a SMART Assay in Drosophila melanogaster.**

Electromagnetic Biology and Medicine, 40(2), 254–263

With the development of today's technology, the electromagnetic radiation spread by mobile phones and base stations is also rapidly increasing, and this causes serious concerns about the environment and human health. The Drosophila model organism is widely used in genetic toxicology studies because its genome is highly similar to the genes identified in human diseases. In this study, the genotoxic effects of radiofrequency electromagnetic radiation were evaluated by the wing Somatic Mutation and Recombination Test (SMART) in Drosophila melanogaster at 900 MHz, 1800 MHz, and 2100 MHz. The SMART method is based on the observation of genetic changes occurring in the trichomes of the Drosophila wings appearing as mutant clones under the microscope. Throughout the study, total clone parameters were evaluated by exposing the Drosophila larvae to electromagnetic fields for two, four, and six hours per day for two days. As a result of the study, it was observed that the number of mutant clones was statistically increased according to the negative control group in all applications except for the six-hour application at 1800 MHz.

<https://doi.org/10.1080/15368378.2021.1878210>

Hardell, L. 2021 **Health Council of the Netherlands and evaluation of the fifth generation, 5G, for wireless communication and cancer risks.** World Journal of Clinical Oncology, 12(6), 393–403

Currently the fifth generation, 5G, for wireless communication is about to be rolled out worldwide. Many persons are concerned about potential health risks from radiofrequency radiation. In September 2017, a letter was sent to the European Union asking for a moratorium on the deployment until scientific evaluation has been made on potential health risks (<http://www.5Gappeal.eu>). This appeal has had little success. The Health Council of the Netherlands released on September 2, 2020 their evaluation on 5G and health. It was largely based on a World Health Organization draft and report by the Swedish Radiation Safety Authority, both criticized for not being impartial. The guidelines by the International Commission on Non-Ionizing Radiation Protection were recommended to be used, although they have been considered to be insufficient to protect against health hazards (<http://www.emfscientist.org>). The Health Council Committee recommended not to use the 26 GHz frequency band until health risks have been studied. For lower frequencies, the International Commission on Non-Ionizing

Radiation Protection guidelines were recommended. The conclusion that there is no reason to stop the use of lower frequencies for 5G is not justified by current evidence on cancer risks as commented in this article. A moratorium is urgently needed on the implementation of 5G for wireless communication.  
<https://doi.org/10.5306/wjco.v12.i6.393>

Jelodar, G., Azimzadeh, M., Radmard, F., & Darvishhoo, N. 2021 **Alteration of intrapancreatic serotonin, homocysteine, TNF- $\alpha$ , and NGF levels as predisposing factors for diabetes following exposure to 900-MHz waves**

Toxicology and Industrial Health, 37(8), 496–503

Exposure to mobile phone radiation causes deleterious health effects on biological systems. The objects of this study were to investigate the effect of 900-MHz radiofrequency waves (RFW) emitted from base transceiver station antenna on intrapancreatic homocysteine (Hcy), tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ), and nerve growth factor (NGF) as predisposing factors involved in pancreatic beta cell damage. Thirty male rats (Sprague-Dawley, 200  $\pm$  10 g) were randomly divided into the control (without any exposure) and exposed groups: short time (2 h/day), long time (4 h/day), and exposed to 900-MHz RFW for 30 consecutive days. On the last days of the experiment, animals were killed and pancreas tissue was dissected out for evaluation of serotonin, Hcy, TNF- $\alpha$ , and NGF. There was a significant decrease in the serotonin and NGF levels in the pancreatic tissue of exposed groups compared to the control group ( $p < 0.05$ ). Also, the levels of serotonin and NGF in the long-time exposure were significantly lower than the short-time exposure ( $p < 0.05$ ). However, levels of Hcy and TNF- $\alpha$  were significantly increased in the pancreas of exposed groups compared to the control groups ( $p < 0.05$ ). Exposure to 900-MHz RFW decreased pancreatic NGF and serotonin levels and increased the proinflammatory markers (Hcy and TNF- $\alpha$ ), which can be a predisposing factor for type 2 diabetes.  
<https://doi.org/10.1177/07482337211022634>

Kaur, S., Vian, A., Chandel, S., Singh, H. P., Batish, D. R., & Kohli, R. K. 2021

**Sensitivity of plants to high frequency electromagnetic radiation: cellular mechanisms and morphological changes** Reviews in Environmental Science and Bio/Technology The technological advancement and increased usage of wireless and other communication devices have greatly enhanced the level of radiofrequency electromagnetic field radiation (EMF-r) in the environment. It has resulted in unprecedented increased exposure of living organisms to these radiations. Most of the studies in past have, however, focused on animal systems and comparatively less attention has been paid to plants with studies reporting various, sometimes contradictory effects. This review is an attempt to provide a critical appraisal of the available reports regarding the impacts of these radiations on plant development and the underlying physiological, biochemical, and molecular mechanisms involved. Here, we propose that the main entry point for the biological effects of EMF-r corresponds to an increase in ROS metabolism and cytosolic calcium that leads to various cellular responses including changes in gene expression and/or enzymatic activities, which could ultimately result in immediate cellular alterations or delayed plant growth. This may constitute a new perspective in the interpretation of plant responses to EMF-r exposure. Understanding the impacts of EMF-r and the inherent abilities of plants to cope up with such changes should lead to EMF-r being considered as full-fledged environmental signals that are perceived by the plants and integrated into their development patterns.

<https://doi.org/10.1007/s11157-020-09563-9>

Keleş, A. İ., & Süt, B. B. 2021

**Histopathological and epigenetic alterations in the spinal cord due to prenatal electromagnetic field exposure: An H3K27me3-related mechanism.** Toxicology and Industrial Health, 37(4), 189–197

Neural system development is one of the most important stages of embryogenesis. Perturbations in this crucial process due to genetic and environmental risk factors cause neural tube defects and other central nervous system diseases. We investigated the effects of prenatal exposure to 900-MHz electromagnetic field (EMF) on the spinal cord. Pregnant rats were exposed to 900-MHz EMF for 1 h/day from E13.5 until birth. Six pups from the control and EMF groups were sacrificed at postnatal day 32, and the upper thoracic region of the spine was removed and processed for histological procedures. For histopathological analyses, hematoxylin&eosin staining and, for stereological analyses and the quantitation of motor neurons, cresyl violet staining was performed. H3K27me3 levels were determined via immunofluorescence staining. Histopathological analysis identified structural alterations of ependymal cells, enlarged central canals, as well as degenerated and shrunken motor neurons in the EMF group, while the control group tissues had normal appearances. We also observed enrichment of H3K27me3 in the ependymal cells and the motor neurons in the spinal cord of the control group rats, while the EMF group had low levels of H3K27me3 staining. Our results suggest that the loss of H3K27me3 signals might correlate with reduced neuronal stem cell potential in the EMF group and result in anatomical and structural differences in the spinal cord. This study provided a comprehensive histopathological analysis of the spinal cord after prenatal EMF exposure and offered an H3K27me3-dependent molecular explanation for the detrimental effects of EMF exposure on the spine.

<https://doi.org/10.1177/0748233721996947>

Kumar, R., Deshmukh, P. S., Sharma, S., & Banerjee, B. D. 2021 **Effect of mobile phone signal radiation on epigenetic modulation in the hippocampus of Wistar rat.** Environmental Research, 192, 110297

Exponential increase in mobile phone uses, given rise to public concern regarding the alleged deleterious health hazards as a consequence of prolonged exposure. In 2018, the U.S. National toxicology program reported, two year toxicological studies for potential health hazards from exposure to cell phone radiations. Epigenetic modulations play a critical regulatory role in many cellular functions and pathological conditions. In this study, we assessed the dose-dependent and frequency-dependent epigenetic modulation (DNA and Histone methylation) in the hippocampus of Wistar rats. A Total of 96 male Wistar rats were segregated into 12 groups exposed to 900 MHz, 1800 MHz and 2450 MHz RF-MW at a specific absorption rate (SAR) of  $5.84 \times 10^{-4}$  W/kg,  $5.94 \times 10^{-4}$  W/kg and  $6.4 \times 10^{-4}$  W/kg respectively for 2 h per day for 1-month, 3-month and 6-month periods. At the end of the exposure duration, animals were sacrificed to collect the hippocampus. Global hippocampal DNA methylation and histone methylation were estimated by ELISA. However, DNA methylating enzymes, DNA methyltransferase1 (DNMT1) and histone methylating enzymes euchromatic histone methyltransferase1 (EHMT1) expression was evaluated by real-time PCR, as well as further validated with Western blot. Alteration in epigenetic modulation was observed in the hippocampus. Global DNA methylation was decreased and histone methylation was increased in the hippocampus. We observed that microwave exposure led to significant epigenetic modulations in the hippocampus with increasing frequency and duration of exposure. Microwave exposure with increasing frequency and exposure duration brings significant ( $p < 0.05$ ) epigenetic modulations which alters gene expression in the hippocampus.

<https://www.sciencedirect.com/science/article/abs/pii/S0013935120311944>

Lai, Y.-F., Wang, H.-Y., & Peng, R.-Y. 2021 **Establishment of injury models in studies of biological effects induced by microwave radiation.** Military Medical Research, 8(1), 12

Microwave radiation has been widely used in various fields, such as communication, industry, medical treatment, and military applications. Microwave radiation may cause injuries to both the structures and functions of various organs, such as the brain, heart, reproductive organs, and endocrine organs, which endanger human health. Therefore, it is both theoretically and clinically important to conduct studies on the biological effects induced by microwave radiation. The successful establishment of injury models is of great importance to the reliability and reproducibility of these studies. In this article, we review the microwave exposure conditions, subjects used to establish injury models, the methods used for the assessment of the injuries, and the indicators implemented to evaluate the success of injury model establishment in studies on biological effects induced by microwave radiation.

<https://doi.org/10.1186/s40779-021-00303-w>

Lai, H. 2021

**Genetic effects of non-ionizing electromagnetic fields.** Electromagnetic Biology and Medicine, 40(2), 264–273

This is a review of the research on the genetic effects of non-ionizing electromagnetic field (EMF), mainly on radiofrequency radiation (RFR) and static and extremely low frequency EMF (ELF-EMF). The majority of the studies are on genotoxicity (e.g., DNA damage, chromatin conformation changes, etc.) and gene expression. Genetic effects of EMF depend on various factors, including field parameters and characteristics (frequency, intensity, wave-shape), cell type, and exposure duration. The types of gene expression affected (e.g., genes involved in cell cycle arrest, apoptosis and stress responses, heat-shock proteins) are consistent with the findings that EMF causes genetic damages. Many studies reported effects in cells and animals after exposure to EMF at intensities similar to those in the public and occupational environments. The mechanisms by which effects are induced by EMF are basically unknown. Involvement of free radicals is a likely possibility. EMF also interacts synergistically with different entities on genetic functions. Interactions, particularly with chemotherapeutic compounds, raise the possibility of using EMF as an adjuvant for cancer treatment to increase the efficacy and decrease side effects of traditional chemotherapeutic drugs. Other data, such as adaptive effects and mitotic spindle aberrations after EMF exposure, further support the notion that EMF causes genetic effects in living organisms.

<https://doi.org/10.1080/15368378.2021.1881866>

Lamkowski, A., Kreitlow, M., Radunz, J., Willenbockel, M., Stiemer, M., Fichte, L. O., ... Abend, M. 2021

**Analyzing the impact of 900 MHz EMF short-term exposure to the expression of 667 miRNAs in human peripheral blood cells.** Scientific Reports, 11(1), 4444

More than ever before, people around the world are frequently exposed to different sections of the electromagnetic spectrum, mainly emitted from wireless modern communication technologies. Especially, the level of knowledge on non-thermal biological EMF effects remains controversial. New technologies allow for a more detailed detection of non-coding RNAs which affect the post-transcriptional control. Such method shall be applied in this work to investigate the response of human blood cells to electromagnetic irradiation. In this ex vivo in vitro study, we exposed peripheral blood cells from 5 male donors to a continuous wave of 900 MHz EMF for 0, 30, 60 and 90 min. Significant micro RNA (miRNA) expression changes ( $p \leq 0.05$ ) above or below the SHAM exposed samples were evaluated using a quantitative real time PCR platform for simultaneous detection of 667 miRNAs

called low density array. Only significant miRNA expression changes which were detectable in at least 60% of the samples per exposure group were analyzed. The results were compared with data from room temperature + 2 °C (RT + 2 °C) samples (here referred to as hyperthermia) to exclude miRNA expression altered by hyperthermia. The validation study by using the same donors and study design was performed after an interval of 2 years. When analyzing a total of 667 miRNAs during the screening study, 2 promising candidate miRNAs were identified, which were down regulated almost twice and showed a complete separation from the unexposed control group (miR-194 at 30 min and miR-939 at 60 min). The p-values even survived the Bonferroni correction for multiple comparisons ( $p = 0.0007$  and  $p = 0.004$ , respectively). None of these miRNAs were expressed at a second time point after EMF exposure. Following an alternative analysis approach, we examined for miRNAs revealing an expected significant association of differential miRNA expression with the dose-time EMF exposure product, separately for each donor. Donors 2 and 3 revealed 11 and 10 miRNA species being significantly associated with EMF exposure which differed significantly from the other donors showing a minor number of differentially expressed miRNAs and could identify donors 2 and 3 as particularly EMF-responsive. The measurements were repeated after 2 years. The number of expressed/non-expressed miRNAs was almost similar (97.4%), but neither the number nor the previously differentially expressed miRNAs could be reproduced. Our data neither support evidence of early changes at miRNA expression level in human whole blood cells after 900 MHz EMF exposure nor the identification of EMF-responsive individuals.

<https://doi.org/10.1038/s41598-021-82278-1>

Levitt, B. B., Lai, H. C., & Manville, A. M. 2021a

**Effects of non-ionizing electromagnetic fields on flora and fauna, Part 1. Rising ambient EMF levels in the environment.**

Reviews on Environmental Health

Ambient levels of electromagnetic fields (EMF) have risen sharply in the last 80 years, creating a novel energetic exposure that previously did not exist. Most recent decades have seen exponential increases in nearly all environments, including rural/remote areas and lower atmospheric regions. Because of unique physiologies, some species of flora and fauna are sensitive to exogenous EMF in ways that may surpass human reactivity. There is limited, but comprehensive, baseline data in the U.S. from the 1980s against which to compare significant new surveys from different countries. This now provides broader and more precise data on potential transient and chronic exposures to wildlife and habitats. Biological effects have been seen broadly across all taxa and frequencies at vanishingly low intensities comparable to today's ambient exposures. Broad wildlife effects have been seen on orientation and migration, food finding, reproduction, mating, nest and den building, territorial maintenance and defense, and longevity and survivorship. Cyto- and geno-toxic effects have been observed. The above issues are explored in three consecutive parts: Part 1 questions today's ambient EMF capabilities to adversely affect wildlife, with more urgency regarding 5G technologies. Part 2 explores natural and man-made fields, animal magnetoreception mechanisms, and pertinent studies to all wildlife kingdoms. Part 3 examines current exposure standards, applicable laws, and future directions. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as "habitat" so EMF can be regulated like other pollutants. Wildlife loss is often unseen and undocumented until tipping points are reached. Long-term chronic low-level EMF exposure standards, which do not now exist, should be set accordingly for wildlife, and environmental laws should be strictly enforced.

<https://doi.org/10.1515/reveh-2021-0026>

Levitt, B. B., Lai, H. C., & Manville, A. M. 2021b

**Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: how species interact with natural and man-made EMF.** Reviews on Environmental Health

Ambient levels of nonionizing electromagnetic fields (EMF) have risen sharply in the last five decades to become a ubiquitous, continuous, biologically active environmental pollutant, even in rural and remote areas. Many species of flora and fauna, because of unique physiologies and habitats, are sensitive to exogenous EMF in ways that surpass human reactivity. This can lead to complex endogenous reactions that are highly variable, largely unseen, and a possible contributing factor in species extinctions, sometimes localized. Non-human magnetoreception mechanisms are explored. Numerous studies across all frequencies and taxa indicate that current low-level anthropogenic EMF can have myriad adverse and synergistic effects, including on orientation and migration, food finding, reproduction, mating, nest and den building, territorial maintenance and defense, and on vitality, longevity and survivorship itself. Effects have been observed in mammals such as bats, cervids, cetaceans, and pinnipeds among others, and on birds, insects, amphibians, reptiles, microbes and many species of flora. Cyto- and geno-toxic effects have long been observed in laboratory research on animal models that can be extrapolated to wildlife. Unusual multi-system mechanisms can come into play with non-human species - including in aquatic environments - that rely on the Earth's natural geomagnetic fields for critical life-sustaining information. Part 2 of this 3-part series includes four online supplement tables of effects seen in animals from both ELF and RFR at vanishingly low intensities. Taken as a whole, this indicates enough information to raise concerns about ambient exposures to nonionizing radiation at ecosystem levels. Wildlife loss is often unseen and undocumented until tipping points are reached. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as "habitat" so EMF can be regulated like other pollutants. Long-term chronic low-level EMF exposure



standards, which do not now exist, should be set accordingly for wildlife, and environmental laws should be strictly enforced - a subject explored in Part 3.

<https://doi.org/10.1515/reveh-2021-0050>

Levitt, B. B., Lai, H. C., & Manville, A. M. 2021c **Effects of non-ionizing electromagnetic fields on flora and fauna, Part 3.**

**Exposure standards, public policy, laws, and future directions.** Reviews on Environmental Health

Due to the continuous rising ambient levels of nonionizing electromagnetic fields (EMFs) used in modern societies—primarily from wireless technologies—that have now become a ubiquitous biologically active environmental pollutant, a new vision on how to regulate such exposures for non-human species at the ecosystem level is needed. Government standards adopted for human exposures are examined for applicability to wildlife. Existing environmental laws, such as the National Environmental Policy Act and the Migratory Bird Treaty Act in the U.S. and others used in Canada and throughout Europe, should be strengthened and enforced. New laws should be written to accommodate the ever-increasing EMF exposures. Radiofrequency radiation exposure standards that have been adopted by worldwide agencies and governments warrant more stringent controls given the new and unusual signaling characteristics used in 5G technology. No such standards take wildlife into consideration. Many species of flora and fauna, because of distinctive physiologies, have been found sensitive to exogenous EMF in ways that surpass human reactivity. Such exposures may now be capable of affecting endogenous bioelectric states in some species. Numerous studies across all frequencies and taxa indicate that low-level EMF exposures have numerous adverse effects, including on orientation, migration, food finding, reproduction, mating, nest and den building, territorial maintenance, defense, vitality, longevity, and survivorship. Cyto- and geno-toxic effects have long been observed. It is time to recognize ambient EMF as a novel form of pollution and develop rules at regulatory agencies that designate air as ‘habitat’ so EMF can be regulated like other pollutants. Wildlife loss is often unseen and undocumented until tipping points are reached. A robust dialog regarding technology’s high-impact role in the nascent field of electroecology needs to commence. Long-term chronic low-level EMF exposure standards should be set accordingly for wildlife, including, but not limited to, the redesign of wireless devices, as well as infrastructure, in order to reduce the rising ambient levels (explored in Part 1). Possible environmental approaches are discussed. This is Part 3 of a three-part series.

<https://doi.org/10.1515/reveh-2021-0083>

Lund, L., Sølvehøj, I. N., Danielsen, D., & Andersen, S. 2021

**Electronic media use and sleep in children and adolescents in western countries: a systematic review.**

BMC Public Health, 21(1), 1598

**BACKGROUND:** Sleep is essential for child and adolescent health and well-being. There is an increasing interest in whether electronic media use affects children and young adolescents’ sleep. Prior reviews have focused on a school-aged population. Moreover, it is crucial that research continuously addresses the processes of technology and media use and the implication on sleep. This systematic review examines the evidence of electronic media use related to sleep among 0-15-year-olds. **METHODS:** Searches were carried out in four databases (CINAHL, Web of Science, EMBASE, and Medline). Inclusion criteria included age ≤ 15 years, and intervention, cohort, or cross-sectional studies from western countries. Methodological quality was rated using the Quality Assessment Tool for Quantitative Studies by two independent reviewers. Data was extracted using a standardized data extraction form. Synthesis was done by summarizing results across studies by age groups of 0-5, 6-12, and 13-15 years within four sleep domains: Bedtime and sleep onset; Sleep quality; Sleep duration; Daytime tiredness. **RESULTS:** The search identified 10,719 unique studies, of which 109 fulfilled inclusion and exclusion criteria and were assessed for methodological quality. In total, 49 studies were included in the review. The study designs were randomized controlled trials (n = 3), quasi-experimental studies (n = 2), prospective cohort studies (n = 15), and cross-sectional studies (n = 29). Evidence for an association between electronic media use and sleep duration was identified, with stronger evidence for 6-15-years-olds than 0-5-year-olds. The evidence for a relationship between electronic media use and other sleep outcomes was more inconclusive. However, for 6-12-year-old children, there was evidence for associations of electronic media use with delayed bedtime and poor sleep quality. For 13-15-year-olds, there was evidence for associations between screen time and problems falling asleep, and between social media use and poor sleep quality. **CONCLUSIONS:** Overall, electronic media use was generally associated with shorter sleep duration in children and adolescents. Studies with stronger research design and of higher quality are needed to draw solid conclusions about electronic media’s impact on other sleep outcomes. Public awareness and interventions could be promoted about the potential negative impact on children’s sleep of electronic media devices that are used excessively and close to bedtime.

<https://doi.org/10.1186/s12889-021-11640-9>

Mai, T. C., Braun, A., Bach, V., Pelletier, A., & de Seze, R. 2021

**Low-Level Radiofrequency Exposure Induces Vasoconstriction in Rats.** Bioelectromagnetics, 42(6), 455–463

Recent studies have revealed that rodents’ physiological responses to low-intensity radiofrequency (RF) electromagnetic fields were similar to thermoregulatory responses to cold conditions. The primary autonomic response to cold exposure is peripheral

vasoconstriction that allows rodents to reduce heat loss and maintain a relatively constant internal body temperature. In the present study, we investigated the effects of 900 MHz RF at a low level (SAR of 0.35 W/kg) on tail skin temperature (Ttail) in rats. We showed that rats exposed to RF had lower Ttail than control rats at ambient temperatures between 27 and 28 °C, suggesting that RF could induce a noticeable degree of vasoconstriction under mild-warm ambient temperatures. This difference in Ttail was suppressed after the intraperitoneal injection of a vasodilator, an  $\alpha$ -adrenergic antagonist, confirming the hypothesis of the vasoconstriction in exposed rats. Moreover, like a response to cold stimuli, RF exposure led to increased plasma concentrations of important factors: noradrenaline (a neurotransmitter responsible for vasoconstriction and thermogenesis) and fatty acids (markers of activated thermogenesis). Taken together, these findings indicate that low-intensity RF levels triggered some key physiological events usually associated with responses to cold in rats.

<https://doi.org/10.1002/bem.22350>

Mansourian, M., Firoozabadi, S. M. P., & Hassan, Z. M. 2021a **The effect of 900 MHz electromagnetic fields on biological pathways induced by electrochemotherapy**. *Electromagnetic Biology and Medicine*, 40(1), 158–168

Electrochemotherapy (ECT) is a new and promising treatment strategy for cancer treatment. The aim of this work is to investigate the effect of 900 MHz radiofrequency electromagnetic fields (RF-EMFs) on the mechanisms of ECT (low voltage, high frequency) including cell permeability in vitro, and tumor hypoxia, immune system response in vivo, and on volume of tumors treated with ECT (70 V/cm, 5 kHz). The 4T1 cells were exposed to RF-EMFs at 17, 162, or 349  $\mu$ W/cm<sup>2</sup> power densities, using GSM900 simulator, 10 min. The cells were then put in individual groups, comprising of no treatment, chemotherapy, electric pulses (EPs), or ECT. The cell viability was evaluated. The mice with 4T1 tumor cells were exposed to RF field 10 min/day until the tumor volume reached about 8 mm. Then, the mice tumors were treated with ECT. Tumor hypoxia and immune system response was analyzed through immunohistochemistry (IHC) assay and ELISA technique, respectively. The volume of tumors was also calculated for 24 days following the treatment. The results showed that RF fields at 349  $\mu$ W/cm<sup>2</sup> could increase tumor hypoxia induced by ECT and cause a significant increase of Interferon-gamma (IFN- $\gamma$ ) in comparison with group ECT alone. However, 900 MHz radiations did not affect the volume of tumors treated to ECT (70 V/cm, 5 kHz) significantly. In this study, 900 MHz EMF could improve some biological pathways induced by ECT. Such a positive effect could utilize in some other treatments to increase efficacy, which should be investigated in further research.

<https://doi.org/10.1080/15368378.2020.1856681>

Mansourian, M., Firoozabadi, S. M. P., & Hassan, Z. M. 2021b **The investigation of Pulse-Modulated GSM-900 MHz electromagnetic field effects on the electrochemotherapy mechanisms in vivo**. *Electromagnetic Biology and Medicine*, 1–9

Electrochemotherapy (ECT) as a tumor treatment modality is approved for cutaneous and subcutaneous tumors. The purpose of the present study was to examine the effect of 900 MHz radiofrequency (RF) pulse-modulated by 217 Hz EMFs similar to those emitted by mobile phones on the mechanisms of ECT in vivo including: tumor hypoxia and immune system response, and on tumor volume. 4 T1 cells were injected subcutaneously into the right flank of Balb/c mice. The mice were exposed to RF fields at specific absorption rate (SAR) 2 W/kg for 10 min/day and then treated with ECT. Two protocols of ECT were used: ((70 V/cm-5 kHz) and 70 V/cm-4 kHz)). Tumor hypoxia was analyzed through HIF-1 $\alpha$  immunohistochemistry assay. Interleukin 4 (IL-4) and IFN- $\gamma$  levels were estimated by enzyme-linked immunosorbent assay (ELISA) technique to evaluate immune system response. Also, tumors volume changes were measured for 24 days following the treatment. The results showed that pulse-modulated RF fields could increase hypoxia induced by ECT, significantly (about 13% in ECT (70 V/cm-5 kHz) and 11% in ECT (70 V/cm-4 kHz)). However, these fields did not have significant effect on immune system response (the levels of IL-4 and IFN- $\gamma$ ) and tumor volume changes induced by ECT. Our results indicated that pulse-modulated RF fields could not affect tumor volume changes in ECT with the frequency of 5 kHz and voltage of 70 V/cm efficacy in vivo. However, investigating the role of other environmental intervening factors on this protocol of ECT is recommended in further studies.

<https://doi.org/10.1080/15368378.2021.2006689>

Moghadas, N., Alimohammadi, I., Safari Variani, A., & Ashtarinezhad, A. 2021 **The Effect of Mobile Radiation on the Oxidative Stress Biomarkers in Pregnant Mice**. *Journal of Family & Reproductive Health*, 15(3), 172–178

Objective: Due to the growing use of communication instruments such as cell phones and wireless devices, there is growing public concern about possible harmful effects, especially in sensitive groups such as pregnant women. This study aimed to investigate the oxidative stress induced by exposure to 900 MHz mobile phone radiation and the effect of vitamin C intake on reducing possible changes in pregnant mice. Materials and methods: Twenty-one pregnant mice were divided into three groups (control, mobile radiation-exposed, and mobile radiation plus with vitamin C intake co-exposed (200 mg /kg)). The mice in exposure groups were exposed to 900 MHz, 2 watts, and a power density of 0.045  $\mu$ W /cm<sup>2</sup> mobile radiation for eight hours/day for ten consecutive days. After five days of rest, MDA (Malondialdehyde), 8-OHdG (8-hydroxy-2' -deoxyguanosine), and TAC (Total Antioxidant Capacity) levels were measured in the blood of animals. The results were analyzed by SPSS.22.0 software. Results: The results showed that exposure to mobile radiation increased MDA (P=0.002), and 8-OHdG (P=0.001) significantly and decreased Total Antioxidant Capacity in the exposed groups (P=0.001). Taking vitamin C inhibited the significant increase in MDA

and 8-OHdG levels in exposed groups. Conclusion: Although exposure to mobile radiation can cause oxidative stress in the blood of pregnant mice, vitamin C as an antioxidant can prevent it.  
<https://doi.org/10.18502/jfrh.v15i3.7134>

Ozel, H. B., Cetin, M., Sevik, H., Varol, T., Isik, B., & Yaman, B. 2021 **The effects of base station as an electromagnetic radiation source on flower and cone yield and germination percentage in *Pinus brutia* Ten.** *Biologia Futura*, 72(3), 359–365

Electromagnetic radiation is a substantial pollution factor that most of the living things found almost everywhere are constantly exposed to with current technology. The number of studies conducted on the effects of this exposed radiation on the living things constantly is limited; and almost all of the studies conducted are aimed at measuring the effects of short-term exposure. In addition to this, most of the studies conducted on plants focus on herbaceous plant species. In this study, the effects of distance to base station on flower and cone yield and germination percentage were investigated in *Pinus brutia* individuals, one of the critical forest tree species. The study results revealed that being close to the base station significantly reduced the number of flowers and cones in *P. brutia* individuals, and that the values obtained in individuals at a distance of 800 m from the base station were 11 times more than the number of flowers and 7 times more than the number of cones compared to the individuals at a distance of 100 m. In the seeds subject to the study, there is a three-times difference in terms of the germination percentage among the individuals located at the furthest and closest distance to the base station. These results show that *P. brutia* individuals are considerably affected by the base station.  
<https://doi.org/10.1007/s42977-021-00085-1>

Ozgur, E., Kayhan, H., Kismali, G., Senturk, F., Sensoz, M., Ozturk, G. G., & Sel, T. 2021 **Effects of radiofrequency radiation on colorectal cancer cell proliferation and inflammation.** *Turkish Journal of Biochemistry*, 46(5), 525–532

**Objectives** The aim of this study is to investigate the effects of radiofrequency radiation (RFR) on apoptosis, proliferation, stress response, and inflammation markers in colorectal cancer cells. **Methods** We tested the effects of intermittent exposure to RFR at different frequencies on two different colorectal cancer cell lines; HCT-116 and DLD-1. Protein levels were subsequently analyzed by ELISA. **Results** RFR led to a decrease in P53, p-P53, p-P38, and p-IkB levels in HCT-116 cells, while leading to an increase in BAD, p-BAD, p-STAT3, NF-κB levels. Two thousand one hundred Megahertz of RFR altered the P53, BAD, and NF-κB expression in HCT-116 cells. P53, p-P53, BAD, p-BAD, NF-κB, p-NF-κB, p-P38, p-SAPK/JNK, p-STAT3, and p-IkB levels increased after exposure to RFR at 900 and 2,100 MHz in DLD-1 cells. Unlike HCT-116 cells, 1,800 MHz of RFR was reported to have no effect on DLD1 cells. **Conclusions** RFR increased apoptosis and inflammatory response in HCT116 cells, while lowering the active P38 and active P53 levels, which are indicators of poor prognosis in several cancers. Genetic differences, such as P53 mutation (DLD-1), are critical to the cell response to RFR, which explains the reason why scientific studies on the effects of RFR yield contradictory results.  
<https://doi.org/10.1515/tjb-2020-0148>

Panagopoulos, D. J., Karabarounis, A., Yakymenko, I., & Chrousos, G. P. 2021 **Human made electromagnetic fields: Ion forced oscillation and voltage gated ion channel dysfunction, oxidative stress and DNA damage (Review).** *International Journal of Oncology*, 59(5), 92

Exposure of animals/biological samples to human made electromagnetic fields (EMFs), especially in the extremely low frequency (ELF) band, and the microwave/radio frequency (RF) band which is always combined with ELF, may lead to DNA damage. DNA damage is connected with cell death, infertility and other pathologies, including cancer. ELF exposure from high voltage power lines and complex RF exposure from wireless communication antennas/devices are linked to increased cancer risk. Almost all human made RF EMFs include ELF components in the form of modulation, pulsing and random variability. Thus, in addition to polarization and coherence, the existence of ELF is a common feature of almost all human made EMFs. The present study reviews the DNA damage and related effects induced by human made EMFs. The ion forced oscillation mechanism for irregular gating of voltage gated ion channels on cell membranes by polarized/coherent EMFs is extensively described. Dysfunction of ion channels disrupts intracellular ionic concentrations, which determine the cell's electrochemical balance and homeostasis. The present study shows how this can result in DNA damage through reactive oxygen species/free radical overproduction. Thus, a complete picture is provided of how human made EMF exposure may indeed lead to DNA damage and related pathologies, including cancer. Moreover, it is suggested that the non thermal biological effects attributed to RF EMFs are actually due to their ELF components.  
<https://doi.org/10.3892/ijo.2021.5272>

Rasouli Mojez, M., Ali Gaeini, A., Choobineh, S., & Sheykhloovand, M. 2021 **Hippocampal Oxidative Stress Induced by Radiofrequency Electromagnetic Radiation and the Neuroprotective Effects of Aerobic Exercise in Rats: A Randomized Control Trial.** *Journal of Physical Activity & Health*, 1–7

**BACKGROUND:** The present study determined whether 4 weeks of moderate aerobic exercise improves antioxidant capacity on the brain of rats against oxidative stress caused by radiofrequency electromagnetic radiation emitted from cell

phones.**METHODS:** Responses of malondialdehyde, catalase, glutathione peroxidase, and superoxide dismutase, as well as the

number of hippocampal dead cells, were examined. Male Wistar rats (10-12 wk old) were randomly assigned to 1 of 4 groups (N = 8): (1) moderate aerobic exercise (EXE) (2 × 15-30 min at 1215 m/min speed with 5 min of active recovery between sets), (2) exposure to 900/1800 MHz radiofrequency electromagnetic waves 3 hours per day (RAD), (3) EXE + RAD, and (4) exposure to an experimental phone without battery. RESULTS: Following the exposure, the number of the hippocampal dead cells was significantly higher in group RAD compared with groups EXE, EXE + RAD, and control group. Malondialdehyde concentration in group RAD was significantly higher than that of groups EXE, EXE + RAD, and control group. Also, the activity of catalase, glutathione peroxidase, and superoxide dismutase in groups EXE, EXE + RAD, and control group was significantly higher compared with those of the exposure group. CONCLUSION: This study demonstrated that moderate aerobic exercise enhances hippocampal antioxidant capacity against oxidative challenge in the form of radiofrequency electromagnetic waves.  
<https://doi.org/10.1123/jpah.2021-0213>

Rodrigues, N. C. P., Dode, A. C., de Noronha Andrade, M. K., O'Dwyer, G., Monteiro, D. L. M., Reis, I. N. C., ... Lino, V. T. S. 2021 **The Effect of Continuous Low-Intensity Exposure to Electromagnetic Fields from Radio Base Stations to Cancer Mortality in Brazil.** International Journal of Environmental Research and Public Health, 18(3)  
BACKGROUND: this study aims to estimate the rate of death by cancer as a result of Radio Base Station (RBS) radiofrequency exposure, especially for breast, cervix, lung, and esophagus cancers. METHODS: we collected information on the number of deaths by cancer, gender, age group, gross domestic product per capita, death year, and the amount of exposure over a lifetime. We investigated all cancer types and some specific types (breast, cervix, lung, and esophagus cancers). RESULTS: in capitals where RBS radiofrequency exposure was higher than 2000/antennas-year, the average mortality rate was 112/100,000 for all cancers. The adjusted analysis showed that, the higher the exposure to RBS radiofrequency, the higher cancer mortality was. The highest adjusted risk was observed for cervix cancer (rate ratio = 2.18). The spatial analysis showed that the highest RBS radiofrequency exposure was observed in a city in southern Brazil that also showed the highest mortality rate for all types of cancer and specifically for lung and breast cancer. CONCLUSION: the balance of our results indicates that exposure to radiofrequency electromagnetic fields from RBS increases the rate of death for all types of cancer.  
<https://doi.org/10.3390/ijerph18031229>

Schuermann, D., & Mevissen, M. 2021 **Manmade Electromagnetic Fields and Oxidative Stress—Biological Effects and Consequences for Health** International Journal of Molecular Sciences, 22(7), 3772  
Concomitant with the ever-expanding use of electrical appliances and mobile communication systems, public and occupational exposure to electromagnetic fields (EMF) in the extremely-low-frequency and radiofrequency range has become a widely debated environmental risk factor for health. Radiofrequency (RF) EMF and extremely-low-frequency (ELF) MF have been classified as possibly carcinogenic to humans (Group 2B) by the International Agency for Research on Cancer (IARC). The production of reactive oxygen species (ROS), potentially leading to cellular or systemic oxidative stress, was frequently found to be influenced by EMF exposure in animals and cells. In this review, we summarize key experimental findings on oxidative stress related to EMF exposure from animal and cell studies of the last decade. The observations are discussed in the context of molecular mechanisms and functionalities relevant to health such as neurological function, genome stability, immune response, and reproduction. Most animal and many cell studies showed increased oxidative stress caused by RF-EMF and ELF-MF. In order to estimate the risk for human health by manmade exposure, experimental studies in humans and epidemiological studies need to be considered as well.  
<https://doi.org/10.3390/ijms22073772>

Sharma, A., Shrivastava, S., & Shukla, S. 2021 **Oxidative damage in the liver and brain of the rats exposed to frequency-dependent radiofrequency electromagnetic exposure: biochemical and histopathological evidence.** Free Radical Research, 55(5), 535–546  
The study aimed to discover a link between the liver and brain's functional status due to frequency dependent-radiofrequency electromagnetic radiation (RF-EMR). Forty Wistar rats were randomly classified as control (sham-exposed) and EMR exposed groups. Animals were exposed to 900, 1800, and 2100 MHz with the specific absorption rate (SAR) 0.434 (W/Kg), 0.433 (W/Kg), and 0.453 (W/Kg) respectively. Animal exposure was limited at 1 h/day, 5 days/week for 1 month with a restricted power density (900 MHz- 11.638 µW/m<sup>2</sup>, 1800- 11.438 µW/m<sup>2</sup> and 2100 MHz frequency- 8.237 µW/m<sup>2</sup>). Exposure at various frequencies showed a frequency-dependent change in the body weight and hematologic parameters (RBCs, WBCs, platelets, hemoglobin, and hematocrit) as compared with the control group (p ≤ 0.01) (p ≤ 0.001). A significant elevation in serum transaminases and bilirubin, urea, uric acid, and creatinine was noted, whereas albumin significantly decreased after EMR exposure (p ≤ 0.01) (p ≤ 0.001). The blood glucose, lipid peroxidation, triglycerides, and cholesterol were elevated while adenosine triphosphatases, acetylcholinesterase, and tissue antioxidants such as glutathione, superoxide dismutase, catalase, glutathione reductase, glutathione Peroxidase, glutathione-S-transferase, and glucose-6-phosphate dehydrogenases were decreased significantly (p ≤ 0.001). Histopathological observations of the liver showed centrilobular mononuclear cell infiltration and swelling in sinusoidal spaces, while in the brain degenerated pyramidal and Purkinje neurons were seen. Furthermore, Substantial evidence

was found that the brain is more susceptible to oxidative mutilation compare to the liver of exposed animals. In conclusion, RF-EMR exposure showed oxidative damage to the liver, increasing the incidence of brain damage in a frequency-dependent manner. Highlights EMR exposure showed frequency-dependent toxicity. Alterations in blood profile and modifications in the serological markers. Increasing lipid peroxidation indicating membrane damage. Inhibition of acetylcholinesterase activity affecting cholinergic neurotransmission. EMR exposure resulted in the loss of cellular energy and production of excess amounts of ROS thereby altering several antioxidant enzymes. Histopathological evidence of severe degenerative changes in the liver and brain.

<https://doi.org/10.1080/10715762.2021.1966001>

Wallace, J., Yahia-Cherif, L., Gitton, C., Hugueville, L., Lemaréchal, J.-D., & Selmaoui, B. 2021

**Human resting-state EEG and radiofrequency GSM mobile phone exposure: the impact of the individual alpha frequency.**

International Journal of Radiation Biology, 1–10

**PURPOSE:** With the extensive use of mobile phone (MP), several studies have been realized to investigate the effects of radiofrequency electromagnetic fields (RF-EMF) exposure on brain activity at rest via electroencephalography (EEG), and the most consistent effect has been seen on the alpha band power spectral density (PSD). However, some studies reported an increase or a decrease of the PSD, while others showed no effect. It has been suggested that these differences might partly be due to a variability of the physiological state of the brain between subjects. So, the aim of this study was to investigate the alpha band modulation, exploring the impact of the alpha band frequency ranges applied in the PSD analysis. **MATERIALS AND METHODS:** Twenty-one healthy volunteers took part to the study with a double-blind, randomized and counterbalanced crossover design, during which eyes-open (EO) and eyes-closed (EC) resting-state EEG was recorded. The exposure system was a sham or a real GSM (global system for mobile) 900 MHz MP (pulse modulated at 217 Hz, mean power of 250 mW and 2 W peak, with a maximum specific absorption rate of 0.70 W/kg on 1 g tissue). The experimental protocol presented a baseline recording phase without MP exposure, an exposure phase during which the exposure system was placed against the left ear, and the post-exposure phase without MP. EEG data from baseline and exposure phases were analyzed and PSD was computed for the alpha band in the fixed range of 8-12 Hz and for the individual alpha band frequency range (IAF). **RESULTS:** Results showed a trend in decrease or increase of EEG power of both alpha oscillations during exposure in relation to EC and EO recording conditions, respectively, but not reaching statistical significance. Findings did not provide evidence for a different sensitivity to RF-EMF MP related to individual variability in the frequency of the alpha band. **CONCLUSION:** In conclusion, these results did not show alpha band activity modulation during resting-state under RF-EMF. It might be argued the need of a delay after the exposure in order to appreciate an EEG spectral power modulation related to RF-EMF exposure.

<https://doi.org/10.1080/09553002.2021.2009146>

Wongkasem, N. 2021

**Electromagnetic pollution alert: Microwave radiation and absorption in human organs and tissues.**

Electromagnetic Biology and Medicine, 1–18

Electromagnetic radiation from communication and electronic devices, networks, systems and base stations has drawn concern due to excessive global usage with increasing power and operating frequency level. Numerous previous researches only focus on how the radiation from certain frequency ranges of particular devices could harm specific human organs and tissues, resulting in distinct symptoms. In this research, electromagnetic propagation and properties in 14 human organs and tissues were analyzed and investigated based on the organs and tissues' electromagnetic and mechanical parameters, and chemical composition. Counting the organs and tissues as electromagnetic materials, their permittivity and conductivity, computed by a 4-Cole-Cole mode, directly respective to the operating frequency, are interrelated to wave behavior and hence influence the organs' response. Tests were conducted in 1 GHz to 105 GHz system settings, covering most microwave frequency uses: 2.4 GHz of 4G-LTE, Wi-Fi, Bluetooth, ZigBee and the 5G ranges: 28 GHz of 5G-mmW and 95 GHz of 5G-IoT. Trial human organs and tissues were placed in the wave propagation direction of 2.4 GHz and 28 GHz dipole antennas, and a waveguide port operating from 95 to 105 GHz. The quantitative data on the effects of 5G penetration and dissipation within human tissues are presented. The absorbance in all organs and tissues is significantly higher as frequency increases. As the wave enters the organ-tissue model, the wavelength is shortened due to the high organ-tissue permittivity. Skin-Bone-Brain layer simulation results demonstrate that both electric and magnetic fields vanish before passing the brain layer at all three focal frequencies of 2.4 GHz, 28 GHz and 100 GHz.

<https://doi.org/10.1080/15368378.2021.1874976>

Wood, A., Mate, R., & Karipidis, K. 2021

**Meta-analysis of in vitro and in vivo studies of the biological effects of low-level millimetre waves.** J. Exposure Science & Environmental Epidemiology

**Background** With the roll-out of new technologies such as 5G, there has been renewed community concern regarding the adequacy of research on possible health effects from associated radiofrequency radiation, mainly in the millimetre wave (MMW) band. <https://doi.org/10.1038/s41370-021-00307-7>



Xie, W., Xu, R., Fan, C., Yang, C., Chen, H., & Cao, Y. 2021

**900 MHz Radiofrequency Field Induces Mitochondrial Unfolded Protein Response in Mouse Bone Marrow Stem Cells.**

Frontiers in Public Health, 9, 724239

**Objective:** To examine whether exposure of mouse bone marrow stromal cells (BMSC) to 900 MHz radiofrequency fields used in mobile communication devices can induce mitochondrial unfolded protein response (UPRmt). **Methods:** BMSCs were exposed to continuous wave 900 MHz radiofrequency fields (RF) at 120  $\mu\text{W}/\text{cm}^2$  power intensity for 4 h/d for 5 consecutive days. Cells in sham group (SH) were cultured in RF exposure system, but without RF radiation. The positive control cells were irradiated with 6 Gy X-ray at a dose rate of 1.103 Gy/min (XR). To inhibit the upstream molecular JNK2 of UPRmt, cells in siRNA + RF, and siRNA + XR group were also pretreated with 100 nM siRNA-JNK2 for 48 h before RF/XR exposure. Thirty minutes, 4 h, and 24 h post-RF/XR exposure, cells were collected, the level of ROS was measured with flow cytometry, the expression levels of UPRmt-related proteins were detected using western blot analysis. **Results:** Compared with Sham group, the level of ROS in RF and XR group was significantly increased 30 min and 4 h post-RF/XR exposure ( $P < 0.05$ ), however, the RF/XR-induced increase of ROS level reversed 24 h post-RF/XR exposure. Compared with Sham group, the expression levels of HSP10/HSP60/ClpP proteins in cells of RF and XR group increased significantly 30 min and 4 h post-RF/XR exposure ( $P < 0.05$ ), however, the RF/XR-induced increase of HSP10/HSP60/ClpP protein levels reversed 24 h post-RF exposure. After interfering with siRNA-JNK2, the RF/XR exposures could not induce the increase of HSP10/HSP60/ClpP protein levels any more. **Conclusions:** The exposure of 900 MHz RF at 120  $\mu\text{W}/\text{cm}^2$  power flux density could increase ROS level and activate a transient UPRmt in BMSC cells. Mitochondrial homeostasis in term of protein folding ability is restored 24 h post-RF exposure. Exposure to RF in our experimental condition did not cause permanent and severe mitochondrial dysfunctions. However, the detailed underlying molecular mechanism of RF-induced UPRmt remains to be further studied.

<https://doi.org/10.3389/fpubh.2021.724239>

## 2020

Ayinmode, B. O., & Farai, I. P. 2020

**Assessing the risk associated with simultaneous exposure to mobile communication signals within 900-2500 MHz in Nigeria.**

Radiation Protection Dosimetry, 192(3), 371–377

In this study, the total exposure due to signals within GSM 900, GSM 1800, CDMA-1900 and 3G-2100 frequency bands at 200 m from the foot of 120, 100 and 80 base station masts in the Nigerian cities of Lagos, Ibadan and Abuja, respectively, was assessed. A calibrated hand-held spectrum analyser was used to measure the level of power (in dBm) of each signal within the mobile frequency bands. The exposure quotient associated with the combine electric field strengths from the various frequency bands in each city was estimated. The maximum value of total electric field strength at each point in Lagos, Ibadan and Abuja was 0.83 V/m, 0.53 V/m and 1.63 V/m, respectively. This study shows that the exposure quotient due to the simultaneous exposure to the four bands of mobile communication signals in each city is far less than one, as recommend by International Commission on Non-Ionizing Radiation Protection.

<https://doi.org/10.1093/rpd/ncaa203>

Azimzadeh, M., & Jelodar, G. 2020a **Prenatal and early postnatal exposure to radiofrequency waves (900 MHz) adversely affects passive avoidance learning and memory** Toxicology and Industrial Health, 36(12), 1024–1030

Prenatal and early postnatal are the most sensitive and high-risk periods to expose to electromagnetic fields (EMFs). This study aimed to investigate the effect of prenatal and early postnatal exposure to 900 MHz radiofrequency waves (RFWs) emitted from a base transceiver station antenna on passive avoidance learning and memory (PALM) and hippocampus histomorphology. Female Sprague Dawley rats (190-230 g) were paired with males. The mated rats, confirmed by observing a vaginal plug, were divided into two groups; control and exposed. The control group ( $n = 7$ ) was not exposed to RFW. The exposed group was divided into three subgroups ( $n = 8$ ); exposed I, exposed during the gestational period (fetal life), and exposed II and III (postnatal exposure), exposed to RFW during the first 21 days of life, for 2 h/d and 4 h/d, respectively. PALM was evaluated by a shuttle box in 45-day-old pups. Learning and memory of animals were demonstrated as the duration of remaining within the light area, which is called the lighting time. Histological sections were prepared from brain tissues and stained with hematoxylin and eosin. An impairment in the PALM performance was noticed in all exposed subgroups (I, II, and III) ( $p < 0.05$ ). Learning (short-term memory) and retention (long-term memory) behaviors were more affected in exposed subgroup I (prenatal exposed) compared to other postnatal exposed subgroups (II and III). Also, a mild decrease in the density of pyramidal cells was observed in the hippocampus of exposed subgroups (I and III). Prenatal and early postnatal exposure to 900 MHz RFW adversely affected PALM performance and hippocampus tissue in rat pups with more impact for prenatal period exposure.

<https://doi.org/10.1177/0748233720973143>

Azimzadeh, M., & Jelodar, G. 2020b

**The protective effect of vitamin supplementation (E and E + C) on passive avoidance learning and memory during exposure to 900 MHz RFW emitted from BTS** Toxicology and Industrial Health, 36(2), 93–98

Deleterious effects of exposure to electromagnetic radiation on public health have been widely studied. This study was conducted to evaluate the protective effect of vitamin supplementation (E or E + C) on passive avoidance learning (PAL) and memory in rats subjected to 900 MHz radiofrequency waves (RFW). Thirty adult male Sprague-Dawley rats ( $190 \pm 20$  g) were randomly divided into six groups as: control I (vehicle), control II (vitamin E 250 mg/kg), control III (vitamin E 100 mg/kg + l-ascorbic acid 200 mg/kg), and three exposed groups to RFW as: sham-exposed, treatment I (vitamin E), and treatment II (vitamin E + C). The duration of exposure was 30 continuous days (4 h/day). The PAL was evaluated on the last day by the shuttle box. Learning and memory of animals demonstrated as the duration of remaining within the light area, which is called the light time (LT). The sham-exposed group showed a significant decrease in LT on the learning, consolidation, and retention days compared to other groups ( $p < 0.05$ ). Pretreatment with vitamins (E and E + C) could protect PAL against adverse effects of RFW, and the administration of vitamin E + C improved PAL performance in control III compared to control I and treatment II groups ( $p < 0.05$ ). Administration of vitamin E + C to exposed group (treatment II) caused a significant increase in LT on the learning ( $p = 0.013$ ), consolidation, and retention ( $p = 0.009$ ) sessions compared to the treatment group I (vitamin E). Long-term exposure to 900 MHz RFW impaired PAL and memory, and pretreatment of vitamin (E or E + C) prevented these effects, which may be a new potential mechanism against side effects of RFW

<https://doi.org/10.1177/0748233720912058>

Azimzadeh, M., & Jelodar, G. 2020c

**Trace elements homeostasis in brain exposed to 900 MHz RFW emitted from a BTS-antenna model and the protective role of vitamin E.** Journal of Animal Physiology and Animal Nutrition, 104(5), 1568–1574.

Advances in telecommunication and their broad usage in the community have become a great concern from the health aspect. The object of the present study was to examine the effects of exposure to 900 MHz RFW on brain Iron (Fe), Copper (Cu), Zinc (Zn) and Manganese (Mn) concentration, and the protective role of pre-treatment of vitamin E on mentioned elements homeostasis. Twenty adult male Sprague-Dawley rats ( $200 \pm 20$  g) randomly were divided into four groups. Control group (without any exposure, received distilled water), treatment control group (orally received 250 mg/kg BW/d vitamin E), treatment group (received 250 mg/kg BW/d vitamin E and exposed to 900 MHz RFW) and sham-exposed group (exposed to 900 MHz RFW). Animals (with freely moving in the cage) were exposed to RFW for 30 consecutive days (4 hr/day). The levels of the above mentioned elements in the brain tissue were determined on the last day using atomic absorption spectrophotometry. Exposure to 900 MHz RFW induced a significant increase in the Fe, Cu, Mn levels and Cu/Zn ratio accompanied by a significant decrease in Zn level in the sham-exposed group compare to control group. Vitamin E pre-treatment improved the level of Fe, Cu, Mn and Cu/Zn ratio, except in the Zn concentration. Exposure to 900 MHz RFW caused disrupted trace elements homeostasis in the brain tissue and administration of vitamin E as an antioxidant and neuroprotective agent improved the situation.

<https://doi.org/10.1111/jpn.13360>

Borzoueisileh, S., Shabestani Monfared, A., Ghorbani, H., Mortazavi, S. M. J., Zabihi, E., Pouramir, M., ... Niksirat, F. 2020a  
**Assessment of function, histopathological changes, and oxidative stress in liver tissue due to ionizing and non-ionizing radiations.** Caspian Journal of Internal Medicine, 11(3), 315–323

Background: Compared to past decades, humans are exposed to rapidly increasing levels of radiofrequency electromagnetic radiations (RF-EMF). Despite numerous studies, the biological effects of human exposure to different levels of RF-EMF are not fully understood yet. This study aimed to evaluate the bioeffects of exposure to “900/1800 MHz” and “2.4 GHz” RF-EMFs, and x-rays alone as well as their potential interactions, i.e. inducing simple additive, adaptive, or synergistic effects. Methods: 120 Wistar rats were randomly divided into ten groups of 12 each. The rats were exposed to RF-EMF, 10 cGy, and 8 Gy x-rays, a combination of these exposures, or only sham-exposed. The levels of liver enzymes were determined in serum samples by an auto-analyzer. Moreover, the histopathological changes, and the levels of malondialdehyde (MDA), nitric oxide, ferric reducing antioxidant power, total thiols, and protein carbonyl (PCO) were measured. Results: Among the markers of liver function, gamma-glutamyltransferase was not associated with irradiation but, aspartate transaminase, alanine transaminase, and alkaline phosphatase showed some levels of association. MDA and PCO levels after 8 Gy irradiation increased, but pre-exposure to RF-EMF could modulate their changes. At the cellular level, the frequency of lobular inflammation was associated with the type of intervention. Conclusion: The exposure to both ionizing and non-ionizing radiations could alter some liver function tests. A short term pre-exposure to RF-EMF before exposure to an 8 Gy challenging dose of x-rays caused the alterations in oxidative stress markers and liver function tests, which indicate that oxidative stress is possibly involved in the adaptive response.

<https://doi.org/10.22088/cjim.11.3.315>

Borzoueisileh, S., Shabestani Monfared, A., Ghorbani, H., Mortazavi, S. M. J., Zabihi, E., Pouramir, M., ... Niksirat, F. 2020b **Combined Effects of Radiofrequency Electromagnetic Fields and X-Ray in Renal Tissue and Function.** Research and Reports in Urology, 12, 527–532

Purpose: Biochemical and histopathological properties of renal tissues were reported to be affected by both radiofrequency electromagnetic fields (RF-EMF) and ionizing radiation. The radiation-induced changes in the kidney, including the serum levels of blood urea nitrogen (BUN) and creatinine (Cr), could lead to adverse health outcomes such as chronic kidney disease. These complications signify the importance of the research in this field. Thus, in this study, the effects of ionizing and non-ionizing radiations, as well as their combination, were assessed by evaluating the alteration in BUN, Cr, and histopathological changes in kidney tissue. Materials and Methods: Ninety-six male Wistar rats were randomly divided into six groups and were exposed to either 900/1800MHz (mobile phone) or 2.4 GHz RF-EMF (Wi-Fi) radiation for 14 days, 8Gy x-ray, or their combination. Sera were collected from 2 mL of rat blood, then BUN and Cr levels were determined. Also, renal samples were stained with hematoxylin and eosin and evaluated histopathologically. Results: Both BUN and Cr levels raised non-significantly after exposure to 8 Gy x-rays. Moreover, all measurements in the samples of x-ray groups were in borderline or higher than normal values. The BUN levels of control, Wi-Fi, x-ray, and Wi-Fi+x-ray groups were not significantly different. However, Cr levels in the Wi-Fi group were significantly higher than those of the controls, and BUN to Cr ratio levels were significantly lower than those of the controls. Also, tubular atrophy and vessel wall thickening were associated with these exposures. Conclusion: Exposure to 900/1800MHz, 2400 MHz EMF can alter the kidney function. However, pre-exposure to 900/1800MHz EMF could modulate the acute adverse effects of lethal x-ray dose, which addresses the adaptive response in the kidney.  
<https://doi.org/10.2147/RRU.S257365>

Bosquillon de Jenlis, A., Del Vecchio, F., Delanaud, S., Bach, V., & Pelletier, A. 2020 **Effects of co-exposure to 900 MHz radiofrequency electromagnetic fields and high-level noise on sleep, weight, and food intake parameters in juvenile rats.** Environmental Pollution (Barking, Essex: 1987), 256, 113461

OBJECTIVE: Electrohypersensitive people attribute various symptoms to exposure of radiofrequency electromagnetic fields (RF-EMF); sleep disturbance is the most frequently cited. However, laboratory experiments have yielded conflicting results regarding sleep alterations. Our hypothesis was that exposure to RF-EMF alone would lead to slight or non-significant effects but that co-exposure to RF-EMFs and other environmental constraints (such as noise) would lead to significant effects. METHODS: 3-week-old male Wistar rats (4 groups, n = 12 per group) were exposed for 5 weeks to continuous RF-EMF (900 MHz, 1.8 V/m, SAR = 30 mW/kg) in the presence or absence of high-level noise (87.5 dB, 50-20000 Hz) during the rest period. After 5 weeks of exposure, sleep (24 h recording), food and water intakes, and body weight were recorded with or without RF-EMF and/or noise. At the end of this recording period, sleep was scored during the 1 h rest time in the absence of noise and of RF-EMF exposure. RESULTS: Exposure to RF-EMF and/or noise was associated with body weight gain, with hyperphagia in the noise-only and RF-EMF + noise groups and hypophagia in the RF-EMF-only group. Sleep parameters recording over 24 h highlighted a higher frequency of active wakefulness in the RF-EMF-only group and a lower non-rapid eye movement/rapid eye movement sleep ratio during the active period in the noise-only group. There were no differences in sleep duration in either group. During the 1-h, constraint-free sleep recording, sleep rebound was observed in the noise-only group but not in the RF-EMF-only and RF-EMF + noise groups. CONCLUSION: Our study showed effects of RF-EMF, regardless of whether or not the animals were also exposed to noise. However, the RF-EMF + noise group presented no exacerbation of those effects. Our results did not support the hypothesis whereby the effects of RF-EMF on physiological functions studied are only visible in animals exposed to both noise and RF-EMF.  
<https://doi.org/10.1016/j.envpol.2019.113461>

Bouji, M., Lecomte, A., Gamez, C., Blazy, K., & Villégier, A.-S. 2020 **Impact of Cerebral Radiofrequency Exposures on Oxidative Stress and Corticosterone in a Rat Model of Alzheimer's Disease** Journal of Alzheimer's Disease: JAD, 73(2), 467–476  
BACKGROUND: Alzheimer's disease (AD) is the most common type of neurodegenerative disease leading to dementia. Several studies suggested that mobile phone radiofrequency electromagnetic field (RF-EMF) exposures modified AD memory deficits in rodent models. OBJECTIVE: Here we aimed to test the hypothesis that RF-EMF exposure may modify memory through corticosterone and oxidative stress in the Samaritan rat model of AD. METHODS: Long-Evans male rats received intracerebroventricular infusion with ferrous sulphate, amyloid-beta 1-42 peptide, and buthionine-sulfoximine (AD rats) or with vehicle (control rats). To mimic cell phone use, RF-EMF were exposed to the head for 1 month (5 days/week, in restraint). To look for hazard thresholds, high brain averaged specific absorption rates (BASAR) were tested: 1.5 W/Kg (15 min), 6 W/Kg (15 min), and 6 W/Kg (45 min). The sham group was in restraint for 45 min. Endpoints were spatial memory in the radial maze, plasmatic corticosterone, heme oxygenase-1 (HO1), and amyloid plaques. RESULTS: Results indicated similar corticosterone levels but impaired memory performances and increased cerebral staining of thioflavine and of HO1 in the sham AD rats compared to the controls. A correlative increase of cortical HO1 staining was the only effect of RF-EMF in control rats. In AD rats, RF-EMF exposures induced a correlative increase of hippocampal HO1 staining and reduced corticosterone. DISCUSSION: According to our data, neither AD nor control rats showed modified memory after RF-EMF exposures. Unlike control rats, AD rats showed

higher hippocampal oxidative stress and reduced corticosterone with the higher BASAR. This data suggests more fragility related to neurodegenerative disease toward RF-EMF exposures.

<https://doi.org/10.3233/JAD-190593>

Carlberg, M., Koppel, T., Hedendahl, L. K., & Hardell, L. 2020 **Is the Increasing Incidence of Thyroid Cancer in the Nordic Countries Caused by Use of Mobile Phones?** International Journal of Environmental Research and Public Health, 17(23), 9129

The International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) categorized in 2011 radiofrequency (RF) as a possible human carcinogen, Group 2B. During use of the handheld wireless phone, especially the smartphone, the thyroid gland is a target organ. During the 21st century, the incidence of thyroid cancer is increasing in many countries. We used the Swedish Cancer Register to study trends from 1970 to 2017. During that time period, the incidence increased statistically significantly in women with average annual percentage change (AAPC) +2.13%, 95% confidence interval (CI) +1.43, +2.83%. The increase was especially pronounced during 2010–2017 with annual percentage change (APC) +9.65%, 95% CI +6.68, +12.71%. In men, AAPC increased during 1970–2017 with +1.49%, 95% CI +0.71, +2.28%. Highest increase was found for the time period 2001–2017 with APC +5.26%, 95% CI +4.05, +6.49%. Similar results were found for all Nordic countries based on NORDCAN 1970–2016 with APC +5.83%, 95% CI +4.56, +7.12 in women from 2006 to 2016 and APC +5.48%, 95% CI +3.92, +7.06% in men from 2005 to 2016. According to the Swedish Cancer Register, the increasing incidence was similar for tumors ≤4 cm as for tumors >4 cm, indicating that the increase cannot be explained by overdiagnosis. These results are in agreement with recent results on increased thyroid cancer risk associated with the use of mobile phones. We postulate that RF radiation is a causative factor for the increasing thyroid cancer incidence.

<https://doi.org/10.3390/ijerph17239129>

Caumo, G. H., Spritzer, D., Carissimi, A., & Tonon, A. C. 2020 **Exposure to electronic devices and sleep quality in adolescents: A matter of type, duration, and timing.** Pediatric and Adolescent Sleep Health 6(2):172-178

Objectives: The objective was to describe (1) the type, (2) the amount of use, and (3) the time of usage of electronic devices, for school days and weekends, as well as its impact on adolescents' sleep quality. Design: A cross-sectional study using hierarchical regressions accounting for confounding sleep-related variables was used. Setting: The participants were from six public schools in Porto Alegre, Brazil. Participants: The participants included 177 students of both sexes aged between 11 and 18 years. Measurements: An electronic usage diary assessed the span of time during which the electronic device was used (separated by "TV and computer monitors", "tablets, e-readers and portable video games," and "cell phones") for school days and weekends. The Munich Chronotype Questionnaire was used to assess sleep duration, midpoint of sleep, and social jetlag. Sleep quality was assessed using the Pittsburgh Sleep Quality Index. Results: Greater nighttime use and last time of use of cell phones at night are associated with worse sleep quality in univariate analyses. A hierarchical regression model shows that poor sleep quality associates with shorter sleep duration on school days and with a delayed midpoint of sleep on weekends. Electronic device use did not reach statistical significance in the regression model with confounding factors. Conclusions: Adequate sleep duration is imperative to maintain a good sleep quality on school days, independently of the use of cell phones. It is important to underpin the need for evaluation of sleep phase and chronotype in future research on the topic aiming to elucidate its relationship with electronic use on school-free days.

<https://doi.org/10.1016/j.sleh.2019.12.004>

Choi, Y.-J., Moskowitz, J. M., Myung, S.-K., Lee, Y.-R., & Hong, Y.-C. 2020 **Cellular Phone Use and Risk of Tumors: Systematic Review and Meta-Analysis.** International Journal of Environmental Research and Public Health, 17(21), 8079

We investigated whether cellular phone use was associated with increased risk of tumors using a meta-analysis of case-control studies. PubMed and EMBASE were searched from inception to July 2018. The primary outcome was the risk of tumors by cellular phone use, which was measured by pooling each odds ratio (OR) and its 95% confidence interval (CI). In a meta-analysis of 46 case-control studies, compared with never or rarely having used a cellular phone, regular use was not associated with tumor risk in the random-effects meta-analysis. However, in the subgroup meta-analysis by research group, there was a statistically significant positive association (harmful effect) in the Hardell et al. studies (OR, 1.15; 95% CI, 1.00 to 1.33; n = 10), a statistically significant negative association (beneficial effect) in the INTERPHONE-related studies (case-control studies from 13 countries coordinated by the International Agency for Research on Cancer (IARC); (OR, 0.81; 95% CI, 0.75 to 0.89; n = 9), and no statistically significant association in other research groups' studies. Further, cellular phone use with cumulative call time more than 1000 h statistically significantly increased the risk of tumors. This comprehensive meta-analysis of case-control studies found evidence that linked cellular phone use to increased tumor risk.

<https://doi.org/10.3390/ijerph17218079>

Clegg, F. M., Sears, M., Friesen, M., Scarato, T., Metzinger, R., Russell, C., ... Miller, A. B. 2020 **Building science and radiofrequency radiation: What makes smart and healthy buildings.** Building and Environment, 176, 106324.

Radiofrequency radiation (RFR), used for wireless communications and “smart” building technologies, including the “Internet of Things,” is increasing rapidly. As both RFR exposures and scientific evidence of harmful effects increase apace, it is timely to heed calls to include low RFR levels as a performance indicator for the health, safety and well-being of occupants and the environment. Adverse biochemical and biological effects at commonly experienced RFR levels indicate that exposure guidelines for the U.S., Canada and other countries are inadequate to protect public health and the environment. Some industry liability insurance providers do not offer coverage against adverse health effects from radiation emitted by wireless technologies, and insurance authorities deem potential liability as “high.” Internationally, governments have enacted laws, and medical and public health authorities have issued recommendations, to reduce and limit exposure to RFR. There is an urgent need to implement strategies for no- or low-RFR emitting technologies, and shielding, in building design and retrofitting. These strategies include installing wired (not wireless) Internet networks, corded rather than cordless phones, and cable or wired connections in building systems (e.g., mechanical, lighting, security). Building science can profit from decades of work to institute performance parameters, operationalizing prudent guidelines and best practices. The goal is to achieve RFR exposures that are ALARA, “As Low As Reasonably Achievable.” We also challenge the business case of wireless systems, because wired or cabled connections are faster, more reliable and secure, emit substantially less RFR, and consume less energy in a sector with rapidly escalating greenhouse gas emissions.

<https://doi.org/10.1016/j.buildenv.2019.106324>

Czerwiński, M., Januszkiewicz, Ł., Vian, A., & Lázaro, A. 2020 **The influence of bioactive mobile telephony radiation at the level of a plant community – Possible mechanisms and indicators of the effects.** *Ecological Indicators*, 108, 105683.

Environmental exposure to radiofrequency electromagnetic fields (RF-EMFs) from mobile telephony has rapidly increased in the last two decades and this trend is expected to continue. The effects of this exposure at plant community level are unknown and difficult to assess in a scientifically appropriate manner. Such an assessment can be scientifically adequate if a studied plant community is completely new and control-impact radiation treatment is used.

<https://doi.org/10.1016/j.ecolind.2019.105683>

Davis, D. L., Pilarcik, A. M., & Miller, A. B. 2020 **Increased Generational Risk of Colon and Rectal Cancer in Recent Birth Cohorts under Age 40 - the Hypothetical Role of Radiofrequency Radiation from Cell Phones** *Annals of Gastroenterology and Digestive Disorders*, 3(1)

To determine if there are shifts in patterns of cancer, rates of disease can be evaluated in terms of Generational Risk (GR), comparing those born recently with those born decades earlier. Using data from the U.S. Centers for Disease Control and Prevention (CDC), the U.S. Surveillance Epidemiology and End-Results (SEER) Program and Iranian cancer registries, increases in GR of colon and rectal cancer in those under age 50 are presented. For the U.S. those born in the 1990s have a doubled risk of colon cancer (GR=2) and a fourfold increase in rectal cancer (GR=4) by the time they reach age 24 compared to those born six decades ago. Experimental studies have determined that the colon and rectum of Sprague-Dawley rats are exquisitely sensitive to both ionizing and non-ionizing radiofrequency radiation (RFR), expressing significant differences in patterns of methylation of a number of well-identified proteins and other biomarkers predictive of cancer risk. Modeling of nonionizing exposures also indicates that absorption of RFR into the colon and rectum from cell phones stored in the pocket exceeds current test limits by up to 5-fold. French government tests of phones positioned next to the body report exposures to nonionizing radiation that are up to 11 times more than current guidelines. Based on these findings, it is prudent to develop policies to reduce direct exposures to RFR from cell phones, as occurs when they are kept next to the body, and to promote advances in hardware and software that reduce direct exposures to RFR.

<https://www.somatopublications.com/increased-generational-risk-of-colon-and-rectal-cancer-in-recent-birth-cohorts-under-age-40-the-hypothetical-role-of-radiofrequency-radiation-from-cell-phones.pdf>

De Giudici, P., Genier, J.-C., Martin, S., Doré, J.-F., Ducimetière, P., Evrard, A.-S., ... Ségala, C. 2020 **Radiofrequency exposure of people living near mobile-phone base stations in France.** *Environmental Research*, 110500

In response to the demand from a growing number of people concerned about the possible impact of RF-EMF on health, the French National Frequency Agency (ANFR) has published a standardized protocol for in-situ measurements of radiofrequency electromagnetic fields (RF-EMF). This protocol was based on the search for the point of highest field strength and the use of spot measurement. In the framework of an epidemiological study, such spot measurements were implemented in the homes of 354 participants located in urban areas within 250 m of a mobile-phone base station (MPBS) and in the main beam direction of the antenna. Among the participants, more than half accepted to be enrolled in a longer-term study, among whom 152 were equipped with a personal exposure meter (PEM) for 48 h and 40 for seven continuous days. Both spot and PEM measurements quantified downlink field strengths, i.e. FM, TV3-4-5, TETRA I-II-III, 2 GHz–5GHz Wi-Fi, WiMax, GSM900, GSM1800, UMTS900, UMTS 2100, LTE800, LTE1800, and LTE2600. Spot measurements showed a mean/median field strength of 0.58/0.44 V/m for total RF-EMF and 0.43/0.27 V/m from the MPBS. RF-EMF from the MPBS was the dominant source of exposure in 64% of households. Exposure to RF-EMF was influenced by the position of the windows with respect to the MPBS, in particular line-of-



site visibility, the distance of the antenna and the floor of the apartment. The PEM surveys showed the measured exposure to be higher during outings than at home and during the day than at night, but there was no difference between the weekends and working days. There was a strong correlation between exposure quantified by both spot and PEM measurements, although spot measures were approximately three times higher than those by PEMs. This study is the first to assess exposure to RF-EMF of people living near a MPBS in urban areas in France. These preliminary results suggest the value of using spot measurements to estimate the impact of the evolution of the mobile-phone network and technology on the exposure of populations to RF-EMF. The low levels of RF-EMF expressed as mean values do not necessarily rule out possible health effects of this exposure.  
<https://doi.org/10.1016/j.envres.2020.110500>

Dos Santos, M. A. L., de Santana, F. S., Soares, A. F., de Sousa, S. F., Menezes, L. S., & Takeshita, W. M. 2020 **Genotoxic and cytotoxic effects of mobile phone use on the oral epithelium: a systematic review with meta-analysis.** General Dentistry, 68(6), 70–74.

The use of mobile phones is based on radiofrequency (RF) waves, and the devices act as transmitters and receivers of non-ionizing energy. The micronucleus test was developed to identify increases in the occurrence of mutations in cells exposed to various agents. This systematic review with meta-analysis adhered to the following protocol: defining the objective, outlining the search method (PICO model), conducting the search, identifying literature, selecting articles, and extracting data. The study aimed to answer the following research question: Does non-ionizing radiation emitted by mobile phones have genotoxic and/or cytotoxic effects on the oral epithelium? The search for evidence published 2009–2019 was conducted in the MEDLINE, PubMed, Scopus, LILACS, Google Scholar, PROSPERO, and Cochrane Library databases. The following inclusion criteria were defined: investigations of effects on the oral mucosa related to RF; investigations of cytotoxic and/or genotoxic effects; investigations involving humans; and investigations using cells exfoliated from the oral epithelium. Investigations related to the parotid gland were excluded. The search strategy found 464 articles; after application of the eligibility criteria, 358 abstracts were analyzed and 351 abstracts excluded. After 7 full texts were reviewed, 1 study was excluded. The 6 included studies were classified as level 5 quality of evidence (observational studies). The meta-analysis included 2 studies that compared the frequency of micronuclei on the side exposed to RF electromagnetic fields (RF-EMFs) to that on the unexposed side. The studies evaluated presented a low degree of evidence, but the meta-analysis indicated that no genotoxic effects are associated with mobile phone use. However, observations of other nuclear abnormalities in some studies suggest the occurrence of cytotoxic effects caused by exposure to the RF-EMFs emitted by mobile phones. More studies are necessary to prove or refute this association.  
<https://pubmed.ncbi.nlm.nih.gov/33136050/>

Er, H., Basaranlar, G., Ozen, S., Demir, N., Kantar, D., Yargicoglu, P., & Derin, N. 2020 **The effects of acute and chronic exposure to 900 MHz radiofrequency radiation on auditory brainstem response in adult rats** Electromagnetic Biology and Medicine, 39(4), 374–386

The aim of this study was to determine the effects of short and long-term RFR exposure on ABR by evaluating lipid peroxidation and antioxidant status in adult rats. Sixty male albino Wistar rats were randomly divided into four groups. S1:1 week sham, S10:10 weeks sham, E1:1 week RFR, E10:10 weeks RFR. Experimental group rats were exposed to RFR 2 h/day, 5 days/week during the test period. Sham rats were kept in the same conditions without RFR. After the experiment, ABRs were recorded from the mastoids of rats using tone burst acoustic stimuli. Biochemical investigations in rat brain and ultrastructural analysis in temporal cortex were performed. ABR wave I latency prolonged in E1-group and shortened in E10-group compared to their shams. TBARS level increased in E1-group, decreased in E10-group, on the contrary, SOD and CAT activities and GSH level decreased in E1-group, increased in E10-group compared to their sham groups. Edema was present in the neuron and astrocyte cytoplasm and astrocyte end-feet in both E1 and E10 groups. Our results suggest that 900 MHz RFR may have negative effects on the auditory system in acute exposure and no adverse effects in chronic exposure without weekends.  
<https://doi.org/10.1080/15368378.2020.1813159>

Favre, D., & Johansson, O. 2020 Does enhanced electromagnetic radiation disturb honeybees' behaviour? Observations during New Year's Eve 2019 International Journal of Research - 8(11), 7–14

Insects, and especially honeybees, are under major threat everywhere around the globe. Current studies lack in the consideration of potential effects which may directly affect other organisms or ecosystems, because of the verPy limited attention which is usually received by the potential adverse ecological effects of radiofrequency electromagnetic fields. Here, it is hypothesized that planetary enhancement of electromagnetic radiation produces a disturbing pollution for honeybees. In order to test this hypothesis, a bi-directional wide frequency range microphone was placed during the New Year's Eve night 2019 in a honeybee hive, in order to detect and analyze potential changes in the acoustic behaviour of the bees due to increased phone induced RF-EMF radiation. It was observed that the honeybees produced strong worker piping signals. Such signals are typically produced shortly before takeoff of a swarm, or as the sign of a disturbed colony. It is therefore hypothesized that planetary enhancement of electromagnetic radiation produces a disturbing pollution for honeybees, such as during the New Year's Eve night. Evidence of

proof of such electromagnetic waves taking place at New Year's Eve should be investigated worldwide during forthcoming similar events based on a global network of long term EM measurements.

<https://doi.org/10.29121/granthaalayah.v8.i11.2020.2151>

Frątczak, M., Vargová, B., Tryjanowski, P., Majláth, I., Jerzak, L., Kurimský, J., ... Majláthová, V. 2020 Infected *Ixodes ricinus* ticks are attracted by electromagnetic radiation of 900 MHz *Ticks and Tick-Borne Diseases*, 11(4), 101416

The electromagnetic field (EMF) is known to influence functions of the nervous, cardiovascular and reproductive systems of many animals, including ticks. The aim of this study was to test the behavior of ticks in the presence of radio-frequency EMF. For testing, 160 adult male and 140 adult female unfed *Ixodes ricinus* ticks were used. Individuals were exposed to 900 MHz EMF in the Radiation-Shielded Tube (RST). Ticks were attracted to the irradiated area. This effect was significantly stronger for ticks infected with *Rickettsia* spp., suggesting that pathogens can alter the ticks' response to environmental stimuli. These results lead to the question of whether man-made EMF may have an impact on *I. ricinus* activity and, as such, be a contributing factor to the ongoing changes in the distribution of the tick and its pathogens currently observed in Europe and elsewhere.

<https://doi.org/10.1016/j.ttbdis.2020.101416>

Grasso, R., Pellitteri, R., Caravella, S. A., Musumeci, F., Raciti, G., Scordino, A., ... Campisi, A. 2020 Dynamic changes in cytoskeleton proteins of olfactory ensheathing cells induced by radiofrequency electromagnetic fields *The Journal of Experimental Biology*, 223(Pt 5), jeb217190

Several evidences have suggested the ability of radiofrequency electromagnetic fields to influence biological systems, even if the action mechanisms are not well understood. There are few data on the effect of radiofrequency electromagnetic fields on self-renewal of neural progenitor cells. A particular glial type that shows characteristics of stem cells is olfactory ensheathing cells (OECs). Herein, we assessed the non-thermal effects induced on OECs through radiofrequency electromagnetic fields changing the envelope of the electromagnetic wave. Primary OEC cultures were exposed to continuous or amplitude-modulated 900 MHz electromagnetic fields, in the far-field condition and at different exposure times (10, 15, 20 min). The expression of OEC markers (S-100 and nestin), cytoskeletal proteins (GFAP and vimentin), apoptotic pathway activation by caspase-3 cleavage and cell viability were evaluated. Our results highlight that 20 min of exposure to continuous or amplitude-modulated 900 MHz electromagnetic fields induced a different and significant decrease in cell viability. In addition, according to the electromagnetic field waveform, diverse dynamic changes in the expression of the analysed markers in OECs and activation of the apoptotic pathway were observed. The data suggest that radiofrequency electromagnetic fields might play different and important roles in the self-renewal of OEC stem cells, which are involved in nervous system repair. <https://doi.org/10.1242/jeb.217190>

Greco, F. 2020 Technical Assessment of Ultrasonic Cerebral Tomosphygmography and New Scientific Evaluation of Its Clinical Interest for the Diagnosis of Electrohypersensitivity and Multiple Chemical Sensitivity. *Diagnostics* (Basel, Switzerland), 10(6) Ultrasonic cerebral tomosphygmography (UCTS), also known as "encephaloscan", is an ultrasound-based pulsatile echoencephalography for both functional and anatomical brain imaging investigations. Compared to classical imaging, UCTS makes it possible to locate precisely the spontaneous brain tissue pulsations that occur naturally in temporal lobes. Scientific publications have recently validated the scientific interest of UCTS technique but clinical use and industrial development of this ancient brain imaging technique has been stopped notably in France, not for scientific or technical reasons but due to a lack of financing support. UCTS should be fundamentally distinguished from transcranial Doppler ultrasonography (TDU), which, although it also uses pulsed ultrasounds, aims at studying the velocity of blood flow (hemodynamics) in the cerebral arteries by using Doppler effect, especially in the middle cerebral artery of both hemispheres. Instead, UCTS has the technical advantage of measuring and locating spontaneous brain tissue pulsations in temporal lobes. Recent scientific work has shown the possibility to make an objective diagnosis of electrohypersensitivity (EHS) and multiple chemical sensitivity (MCS) by using UCTS, in conjunction with TDU investigation and the detection of several biomarkers in the peripheral blood and urine of the patients. In this paper, we independently confirm the clinical interest of using UCTS for the diagnosis of EHS and MCS. Moreover, it has been shown that repetitive use of UCTS in EHS and/or MCS patients can contribute to the objective assessment of their therapeutic follow-up. Since classical CT scan and MRI are usually not contributive for the diagnosis and are poorly tolerated by these patients, UCTS should therefore be considered as one of the best imaging technique to be used for the diagnosis of these new disorders and the follow-up of patients.

<https://doi.org/10.3390/diagnostics10060427>

Gulati, S., Kosik, P., Durdik, M., Skorvaga, M., Jakl, L., Markova, E., & Belyaev, I. 2020 Effects of different mobile phone UMTS signals on DNA, apoptosis and oxidative stress in human lymphocytes *Environmental Pollution*, 267, 115632

Different scientific reports suggested link between exposure to radiofrequency radiation (RF) from mobile communications and induction of reactive oxygen species (ROS) and DNA damage while other studies have not found such a link. However, the available studies are not directly comparable because they were performed at different parameters of exposure, including carrier frequency of RF signal, which was shown to be a critical for appearance of the RF effects. For the first time, we comparatively analyzed genotoxic

effects of UMTS signals at different frequency channels used by 3G mobile phones (1923, 1947.47, and 1977 MHz). Genotoxicity was examined in human lymphocytes exposed to RF for 1 h and 3 h using complimentary endpoints such as induction of ROS by imaging flow cytometry, DNA damage by alkaline comet assay, mutations in TP53 gene by RSM assay, preleukemic fusion genes (PFG) by RT-qPCR, and apoptosis by flow cytometry. No effects of RF exposure on ROS, apoptosis, PFG, and mutations in TP53 gene were revealed regardless the UMTS frequency while inhibition of a bulk RNA expression was found. On the other hand, we found relatively small but statistically significant induction of DNA damage in dependence on UMTS frequency channel with maximal effect at 1977.0 MHz. Our data support a notion that each specific signal used in mobile communication should be tested in specially designed experiments to rule out that prolonged exposure to RF from mobile communication would induce genotoxic effects and affect the health of human population.

<https://doi.org/10.1016/j.envpol.2020.115632>

Gultekin, D. H., & Siegel, P. H. 2020 Absorption of 5G Radiation in Brain Tissue as a Function of Frequency, Power and Time IEEE Access, 8, 115593–115612 The rapid release of 5G wireless communications networks has spurred renewed concerns regarding the interactions of higher radiofrequency (RF) radiation with living species. We examine RF exposure and absorption in ex vivo bovine brain tissue and a brain simulating gel at three frequencies: 1.9 GHz, 4 GHz and 39 GHz that are relevant to current (4G), and upcoming (5G) spectra. We introduce a highly sensitive thermal method for the assessment of radiation exposure, and derive experimentally, accurate relations between the temperature rise ( $\Delta T$ ), specific absorption rate (SAR) and the incident power density ( $S_{\text{F}}$ ), and tabulate the coefficients,  $\Delta T/\Delta F$  and  $\Delta T(\text{SAR})/\Delta F$ , as a function of frequency, depth and time. This new method provides both  $\Delta T$  and SAR applicable to the frequency range below and above 6 GHz as shown at 1.9, 4 and 39 GHz, and demonstrates the most sensitive experimental assessment of brain tissue exposure to millimeter-wave radiation to date, with a detection limit of 1 mW. We examine the beam penetration, absorption and thermal diffusion at representative 4G and 5G frequencies and show that the RF heating increases rapidly with frequency due to decreasing RF source wavelength and increasing power density with the same incident power and exposure time. We also show the temperature effects of continuous wave, rapid pulse sequences and single pulses with varying pulse duration, and we employ electromagnetic modeling to map the field distributions in the tissue. Finally, using this new methodology, we measure the thermal diffusivity of ex vivo bovine brain tissue experimentally.

<https://doi.org/10.1109/ACCESS.2020.3002183>

Habauzit, D., Nogue, G., Bourbon, F., Martin, C., Del Vecchio, F., Maunoir-Regimbal, S., ... Debouzy, J. C. 2020 Evaluation of the Effect of Chronic 94 GHz Exposure on Gene Expression in the Skin of Hairless Rats In Vivo Radiation Research 193(4), 351 Millimeter waves (MMW) are broadband frequencies that have recently been used in several applications in wireless communications, medical devices and nonlethal weapons [i.e., the nonlethal weapon, Active Denial Systems, (ADS) operating at 94-95 GHz, CW]. However, little information is available on their potential effects on humans. These radiofrequencies are absorbed and stopped by the first layer of the skin. In this study, we evaluated the effects of 94 GHz on the gene expression of skin cells. Two rat populations consisting of 17 young animals and 14 adults were subjected to chronic long-term 94 GHz MMW exposure. Each group of animals was divided into exposed and sham subgroups. The two independent exposure experiments were conducted for 5 months with rats exposed 3 h per day for 3 days per week to an incident power density of 10 mW/cm<sup>2</sup>, which corresponded to twice the ICNIRP limit of occupational exposure for humans. At the end of the experiment, skin explants were collected and RNA was extracted. Then, the modifications to the whole gene expression profile were analyzed with a gene expression microarray. Without modification of the animal's temperature, long-term chronic 94 GHz-MMW exposure did not significantly modify the gene expression of the skin on either the young or adult rats. <https://doi.org/10.1667/RR15470.1>

Haghani M, Pouladvand V, Mortazavi S M J, Razavinasab M, Bayat M, & Shabani M. 2020 Exposure to Electromagnetic Field during Gestation Adversely Affects the Electrophysiological Properties of Purkinje Cells in Rat Offspring Journal of Biomedical Physics & Engineering, 10(4), 433–440 Background: Prenatal adverse effects of radiofrequency electromagnetic fields (RF-EMF) exposure on nervous system are an issue of major concern. Objective: Thus, in this study we evaluated the membrane current flow properties of Purkinje neurons after maternal exposure to 900 MHz pulsed RF-EMF. Material and Methods: In this experimental study, during all days of pregnancy, rats in the EMF-exposed group were exposed to 900 MHz pulsed-EMF radiation for 6 h per day. The effects of RF-EMF exposure on the electrophysiological properties of the Purkinje cerebellum neurons from male pups were evaluated by whole-cell patch clamp recordings in current and voltage clamp modes. In voltage-clamp experiments, the holding potential was -60mV, and a depolarizing voltage step (1000 ms duration) was applied from -60 to +50 mV in 10 mV increments at 2s intervals. Results: The exposure group demonstrated reduced spontaneous firing associated with upward and rightward shift in I/V curve compared to the control rats. Moreover, the peak amplitude of the current for the exposure pups also revealed a significant decrement. The reversal potential was +40 mV and +20 mV for the control and RF-EMF groups, respectively and showed significant differences between the two groups. Conclusion: The decrease in ion's conductance could be attributed to the observed decrease in the voltage onset of the inward current, peak amplitude and voltage shift.

<https://doi.org/10.31661/jbpe.v0i0.560>

Hardell, L., Carlberg, M., Koppel, T., Nordström, M., & Hedendahl, L. K. 2020 Central nervous system lymphoma and radiofrequency radiation – A case report and incidence data in the Swedish Cancer Register on non-Hodgkin lymphoma Medical Hypotheses, 144, 110052 Earlier animal studies have provided evidence that non-Hodgkin lymphoma (NHL) may be caused by exposure to radiofrequency (RF) radiation. This was recently confirmed by the U.S. National Toxicology (NTP) study that showed an increased incidence of malignant lymphoma in female mice exposed to the GSM modulated or the CDMA modulated cell phone RF radiation. Primary central nervous system lymphoma (PCNSL) is a rare malignancy in humans with poor prognosis. An increasing incidence has been reported in recent years. Based on a case-report we present the hypothesis that use of the hand-held mobile phone may be a risk factor for PCNSL. The increasing incidence of non-Hodgkin lymphoma in Sweden is discussed in relation to etiologic factors.

<https://doi.org/10.1016/j.mehy.2020.110052>

Keleş, A. İ. 2020 Morphological changes in the vertebrae and central canal of rat pups born after exposure to the electromagnetic field of pregnant rats Acta Histochemica, 122(8), 151652

Several studies have investigated the effects of the electromagnetic field (EMF) on the central nervous system. However, we encountered no studies of the effects of EMF applied in the prenatal period on the offspring vertebrae. The aim of this study is to investigate the effect of a 900 megahertz (MHz) EMF applied to rat dams in the prenatal period on the vertebrae of rat pups. Female Sprague Dawley rats weighing 180-250 g were used in the experiment. Rats identified as pregnant were divided into two groups, control (n = 3) and EMF (n = 3). No EMF was applied to the control group pregnant rats. EMF was applied to the EMF group rats for 1 h daily on an equal and standard basis on prenatal days 13-21. All newborn rat pups were divided into pup control (n = 6) (PC) and pup EMF (n = 6) (PEMF) groups, and no treatment was performed on either. All animals were decapitated on day 32, and the spinal cord in the upper thoracic region was harvested. Vertebral tissues were subjected to routine histological procedures. Histopathological examination revealed that PEMF group vertebral cartilage had been converted into bone tissue. Comparison of central canal diameter and area values between the PEMF group and the PC group revealed statistically significant increases in the PEMF group (p = 0.000 and p = 0.001, respectively). Statistical analysis revealed no significant difference in mean body weights between the two groups (p > 0.530). Based on these findings, we think that 900 MHz EMF applied in the prenatal period affects the development of the vertebrae. This effect causes pathological changes in the rat pup vertebrae. These findings now raise the question of whether EMF also has an impact on neurological and neurosurgical diseases involving the vertebrae.

<https://doi.org/10.1016/j.acthis.2020.151652>

Khalil, A. M., Aleman, I., & Al-Qaoud, K. M. 2020 Association between Mobile Phone Using and DNA Damage of Epithelial Cells of the Oral Mucosa J Biotech Biomed, 3, 50–66 Exposure to high levels of radiofrequency radiation can potentially cause tissue damage characteristic of many diseases including cancer. This study explored relationship between use of mobile phone and DNA damage in oral mucosal cells. One hundred individuals completed a questionnaire were grouped according to frequency and duration of mobile usage. Comet and TUNEL assays were used to determine DNA damage and rate of apoptosis, respectively. Number of damaged cells in right cheek was significantly higher than in left cheek in right ear phone dominant users, but not in left ear dominant people. Years of phone use was not positively correlated to degree of DNA damage, however, damage increased with increased frequency of phone use. Apoptotic cells were highest in medium (30-60 min/day) phone users. Although no significant correlation was observed between degree of apoptosis and cumulative year of mobile phone use, phone use must be minimized to reduce health effects. <https://www.semanticscholar.org/paper/Association-between-Mobile-Phone-Using-and-DNA-of-Khalil-Alemam/35df732df62fadebc193b7ef516c8fc22cf5d93b>

Kumar, A., Kaur, S., Chandel, S., Singh, H. P., Batish, D. R., & Kohli, R. K. 2020 Comparative cyto- and genotoxicity of 900 MHz and 1800 MHz electromagnetic field radiations in root meristems of Allium cepa Ecotoxicology and Environmental Safety, 188, 109786 In the last few decades, tremendous increase in the use of wireless electronic gadgets, particularly the cell phones, has significantly enhanced the levels of electromagnetic field radiations (EMF-r) in the environment. Therefore, it is pertinent to study the effect of these radiations on biological systems including plants. We investigated comparative cytotoxic and DNA damaging effects of 900 and 1800 MHz EMF-r in Allium cepa (onion) root meristematic cells in terms of mitotic index (MI), chromosomal aberrations (CAs) and single cell gel electrophoresis (comet assay). Onion bulbs were subjected to 900 and 1800 MHz (at power densities  $261 \pm 8.50$  mW m<sup>-2</sup> and  $332 \pm 10.36$  mW m<sup>-2</sup>, respectively) of EMF-r for 0.5 h, 1 h, 2 h, and 4 h. Root length declined by 13.2% and 12.3%, whereas root thickness was increased by 46.7% and 48.3% after 4 h exposure to 900 MHz and 1800 MHz, respectively. Cytogenetic studies exhibited clastogenic effect of EMF-r as depicted by increased CAs and MI. MI increased by 36% and 53% after 2 and 4 h exposure to 900 MHz EMF-r, whereas it increased by 41% and 67% in response to 1800 MHz EMF-r. Aberration index was increased by 41%-266% and 14%-257% during 0.5-4 h of exposure to 900 MHz and 1800 MHz, respectively, over the control. EMF-r exposure decreased % head DNA (DNAH) and increased % tail DNA (DNAT) and olive tail moment (OTM) at both 900 and 1800 EMF-r. In 4 h exposure treatments, head DNA (%) declined by 19% and 23% at 900 MHz and 1800 MHz, respectively. DNAT and OTM were increased by 2.3 and 3.7 fold upon exposure to 900 MHz EMF-r over

that in the control, whereas 2.8 and 5.8 fold increase was observed in response to 1800 MHz EMF-r exposure for 4 h and the difference was statistically significant. The study concludes that EMF-r in the communication range (900 and 1800 MHz) adversely affect root meristems in plants and induce cytotoxic and DNA damage. EMF-r induced DNA damage was more pronounced at 1800 MHz than that at 900 MHz. <https://doi.org/10.1016/j.ecoenv.2019.109786>

Kumar, S., Singh, V. K., Nath, P., & Joshi, P. C. 2020 An overview of anthropogenic electromagnetic radiations as risk to pollinators and pollination *Journal of Applied and Natural Science*, 12(4), 675–681 Pollinators play a key functional role in most terrestrial ecosystems and provide important ecosystem service to maintain wild plant communities and agricultural productivity. The decline in pollinators has been related to anthropogenic disturbances such as habitat loss, alterations in land use, and climate change. The surge in mobile telephony has led to a marked increase in electromagnetic fields in the atmosphere, which may affect pollinator and pollination. Several laboratory studies have reported negative effects of electromagnetic radiation on reproduction, development, and navigation in insects. The abundance of insects such as the beetle, wasp, and hoverfly, decreased with electromagnetic radiation (EMR), whereas the abundance of underground-nesting wild bees and bee fly unexpectedly increased with EMR. Potential risks for pollinators and biodiversity are anthropogenic radiofrequency electromagnetic radiation (AREMR) (light, radiofrequency). Artificial light at night (ALAN) can alter the function and abundance of pollinator. Evidence of impacts of AREMR is not adequate due to a lack of high quality, field-realistic studies. Whether pollinators experiencing a threat of ALAN or AREMR, while major knowledge gap exists. In this review, the effects of EMR on wild pollinator groups such as wild bees, hoverflies, bee flies, beetles, butterflies, and wasps etc. have been highlighted. Researchers are also recommended for further study on the effects of EMR on insects. This study will be significant to conserve pollinators and other important insects. <https://doi.org/10.31018/jans.v12i4.2420>

Leszczynski, D. 2020 Physiological effects of millimeter-waves on skin and skin cells: an overview of the to-date published studies. *Reviews on Environmental Health*, 35(4), 493–515. The currently ongoing deployment of the fifth generation of the wireless communication technology, the 5G technology, has reignited the health debate around the new kind of radiation that will be used/emitted by the 5G devices and networks - the millimeter-waves. The new aspect of the 5G technology, that is of concern to some of the future users, is that both, antennas and devices will be continuously in a very close proximity of the users' bodies. Skin is the only organ of the human body, besides the eyes, that will be directly exposed to the mm-waves of the 5G technology. However, the whole scientific evidence on the possible effects of millimeter-waves on skin and skin cells, currently consists of only some 99 studies. This clearly indicates that the scientific evidence concerning the possible effects of millimeter-waves on humans is insufficient to devise science-based exposure limits and to develop science-based human health policies. The sufficient research has not been done and, therefore, precautionary measures should be considered for the deployment of the 5G, before the sufficient number of quality research studies will be executed and health risk, or lack of it, scientifically established. <https://doi.org/10.1515/reveh-2020-0056>

Luo, J., Li, H., Deziel, N. C., Huang, H., Zhao, N., Ma, S., ... Zhang, Y. 2020 Genetic susceptibility may modify the association between cell phone use and thyroid cancer: A population-based case-control study in Connecticut *Environmental Research*, 182, 109013 Emerging studies have provided evidence on the carcinogenicity of radiofrequency radiation (RFR) from cell phones. This study aims to test the genetic susceptibility on the association between cell phone use and thyroid cancer. Population-based case-control study was conducted in Connecticut between 2010 and 2011 including 440 thyroid cancer cases and 465 population-based controls with genotyping information for 823 single nucleotide polymorphisms (SNPs) in 176 DNA genes. We used multivariate unconditional logistic regression models to estimate the genotype-environment interaction between each SNP and cell phone use and to estimate the association with cell phone use in populations according to SNP variants. Ten SNPs had  $P < 0.01$  for interaction in all thyroid cancers. In the common homozygote groups, no association with cell phone use was observed. In the variant group (heterozygotes and rare homozygotes), cell phone use was associated with an increased risk for rs11070256 (odds ratio (OR): 2.36, 95% confidence interval (CI): 1.30–4.30), rs1695147 (OR: 2.52, 95% CI: 1.30–4.90), rs6732673 (OR: 1.59, 95% CI: 1.01–2.49), rs396746 (OR: 2.53, 95% CI: 1.13–5.65), rs12204529 (OR: 2.62, 95% CI: 1.33–5.17), and rs3800537 (OR: 2.64, 95% CI: 1.30–5.36) with thyroid cancers. In small tumors, increased risk was observed for 5 SNPs (rs1063639, rs1695147, rs11070256, rs12204529 and rs3800537), In large tumors, increased risk was observed for 3 SNPs (rs11070256, rs1695147, and rs396746). Our result suggests that genetic susceptibilities modify the associations between cell phone use and risk of thyroid cancer. The findings provide more evidence for RFR carcinogenic group classification. <https://doi.org/10.1016/j.envres.2019.109013>

Lupi, D., Tremolada, P., Colombo, M., Giacchini, R., Benocci, R., Parenti, P., ... Vighi, M. 2020 Effects of Pesticides and Electromagnetic Fields on Honeybees: A Field Study Using Biomarkers *International Journal of Environmental Research*, 14 The effects of pesticide mixtures and electric and magnetic fields on honeybees were evaluated in three experimental sites located in RF-EMR References 2017 to mid-2022

northern Italy: a control site far from anthropogenic-stress sources, a semi-natural site close to a high-voltage electric line and an agricultural site with intensive pesticide use. From each experimental site, young workers and foraging bees were taken monthly from May to October and analyzed for four enzymatic biomarkers: acetylcholinesterase (AChE), catalase (CAT), glutathione S-transferase (GST) and alkaline phosphatase (ALP). The results revealed time- and site-specific effects in respect to control site, confirming the role of biomarkers as diagnostic and early-warning tools for multi-stress sources on honeybees. In the electromagnetic-stress site, the effect of an over-activation of all analyzed biomarkers was observed at the end of the season. According to other literature findings, this event was related to a behavioral over-activation in a period in which bees should prepare themselves for overwintering. This finding poses potential problems for winter survival. In the pesticide-stress site, different pesticide-induced responses were identified. We demonstrated in the field that pesticide mixtures currently used in agriculture could greatly affect the biochemical parameters of bees (with both enzymatic under- and over-activations).  
<https://doi.org/10.1007/s41742-019-00242-4>

Özsobacı, N. P., Ergün, D. D., Tunçdemir, M., & Özçelik, D. 2020 Protective Effects of Zinc on 2.45 GHz Electromagnetic Radiation-Induced Oxidative Stress and Apoptosis in HEK293 Cells *Biological Trace Element Research*, 194(2), 368–378  
 Several epidemiological studies have shown that exposure to electromagnetic radiation (EMR) can be harmful to human health. The purpose of this study was to examine oxidative parameters and apoptosis induced by EMR in human kidney embryonic cells (HEK293) and to investigate whether zinc (Zn) has protective effect on EMR-induced apoptosis in HEK293 cells. For our experiment, HEK293 cells were divided into four main groups, control, EMR, 50  $\mu$ M Zn + EMR, and 100  $\mu$ M Zn + EMR. HEK293 cells of EMR groups were exposed to 2.45 GHz EMR for 1 h. In Zn groups, HEK293 cells were incubated with different concentrations of Zn for 48 h before EMR exposure. Oxidative stress parameters were determined by spectrophotometric method; bcl-2 and caspase-3 were assessed immunohistochemically and TUNEL method was performed for apoptotic activity. EMR group had higher malondialdehyde (MDA) level and lower superoxide dismutase (SOD) activity compared with control group. In Zn-applied groups, MDA was decreased and SOD activity was increased compared with EMR group. The number of the apoptotic cells and caspase-3 immunopositive cells at EMR group was increased significantly compared with the control group, whereas bcl-2 was decreased. Besides, Zn-treated groups showed a significant reduction in the number of apoptotic cells and caspase-3 from that of EMR group, whereas there was an increase in bcl-2 immunopositivity. Our findings show that EMR caused oxidative stress and apoptotic activation in HEK293 cells. Zn seems to have protective effects on the EMR by increasing SOD activity and bcl-2 immunopositivity, decreasing lipid peroxidation and caspas-3 immunopositivity.  
<https://doi.org/10.1007/s12011-019-01811-6>

Panagopoulos, D. J. 2020 Comparing chromosome damage induced by mobile telephony radiation and a high caffeine dose: Effect of combination and exposure duration *General Physiology and Biophysics*, 39(6), 531–544  
 I recently reported induction of chromatid-type aberrations in human peripheral blood lymphocytes after a single 15 min exposure to universal mobile telecommunications system (UMTS) mobile telephony (MT) electromagnetic field (EMF) from a mobile phone. Lymphocytes from six healthy subjects were stimulated for mitosis, and exposed during the G2/M phase at 1 cm distance from the handset during an active phone call in “talk” mode. The same type of cells from the same subjects treated with a high caffeine dose (~ 290 times above the permissible single dose for an adult human) exhibited the same type of aberrations in a little smaller but comparable degree. The combination of this caffeine dose and the 15 min MT EMF exposure increased dramatically the number of aberrations in all subjects. The combined effect increased almost linearly with increasing duration of exposure to the MT EMF. Thus, MT EMF exposure ~ 136 times below the official limit (ICNIRP 2020) exerts a genotoxic action even greater than that of a caffeine dose ~ 290 times above the corresponding limit. Therefore, with a reasonable approximation, the limit for MT EMFs should be lowered by at least ~  $4 \times 10^4$  times ( $136 \times 290$ ) for short-term exposures, and ~  $4 \times 10^6$  times for long-term exposures. [https://doi.org/10.4149/gpb\\_2020036](https://doi.org/10.4149/gpb_2020036)

Ren, D.-D., Lu, X.-X., Zhong, W., Ma, H.-R., Chen, J.-W., & Sun, L.-J. 2020 [Guilingji Capsules reduce 900 MHz cellphone electromagnetic radiation-induced testicular oxidative damage and downregulate Prdx2 protein expression in the rat testis] *Zhonghua Nan Ke Xue = National Journal of Andrology*, 26(10), 926–933  
 OBJECTIVE: To investigate the relationship of electromagnetic radiation (EMR) from 900 MHz cellphone frequency with testicular oxidative damage and its influence on the Prdx2 protein expression in the rat testis, and to explore the mechanism of Guilingji Capsules (GC) alleviating oxidative damage to the testis tissue. METHODS: Fifty healthy SD male rats were randomly divided into five groups of equal number, sham-EMR, 4-h EMR, 8-h EMR, 4-h EMR+GC and 8-h EMR+GC and exposed to 900 MHz EMR (370  $\mu$ W/cm<sup>2</sup>) for 0, 4 or 8 hours daily for 15 successive days. The rats of the latter two groups were treated intragastrically with GC suspension and those of the first three groups with pure water after exposure to EMR each day. After 15 days of exposure and treatment, all the rats were sacrificed and their testis tissue collected for observation of the histomorphological and ultrastructural changes by HE staining and transmission electron microscopy, measurement of the levels of serum glutathione (GSH), superoxide dismutase (SOD) and malondialdehyde (MDA) with thiobarbituric acid and determination of the Prdx2 protein expression by immunohistochemistry and Western blot. RESULTS: Compared with the rats in the sham-EMR group, those in the 4-h and 8-h EMR groups showed different degrees of

histomorphological and ultrastructural changes in the testis tissue, significantly decreased levels of GSH (  $[80.62 \pm 10.99$  vs  $[69.58 \pm 4.18]$  and  $[66.17 \pm 8.45]$  mg/L,  $P < 0.05$ ) and SOD (  $[172.29 \pm 10.98]$  vs  $[158.92 \pm 6.46]$  and  $[148.91 \pm 8.60]$  U/ml,  $P < 0.05$ ) and increased level of MDA (  $[7.51 \pm 1.73]$  vs  $[9.84 \pm 1.03]$  and  $[11.22 \pm 2.13]$  umol/ml,  $P < 0.05$ ), even more significantly in the 8-h than in the 4-h EMR group ( $P < 0.05$ ). In comparison with the sham-EMR group, the expression of the Prdx2 protein was markedly downregulated in the 4-h and 8-h EMR groups ( $0.56 \pm 0.03$  vs  $0.49 \pm 0.03$ ,  $0.21 \pm 0.01$ ,  $P < 0.05$ ), but again upregulated in the 4-h and 8-h EMR+GC groups ( $0.55 \pm 0.03$  and  $0.37 \pm 0.04$ ) ( $P < 0.05$ ). **CONCLUSIONS:** Electromagnetic radiation from cellphones can cause ultrastructural damage to the testis tissue of male rats, while Guilingji Capsules can alleviate it, presumably by upregulating the Prdx2 protein expression in the testis tissue and reducing testicular oxidative damage.

<https://pubmed.ncbi.nlm.nih.gov/33382226/>

Revanth, M. P., Aparna, S., & Madankumar, P. D. 2020 Effects of mobile phone radiation on buccal mucosal cells: A systematic review. *Electromagnetic Biology and Medicine*, 39(4), 273–281 The worldwide increased use of mobile phone in recent years has raised many questions on whether their use is safe to user who is exposed to electromagnetic radiation. The aim of the review is to find out the effect of mobile phone emitted radiations on buccal mucosal cells. To identify suitable literature, an electronic search was performed using PubMed, Trip database, Cochrane, Google Scholar and EBSCO host database. The search was focused on the effect of mobile phone radiation on buccal cells. Among the literature available in English, the screening of the related titles and abstracts was done, and only those articles were selected for full-text reading that fulfilled the inclusion and exclusion criteria. The initial literature search resulted in 23 articles out of which only 7 articles fulfilled the criteria were included in this systematic review. The Studies showed that mobile phone-emitted radiations have adverse effects on buccal mucosal cells such as the formation of micronuclei and broken egg which was considered as bio-markers of genotoxicity. <https://doi.org/10.1080/15368378.2020.1793168>

Romeo, S., Sannino, A., Zeni, O., Angrisani, L., Massa, R., & Scarfi, M. R. 2020 Effects of Radiofrequency Exposure and Co-Exposure on Human Lymphocytes: The Influence of Signal Modulation and Bandwidth *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, 4(1), 17–23 The occurrence of modulation-specific effects after co-exposures to radio-frequency (RF) and other agents has been discussed in the literature. In this paper, the influence of modulation and bandwidth in eliciting the DNA damage of RF alone and in combination with mitomycin-C (MMC) is analyzed in human lymphocytes. Blood cultures from healthy donors were exposed to 1950 MHz, and continuous wave (CW), wideband direct-sequence code division multiple access (WCDMA, 4.5 MHz bandwidth), and additive white Gaussian noise (AWGN, 9 MHz bandwidth) signals were considered. For each signal, specific absorption rate (SAR) values of 0.15, 0.3, 0.6, 1.25 W/kg were tested. RF exposure alone never induced DNA damage in the micronucleus assay. When RF exposure was followed by MMC treatment, the effect depended on modulation and bandwidth. CW exposure never altered the MMC-induced DNA damage, while such damage was reduced when either signals WCDMA at 0.3 W/kg SAR or AWGN at 0.15 and 0.3 W/kg were applied. These results indicate the influence of modulation for the occurrence of the protective effect, with a relation between the bandwidth and the power absorbed by samples. If confirmed in vivo, clinical applications using modulated RF signals could be devised to protect cells from side effects of therapeutic treatments. <https://doi.org/10.1109/JERM.2019.2918023>

Schuermann, D., Ziemann, C., Barekati, Z., Capstick, M., Oertel, A., Focke, F., ... Schär, P. 2020 Assessment of Genotoxicity in Human Cells Exposed to Modulated Electromagnetic Fields of Wireless Communication Devices. *Genes*, 11(4), 347. Modulated electromagnetic fields (wEMFs), as generated by modern communication technologies, have raised concerns about adverse health effects. The International Agency for Research on Cancer (IARC) classifies them as “possibly carcinogenic to humans” (Group 2B), yet, the underlying molecular mechanisms initiating and promoting tumorigenesis remain elusive. Here, we comprehensively assess the impact of technologically relevant wEMF modulations on the genome integrity of cultured human cells, investigating cell type-specificities as well as time- and dose-dependencies. Classical and advanced methodologies of genetic toxicology and DNA repair were applied, and key experiments were performed in two separate laboratories. Overall, we found no conclusive evidence for an induction of DNA damage nor for alterations of the DNA repair capacity in cells exposed to several wEMF modulations (i.e., GSM, UMTS, WiFi, and RFID). Previously reported observations of increased DNA damage after exposure of cells to GSM-modulated signals could not be reproduced. Experimental variables, presumably underlying the discrepant observations, were investigated and are discussed. On the basis of our data, we conclude that the possible carcinogenicity of wEMF modulations cannot be explained by an effect on genome integrity through direct DNA damage. However, we cannot exclude non-genotoxic, indirect, or secondary effects of wEMF exposure that may promote tumorigenesis in other ways.

<https://doi.org/10.3390/genes11040347>

Sharma, S., & Shukla, S. 2020 Effect of electromagnetic radiation on redox status, acetylcholine esterase activity and cellular damage contributing to the diminution of the brain working memory in rats *Journal of Chemical Neuroanatomy*, 106, RF-EMR References 2017 to mid-2022

101784 Behavioral impairments are the most pragmatic outcome of long-term mobile uses but the underlying causes are still poorly understood. Therefore, the Aim of the present study to determine the possible mechanism of mobile induced behavioral alterations by observing redox status, cholinesterase activity, cellular, genotoxic damage and cognitive alterations in rat hippocampus. This study was carried out on 24 male Wistar rats, randomly divided into four groups (n = 6 in each group): group I consisted of sham-exposed (control) rats, group II-IV consisted of rats exposed to microwave radiation (900 MHz) at different time duration 1 h, 2 h, and 4 h respectively for 90 days. After 90 days of exposure, rats were assessing learning ability by using T-Maze. A significantly increased level of malondialdehyde (MDA) with concomitantly depleted levels of superoxide dismutase (SOD), catalase (CAT) and redox enzymes (GSH, GPX, GR, GST, G-6PDH) indicated an exposure of mobile emitted EMR induced oxidative stress by the depleted redox status of brain cells. The depletion in the acetylcholinesterase (AChE) level reveals altered neurotransmission in brain cells. Resultant cellular degeneration was also observed in the radiation-exposed hippocampus. Conclusively, the present study revealed that microwave radiation induces oxidative stress, depleted redox status, and causes DNA damage with the subsequent reduction in working memory in a time-dependent manner. This study provides insight over the associative reciprocity between redox status, cellular degeneration and reduced cholinergic activity, which presumably leads to the behavioral alterations following mobile emitted electromagnetic radiation.  
<https://doi.org/10.1016/j.jchemneu.2020.101784>

Shokri, M., Shamsaei, M. E., Malekshah, A. K., & Amiri, F. T. 2020 The protective effect of melatonin on radiofrequency electromagnetic fields of mobile phone-induced testicular damage in an experimental mouse model *Andrologia*, 52(11), e13834 Radiofrequency electromagnetic radiation (RF-EMR) from mobile devices has undesirable effects on the male reproductive organs. Melatonin with antioxidant potential can help to prevent these damages. Therefore, the aim of this study was to evaluate the protective effect of melatonin on testicular damage induced by RF-EMR of mobile phone. In this experimental study, 32 adult male BALB/c mice were divided randomly into four groups: control, melatonin (2 mg/kg, for 30 consecutive days, intraperitoneally), RF-EMR (900 MHz, 100 to 300 MT, 54 to 160 W/m) (4 hr per day, whole body) and melatonin + RF-EMR groups. One day after the last prescription were evaluated oxidative stress parameters, testosterone level and histopathological assays of the testis. EMR of mobile phone led to the induction of oxidative stress, testicular tissue damage and decreased testosterone. Treatment with melatonin improved oxidative stress parameters such as MDA and GSH, and testis injury score, increased the thickness of the germinal epithelial thickness and diameter of the seminiferous tubule, and decreased testosterone hormone in the EMR-exposed mice, and these differences were significant ( $p < .05$ ). Data showed that melatonin with its antioxidant property can decrease oxidative damage induced by RF-EMR of mobile phones on testis tissue.  
<https://doi.org/10.1111/and.13834>

Smith-Roe, S. L., Wyde, M. E., Stout, M. D., Winters, J. W., Hobbs, C. A., Shepard, K. G., ... Witt, K. L. 2020 Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure *Environ. Mol. Mutagen.* 61:276-290, 2020 The National Toxicology Program tested two common radiofrequency radiation (RFR) modulations emitted by cellular telephones in a 2-year rodent cancer bioassay that included interim assessments of additional animals for genotoxicity endpoints. Male and female Hsd:Sprague Dawley SD rats and B6C3F1/N mice were exposed from Gestation day 5 or Postnatal day 35, respectively, to code division multiple access (CDMA) or global system for mobile modulations over 18 hr/day, at 10-min intervals, in reverberation chambers at specific absorption rates of 1.5, 3, or 6 W/kg (rats, 900 MHz) or 2.5, 5, or 10 W/kg (mice, 1,900 MHz). After 19 (rats) or 14 (mice) weeks of exposure, animals were examined for evidence of RFR-associated genotoxicity using two different measures. Using the alkaline (pH > 13) comet assay, DNA damage was assessed in cells from three brain regions, liver cells, and peripheral blood leukocytes; using the micronucleus assay, chromosomal damage was assessed in immature and mature peripheral blood erythrocytes. Results of the comet assay showed significant increases in DNA damage in the frontal cortex of male mice (both modulations), leukocytes of female mice (CDMA only), and hippocampus of male rats (CDMA only). Increases in DNA damage judged to be equivocal were observed in several other tissues of rats and mice. No significant increases in micronucleated red blood cells were observed in rats or mice. In conclusion, these results suggest that exposure to RFR is associated with an increase in DNA damage.  
<https://doi.org/10.1002/em.22343>

Szilágyi, Z., Németh, Z., Bakos, J., Necz, P. P., Sáfár, A., Kubinyi, G., ... Thuróczy, G. 2020 Evaluation of Inflammation by Cytokine Production Following Combined Exposure to Ultraviolet and Radiofrequency Radiation of Mobile Phones on 3D Reconstructed Human Skin In Vitro *International Journal of Environmental Research and Public Health*, 17(12), E4401 The absorption of exposure to radiofrequency (RF) emitted by wireless devices leads to a high specific absorption rate in the skin. Ultraviolet (UV) radiation can induce several damages to the skin. The aim of this study was to examine whether combined, consecutive exposure to solar UV radiation and 1950 MHz RF exposure of third generation (3G) mobile system have any effect on inflammation processes in the skin. Under in vitro experiments, the inflammation process was examined by cytokines (IL-1 $\alpha$ , IL-6, and IL-8) and MMP-1 enzyme secretion on 3D full thickness human skin model. The RF exposure was applied before or after UV irradiation, in order to study either the possible cooperative or protective effects of exposure to RF and UV. We did not find RF-EMR  
 RF-EMR References 2017 to mid-2022



changes in cytokines due to exposure to RF alone. The RF exposure did not enhance the effects of UV radiation. There was a statistically not-significant decrease in cytokines when the skin tissues were pre-exposed to RF before being exposed to 4 standard erythral dose (SED) UV compared to UV exposure alone. We found that RF exposure reduced the previously UV-treated MMP-1 enzyme concentration. This study might support the evaluation of the effects on the skin exposed to microwave radiation of 5G mobile technology. <https://doi.org/10.3390/ijerph17124401>

Szymański, Ł., Sobiczewska, E., Cios, A., Szymanski, P., Ciepielak, M., & Stankiewicz, W. 2020 Immunotropic effects in cultured human blood mononuclear cells exposed to a 900 MHz pulse-modulated microwave field *Journal of Radiation Research*, 61(1), 27–33 The specific biological effect of electromagnetic field (EMF) remains unknown even though devices present in our daily lives, such as smartphones and Wi-Fi antennae increase the environmental level of electromagnetic radiation. It is said that the human immune system is able to react to discrete environmental stimuli like EMF. To investigate the effect of 900 MHz microwave stimulation on the immune system our research aimed to analyze lymphocyte proliferation and observe and assess the basic immunoregulatory activities using a newly developed and improved anechoic chamber. Samples of mononuclear cells (PBMC) isolated from the blood of healthy donors were exposed to 900 MHz pulse-modulated radiofrequency radiation (20 V/m, SAR 0.024 W/kg) twice (15 min each) or left without irradiation (control group). Subsequently, the control and exposed cells were set up to determine several parameters characterizing T cell immunocompetence and monocyte immunogenic activity. Although the microcultures of PBMC exposed to radiofrequency radiation demonstrated higher immunogenic activity of monocytes (LM index) and T-cell response to concanavalin A than control cultures after first exposure, this parameter decreased after a second stimulation. Saturation of the interleukin-2 (IL-2) receptor rose significantly after the second day of exposure. On the other hand, response to mitogen dropped after EMF stimulation. The results suggest that PBMC are able to overcome stress caused by mitogens after stimulation with 900 MHz radiation. <https://doi.org/10.1093/jrr/rrz085>

Tafakori, S., Farrokhi, A., Shalchyan, V., & Daliri, M. R. 2020 Investigating the impact of mobile range electromagnetic radiation on the medial prefrontal cortex of the rat during working memory *Behavioural Brain Research*, 391, 112703 Research has been focused on the effects of radiofrequency electromagnetic radiation (RF-EMR) emitted from a mobile phone on general health, especially the nervous system. The purpose of this study was to investigate the impact of RF-EMR on the brain mechanism of rats by recording local field potentials (LFPs) signals during working memory (WM) task. Subjects were exposed to 900 MHz from a dipole antenna daily for three hours. Exposure was applied, first on a short term base (1 week) and then on a long term base (4 weeks). Behavioral parameters were measured weekly while rats performed T-maze tasks in two types of normal and delayed. LFPs signals were simultaneously recorded by implanted microelectrode arrays on the medial prefrontal cortex (mPFC) of rats. Results showed a significant increase (\* $p < 0.05$ ) in the task completion time of exposed rats which vanished shortly after the end of short term RF-EMR exposure. Before exposure, during correctly performed delayed tasks, an increase (peak) in power changes of theta band (4-12 Hz) was observed. But during correctly performed normal tasks, an increase appeared only by applying RF-EMR exposure. The similarity in power changes pattern of theta band in both types of tasks was observed after long term exposure. Classification accuracy of LFPs in truly done normal and delayed tasks was compared in pre and post-exposure states. Initial classification accuracy was 84.2 % which decreased significantly (\* $P < 0.05$ ) after exposure. These observations indicated that RF-EMR may cause unusual brain functioning which is temporary at least for short term exposure.

<https://doi.org/10.1016/j.bbr.2020.112703>

Thielens, A., Greco, M. K., Verloock, L., Martens, L., & Joseph, W. 2020 Radio-Frequency Electromagnetic Field Exposure of Western Honey Bees *Scientific Reports*, 10(1), 1–14 Radio-frequency electromagnetic fields (RF-EMFs) can be absorbed in all living organisms, including Western Honey Bees (*Apis Mellifera*). This is an ecologically and economically important global insect species that is continuously exposed to environmental RF-EMFs. This exposure is studied numerically and experimentally in this manuscript. To this aim, numerical simulations using honey bee models, obtained using micro-CT scanning, were implemented to determine RF absorbed power as a function of frequency in the 0.6 to 120 GHz range. Five different models of honey bees were obtained and simulated: two workers, a drone, a larva, and a queen. The simulations were combined with in-situ measurements of environmental RF-EMF exposure near beehives in Belgium in order to estimate realistic exposure and absorbed power values for honey bees. Our analysis shows that a relatively small shift of 10% of environmental incident power density from frequencies below 3 GHz to higher frequencies will lead to a relative increase in absorbed power of a factor higher than 3.

<https://doi.org/10.1038/s41598-019-56948-0>

Wallace, J., Andrianome, S., Ghosn, R., Blanchard, E. S., Telliez, F., & Selmaoui, B. 2020 Heart rate variability in healthy young adults exposed to global system for mobile communication (GSM) 900-MHz radiofrequency signal from mobile phones *Environmental Research*, 191, 110097 Given the large number of mobile phone users and the increasing exposure to radiofrequency electromagnetic field (RF-EMF) worldwide, we aimed to study the effect of RF-EMF related to mobile phones on

heart rate variability (HRV). Twenty-six healthy young adults participated in two experimental sessions with a double-blind, randomized and counter-balanced crossover design. During each session, participants were exposed for 26 min to a sham or real 900 MHz RF-EMF, generated by a commercial dual-band Global System for Mobile technology (GSM) mobile phone. We recorded an electrocardiogram at rest during the exposure. We evaluated HRV by time- and frequency-domain analysis. Evaluation of time-domain HRV parameters revealed a statistically significant increase of the standard deviation of interbeat intervals (SDNN) during the real exposure. Other time-domain parameters were not affected. Analysis in the frequency-domain demonstrated that total spectral power and low-frequency band (LF) absolute power were significantly increased during exposure ( $p = .046$  and  $p = .043$ , respectively). However, other parameters were not affected. In conclusion, it seems that most HRV parameters were not affected by GSM signal exposure in our study. The weak effect observed on HRV frequency-domain is likely to represent a random occurrence rather than a real effect. <https://doi.org/10.1016/j.envres.2020.110097>

Wang, J., Li, M., Zhu, D., & Cao, Y. 2020 Smartphone Overuse and Visual Impairment in Children and Young Adults: Systematic Review and Meta-Analysis. *Journal of Medical Internet Research*, 22(12), e21923. Background: Smartphone overuse has been cited as a potentially modifiable risk factor that can result in visual impairment. However, reported associations between smartphone overuse and visual impairment have been inconsistent. Objective: The aim of this systematic review was to determine the association between smartphone overuse and visual impairment, including myopia, blurred vision, and poor vision, in children and young adults. Methods: We conducted a systematic search in the Cochrane Library, PubMed, EMBASE, Web of Science Core Collection, and ScienceDirect databases since the beginning of the databases up to June 2020. Fourteen eligible studies (10 cross-sectional studies and 4 controlled trials) were identified, which included a total of 27,110 subjects with a mean age ranging from 9.5 to 26.0 years. We used a random-effects model for meta-analysis of the 10 cross-sectional studies (26,962 subjects) and a fixed-effects model for meta-analysis of the 4 controlled trials (148 subjects) to combine odds ratios (ORs) and effect sizes (ES). The  $I^2$  statistic was used to assess heterogeneity. Results: A pooled OR of 1.05 (95% CI 0.98-1.13,  $P = .16$ ) was obtained from the cross-sectional studies, suggesting that smartphone overuse is not significantly associated with myopia, poor vision, or blurred vision; however, these visual impairments together were more apparent in children (OR 1.06, 95% CI 0.99-1.14,  $P = .09$ ) than in young adults (OR 0.91, 95% CI 0.57-1.46,  $P = .71$ ). For the 4 controlled trials, the smartphone overuse groups showed worse visual function scores compared with the reduced-use groups. The pooled ES was 0.76 (95% CI 0.53-0.99), which was statistically significant ( $P < .001$ ). Conclusions: Longer smartphone use may increase the likelihood of ocular symptoms, including myopia, asthenopia, and ocular surface disease, especially in children. Thus, regulating use time and restricting the prolonged use of smartphones may prevent ocular and visual symptoms. Further research on the patterns of use, with longer follow up on the longitudinal associations, will help to inform detailed guidelines and recommendations for smartphone use in children and young adults. <https://doi.org/10.2196/21923>

Yahyazadeh, A., & Altunkaynak, B. Z. 2020a Effect of Luteolin on Biochemical, Immunohistochemical, and Morphometrical Changes in Rat Spinal Cord following Exposure to a 900 MHz Electromagnetic Field *Biomedical and Environmental Sciences: BES*, 33(8), 593–602. Objective: This study aimed to investigate the effect of exposure to a 900 MHz electromagnetic field (EMF) on the cervical spinal cord (CSC) of rats and the possible protective effect of luteolin (LUT) against CSC tissue damage. Methods: Quantitative data were obtained via stereological, biochemical, immunohistochemical, and histopathological techniques. We investigated morphometric value, superoxide dismutase (SOD) level, and the expression of high-mobility group box 1 protein molecules, as well as histological changes. Results: The total number of motor neurons in the EMF group significantly decreased in comparison with that in the control group ( $P < 0.05$ ). In the EMF + LUT group, we found a significant increase in the total number of motor neurons compared with that in the EMF group ( $P < 0.05$ ). SOD enzyme activity in the EMF group significantly increased in comparison with that in the control group ( $P < 0.05$ ). By contrast, the EMF+LUT group exhibited a decrease in SOD level compared with the EMF group ( $P < 0.05$ ). Conclusion: Our results suggested that exposure to EMF could be deleterious to CSC tissues. Furthermore, the protective efficacy of LUT against SC damage might have resulted from the alleviation of oxidative stress caused by EMF. <https://doi.org/10.3967/bes2020.078>

Yahyazadeh, A., & Altunkaynak, B. Z. 2020b Neuroprotective efficacy of luteolin on a 900-MHz electromagnetic field-induced cerebellar alteration in adult male rat *Brain Research*, 1744, 146919 The adverse health consequences of exposure to electromagnetic field emitted from cell phone has recently raised public concerns worldwide. Also, the Global System for Mobile Communications (GSM) standard that operates in 900 MHz frequency is the most popular. Therefore, we aimed to investigate the adverse effect of exposure to 900 MHz EMF (1 h/day) on the cerebella of 12-week-old rats. We also evaluated the protective activity of luteolin (20  $\mu$ g/kg/day) against possible biological change in the cerebellar tissues exposed to EMF. Twenty-four male wistar albino rats were randomly assigned into four group of six rats: Control, EMF, EMF + luteolin, luteolin. Serological and biochemical analyses, as well as histopathological examination were performed on all cerebellar samples. We found that SOD (superoxide dismutase) level was significantly increased in the EMF group compared to the control group ( $p < 0.05$ ). To the contrary, decreased SOD activity was detected in the EMF + luteolin group compared to control group ( $p < 0.05$ ). The total number of Purkinje and granular cells was significantly decreased in the EMF group compared to the control

group ( $p < 0.05$ ). In the EMF + luteolin group, the total number of Purkinje and granular cells was significantly higher than the EMF group ( $p < 0.05$ ). Histopathological evaluation also showed destructive damage to the architectures of cerebellar tissues. Our results suggest that exposure to EMF may cause cellular damage to the rat cerebellum. Further, the improvement of cerebellar damage may have resulted from antioxidant efficacy of luteolin by alleviating oxidative stress.  
<https://doi.org/10.1016/j.brainres.2020.146919>

Yahyazadeh, A., Altunkaynak, B. Z., & Kaplan, S. 2020 Biochemical, immunohistochemical and morphometrical investigation of the effect of thymoquinone on the rat testis following exposure to a 900-MHz electromagnetic field *Acta Histochemica*, 122(1), 151467 Long-term use of cell phones emitting electromagnetic fields (EMFs) have raised concerns regarding public health in recent year. We aimed to investigate the possible effects of 900 MHz EMF exposure (60 min/day for 28 days) on the rat testis. Another objective was to determine whether the deleterious effect of EMF radiation would be reduced by the administration of thymoquinone (TQ) (10 mg/kg/day). Twenty-four male adult Wistar albino rats were randomly selected, then assigned into four groups as follow Control, EMF, TQ and EMF + TQ. Testicular samples were analyzed using histological, stereological, biochemical and immunohistochemical techniques. Total numbers of primary spermatocytes and spermatids as well as Leydig cells were significantly decreased in the EMF group compared to the Control group ( $p < 0.05$ ). In the EMF + TQ group, the total number of primary spermatocytes was significantly increased compared to the EMF group ( $p < 0.05$ ). Superoxide dismutase (SOD) activity was significantly increased in the EMF group compared to the Control group ( $p < 0.05$ ). Also, serum testosterone levels and wet weight of testes were significantly decreased in the EMF group compared to the Control group ( $p < 0.05$ ). Our findings suggested that exposure to a 900 MHz EMF had adverse effects on rat testicular tissue and that the administration of TQ partially mitigated testicular oxidative damages caused by EMF radiation.  
<https://doi.org/10.1016/j.acthis.2019.151467>

Yang, M.-L., Hong, S.-Y., Huang, H.-H., Lyu, G.-R., & Wang, L.-X. 2020 [The effects of prenatal radiation of mobile phones on white matter in cerebellum of rat offspring] *Zhongguo Ying Yong Sheng Li Xue Za Zhi = Chinese Journal of Applied Physiology*, 36(1), 77-81 OBJECTIVE: To evaluate the effects of prenatal radiation of 850~1 900 MHz mobile phone on white matter in cerebellum of adult rat offspring. METHODS: Pregnant rats were randomly divided into short term maternal radiation group, long term maternal radiation group and control group. Rats in short term and long term maternal radiation group were exposed to 6 h/d and 24 h/d mobile phone radiation during 1-17 days of pregnancy, respectively. The cerebellums of offspring rats at the age of 3 month( $n=8$ ) were taken. Cell morphology in cerebellum was studied by hematoxylin-eosin (HE) staining. The expressions of myelin basic protein (MBP), neurofilament-L (NF-L) and glial fibrillary acidic protein (GFAP) in cerebellum of rat offspring were detected by immunohistochemistry and Western blot. RESULTS: Compared to control group, the morphological changes of purkinje cells in cerebellum were obvious in rat offspring of short term and long term maternal radiation group. Compared to control group, decreased MBP and NF-L expressions and increased GFAP expression were observed in long term maternal radiation group(all  $P < 0.05$ ). Compared to short term radiation group, the expressions of MBP and NF-L were down-regulated (all  $P < 0.05$ ) and the expression of GFAP was up-regulated( $P < 0.05$ ) in long term radiation group. CONCLUSION: Prenatal mobile phone radiation might lead to the damage of myelin and axon with activity of astrocytes in cerebellum of male rat offspring, which is related to the extent of radiation.  
<https://doi.org/10.12047/j.cjap.5880.2020.017>

## 2019

Alkış, M., Akdag, M., Dasdag, S., Yegin, K., & Akpolat, V. 2019 Single-strand DNA breaks and oxidative changes in rat testes exposed to radiofrequency radiation emitted from cellular phones. *Biotechnology & Biotechnological Equipment*, 33, 1733-1740. The testes are a sensitive organ to electromagnetic pollution and people are concerned about the harmful effects of the radiofrequency radiation (RFR) emitted from cellular phones. Therefore, the purpose of this study was to investigate the effects of long-term exposure to different RFR frequencies on single-strand DNA breaks and oxidative changes in rat testicular tissue. Twenty-eight male Sprague-Dawley rats were divided randomly into four groups. Three groups were exposed to radiation emitted from 900, 1800 and 2100 MHz RF generators, 2 h/day for 6 months. The sham-control group was kept under the same experimental conditions but the RFR generator was turned off. Immediately after the last exposure, testes were removed and DNA damage, 8-hydroxydeoxyguanosine (8-OHdG), malondialdehyde (MDA), total antioxidant status (TAS), total oxidant status (TOS) and oxidative stress index (OSI) were analyzed. The results of this study indicated that RFR increased TOS, OSI, MDA and 8-OHdG ( $p < 0.05$ ). TAS levels in the exposed group were lower than in the sham group ( $p < 0.05$ ). In terms of DNA damage, the tail intensities in the comet assay were higher in the exposure groups ( $p < 0.05$ ). This study demonstrated that long-term exposure to RFR emitted by cellular phones may cause oxidative stress and oxidative DNA damage in rat testicular tissue and may generate DNA single-strand breaks at high frequencies (1800 and 2100 MHz). Our results showed that some RFR emitted from cellular phones has potential to lead to cell damage in the testes.  
<https://doi.org/10.1080/13102818.2019.1696702>

Alkis, M. E., Bilgin, H. M., Akpolat, V., Dasdag, S., Yegin, K., Yavas, M. C., & Akdag, M. Z. 2019 Effect of 900-, 1800-, and 2100-MHz radiofrequency radiation on DNA and oxidative stress in brain. *Electromagnetic Biology and Medicine*, 38(1), 32–47. Ubiquitous and ever increasing use of mobile phones led to the growing concern about the effects of radiofrequency radiation (RFR) emitted by cell phones on biological systems. The aim of this study is to explore whether long-term RFR exposure at different frequencies affects DNA damage and oxidant-antioxidant parameters in the blood and brain tissue of rats. 28 male Sprague Dawley rats were randomly divided into four equal groups (n = 7). They were identified as Group 1: sham-control, Group 2: 900 MHz, Group 3: 1800 MHz, and Group 4: 2100 MHz. Experimental groups of rats were exposed to RFR 2 h/day for 6 months. The sham-control group of rats was subjected to the same experimental condition but generator was turned off. Specific absorption rates (SARs) at brain with 1 g average were calculated as 0.0845 W/kg, 0.04563 W/kg, and 0.03957, at 900 MHz, 1800 MHz, and 2100 MHz, respectively. Additionally, malondialdehyde (MDA), 8-hydroxydeoxyguanosine (8-OHdG), total antioxidant status (TAS), and total oxidant status (TOS) analyses were conducted in the brain tissue samples. Results of the study showed that DNA damage and oxidative stress indicators were found higher in the RFR exposure groups than in the sham-control group. In conclusion, 900-, 1800-, and 2100-MHz RFR emitted from mobile phones may cause oxidative damage, induce increase in lipid peroxidation, and increase oxidative DNA damage formation in the frontal lobe of the rat brain tissues. Furthermore, 2100-MHz RFR may cause formation of DNA single-strand breaks. <https://doi.org/10.1080/15368378.2019.1567526>

Azimzadeh, M., & Jelodar, G. 2019 Alteration of testicular regulatory and functional molecules following long-time exposure to 900 MHz RFW emitted from BTS. *Andrologia*, 51(9), e13372 The aim of this investigation was to evaluate changes in testosterone and some of the functional and regulatory molecules of testis such as P450<sub>scc</sub>, steroidogenic acute regulatory protein (StAR), tumour necrosis factor- $\alpha$  (TNF- $\alpha$ ), interleukin-1 $\alpha$  (IL-1 $\alpha$ ), interleukin-1 $\beta$  (IL-1 $\beta$ ) and nerve growth factor (NGF) following exposure to 900 MHz radio frequency (RF). Thirty adult male Sprague Dawley rats (190  $\pm$  20 g BW) were randomly classified in three equal groups, control (sham, without any exposure), short-time exposure (2 hr) (STE) and long-time exposure (4 hr) (LTE). The exposure was performed for 30 consecutive days. The testosterone level in both exposed groups was significantly less than control (p < .05). Level of TNF- $\alpha$  in both exposed groups was significantly greater than control (p < .05). IL-1 $\alpha$  and NGF levels in LTE were significantly higher than the STE and control groups (p < .05). Level of IL-1 $\beta$  in LTE was significantly higher than control (p < .05). Expression of both P450<sub>scc</sub> and StAR mRNA was significantly down-regulated in both exposed groups compared to control (p < .05). Our results showed that RFW can affect testis and reproductive function through changes in factors, which are important during steroidogenesis, and also through changes in inflammatory factors, which regulate Leydig cell functions. <https://doi.org/10.1111/and.13372>

Bartos, P., Netusil, R., Slaby, P., Dolezel, D., Ritz, T., & Vacha, M. 2019a Weak radiofrequency fields affect the insect circadian clock. *Journal of the Royal Society Interface*, 16(158), 20190285. It is known that the circadian clock in *Drosophila* can be sensitive to static magnetic fields (MFs). Man-made radiofrequency (RF) electromagnetic fields have been shown to have effects on animal orientation responses at remarkably weak intensities in the nanotesla range. Here, we tested if weak broadband RF fields also affect the circadian rhythm of the German cockroach (*Blattella germanica*). We observed that static MFs slow down the cockroach clock rhythm under dim UV light, consistent with results on the *Drosophila* circadian clock. Remarkably, 300 times weaker RF fields likewise slowed down the cockroach clock in a near-zero static magnetic field. This demonstrates that the internal clock of organisms can be sensitive to weak RF fields, consequently opening the possibility of an influence of man-made RF fields on many clock-dependent events in living systems. <https://doi.org/10.1098/rsif.2019.0285>

Bartos, P., Netusil, R., Slaby, P., Dolezel, D., Ritz, T., & Vacha, M. 2019b Supplementary materials from Weak radiofrequency fields affect the insect circadian clock. File provides additional results, complete survey of statistics, detailed description of materials and methods incl. RF spectra. <https://doi.org/10.6084/m9.figshare.9850235.v1>

Chang, H., Guo, J.-L., Fu, X.-W., Wang, M.-L., Hou, Y.-M., & Wu, K.-M. 2019 Molecular Characterization and Expression Profiles of Cryptochrome Genes in a Long-Distance Migrant, *Agrotis segetum* (Lepidoptera: Noctuidae). *Journal of Insect Science (Online)*, 19(1) Cryptochromes act as photoreceptors or integral components of the circadian clock that involved in the regulation of circadian clock and regulation of migratory activity in many animals, and they may also act as magnetoreceptors that sensed the direction of the Earth's magnetic field for the purpose of navigation during animals' migration. Light is a major environmental signal for insect circadian rhythms, and it is also necessary for magnetic orientation. We identified the full-length cDNA encoding As-CRY1 and As-CRY2 in *Agrotis segetum* Denis and Schiffermaller (turnip moth (Lepidoptera: Noctuidae)). The DNA photolyase domain and flavin adenine dinucleotide-binding domain were found in both cry genes, and multiple alignments showed that those domains that are important for the circadian clock and magnetosensing were highly conserved among

different animals. Quantitative polymerase chain reaction showed that cry genes were expressed in all examined body parts, with higher expression in adults during the developmental stages of the moths. Under a 14:10 (L:D) h cycle, the expression of cry genes showed a daily biological rhythm, and light can affect the expression levels of As-cry genes. The expression levels of cry genes were higher in the migratory population than in the reared population and higher in the emigration population than in the immigration population. These findings suggest that the two cryptochrome genes characterized in the turnip moth might be associated with the circadian clock and magnetosensing. Their functions deserve further study, especially for potential control of the turnip moth. <https://doi.org/10.1093/jisesa/iey127>

de Vocht, F. 2019 Analyses of temporal and spatial patterns of glioblastoma multiforme and other brain cancer subtypes in relation to mobile phones using synthetic counterfactuals. *Environmental Research*, 168, 329–335 This study assesses whether temporal trends in glioblastoma multiforme (GBM) in different brain regions, and of different malignant and benign (including acoustic neuroma and meningioma) subtypes in the temporal lobe, could be associated with mobile phone use. Annual 1985-2005 incidence of brain cancer subtypes for England were linked to population-level covariates. Bayesian structural timeseries were used to create 2006-2014 counterfactual trends, and differences with measured newly diagnosed cases were interpreted as causal effects. Increases in excess of the counterfactuals for GBM were found in the temporal (+38% [95% Credible Interval -7%,78%]) and frontal (+36% [-8%,77%]) lobes, which were in agreement with hypothesised temporal and spatial mechanisms of mobile phone usage, and cerebellum (+59% [-0%,120%]). However, effects were primarily present in older age groups, with largest effects in 75 + and 85 + groups, indicating mobile phone use is unlikely to have been an important putative factor. There was no evidence of an effect of mobile phone use on incidence of acoustic neuroma and meningioma. Although 1985-2014 trends in GBM in the temporal and frontal lobes, and probably cerebellum, seem consistent with mobile phone use as an important putative factor, age-group specific analyses indicate that it is unlikely that this correlation is causal. <https://doi.org/10.1016/j.envres.2018.10.011>

Del Re, B., Bersani, F., & Giorgi, G. 2019 Effect of electromagnetic field exposure on the transcription of repetitive DNA elements in human cells. *Electromagnetic Biology and Medicine*, 38(4), 262–270 Electromagnetic Biology and Medicine, 38(4), 262–270 Repetitive DNA (RE-DNA) was long thought to be silent and inert; only recent research has shown that it can be transcribed and that transcription alteration can be induced by environmental stress conditions, causing human pathological effects. The aim of this study was to determine whether exposure to radiofrequency electromagnetic fields (RF-EMF) could affect the transcription of RE-DNA. To this purpose, three different human cell lines (HeLa, BE(2)C and SH-SY5Y) were exposed to 900 MHz GSM-modulated RF-EMF at specific absorption rate of 1 W/kg or to sham. After exposure, mRNA levels of RE-DNA were evaluated through quantitative real-time PCR. The following RE-DNA types were investigated: Long Interspersed nucleotide Element 1, DNA alpha satellite and Human Endogenous Retroviruses-like sequences. When comparing cells exposed to RF-EMF versus control samples, different results were found for the three cell lines evaluated, indicating that RF-EMF exposure can significantly affect RE-DNA transcription and that the effects strongly depend on the cellular context and the tissue type. Further studies are needed to elucidate which molecular mechanisms could be involved. <https://doi.org/10.1080/15368378.2019.1669634>

Durdik, M., Kosik, P., Markova, E., Somsedikova, A., Gajdosechova, B., Nikitina, E., ... Belyaev, I. 2019 Microwaves from mobile phone induce reactive oxygen species but not DNA damage, preleukemic fusion genes and apoptosis in hematopoietic stem/progenitor cells. *Scientific Reports*, 9(1), 16182. Exposure to electromagnetic fields (EMF) has been associated with the increased risk of childhood leukemia, which arises from mutations induced within hematopoietic stem cells often through preleukemic fusion genes (PFG). In this study we investigated whether exposure to microwaves (MW) emitted by mobile phones could induce various biochemical markers of cellular damage including reactive oxygen species (ROS), DNA single and double strand breaks, PFG, and apoptosis in umbilical cord blood (UCB) cells including CD34+ hematopoietic stem/progenitor cells. UCB cells were exposed to MW pulsed signals from GSM900/UMTS test-mobile phone and ROS, apoptosis, DNA damage, and PFG were analyzed using flow cytometry, automated fluorescent microscopy, imaging flow cytometry, comet assay, and RT-qPCR. In general, no persisting difference in DNA damage, PFG and apoptosis between exposed and sham-exposed samples was detected. However, we found increased ROS level after 1 h of UMTS exposure that was not evident 3 h post-exposure. We also found that the level of ROS rise with the higher degree of cellular differentiation. Our data show that UCB cells exposed to pulsed MW developed transient increase in ROS that did not result in sustained DNA damage and apoptosis. <https://doi.org/10.1038/s41598-019-52389-x>

Elliott, P., Aresu, M., Gao, H., Vergnaud, A.-C., Heard, A., McRobie, D., ... Muller, D. C. 2019 Use of TETRA personal radios and sickness absence in the Airwave Health Monitoring Study of the British police forces. *Environmental Research*, 175, 148–155. BACKGROUND: Terrestrial Trunked Radio (TETRA) is used for radiocommunications among the British police forces. OBJECTIVES: To investigate association of personal radio use and sickness absence among police officers and staff from the Airwave Health Monitoring Study.METHODS: Participant-level sickness absence records for 26 forces were linked with personal radio use for RF-EMR References 2017 to mid-2022

32,102 participants. We used multivariable logistic regression to analyse TETRA usage in year prior to enrolment and sickness absence (lasting more than 7 or 28 consecutive days) in the following year and a zero-inflated negative binomial model for analyses of number of sickness absence episodes of any duration ('spells') over the same period. In secondary analyses, we looked at an extended period of observation among a sub-cohort with linked data over time, using Cox proportional hazards regression. RESULTS: Median personal radio use (year prior to enrolment) was 29.7 min per month (interquartile range 7.5, 64.7) among users. In the year following enrolment there were 25,655 sickness absence spells among 15,248 participants. There were similar risks of sickness absence lasting more than seven days among users and non-users, although among users risk was higher with greater use, odds ratio = 1.04 (95% confidence interval [CI] 1.02 to 1.06) per doubling of radio use. There was no association for sickness absence of more than 28 days. For sickness absence spells, risk was lower among users than non-users (incidence rate ratio = 0.91; 95% CI 0.75 to 1.11), again with higher risk among users for greater radio use. There was no association between radio use and sickness absence in secondary analyses. DISCUSSION: There were similar or lower risks of sickness absence in TETRA radio users compared with non-users. Among users, the higher risk of sickness absence with greater radio use may reflect working pattern differences among police personnel rather than effects of radiofrequency exposure. <https://doi.org/10.1016/j.envres.2019.05.012>

Gupta, S. K., Patel, S. K., Tomar, M. S., Singh, S. K., Mesharam, M. K., & Krishnamurthy, S. 2019 Long-term exposure of 2450 MHz electromagnetic radiation induces stress and anxiety like behavior in rats. *Neurochemistry International*, 128, 1– Long term exposure of electromagnetic radiations (EMR) from cell phones and Wi-Fi hold greater propensity to cause anxiety disorders. However, the studies investigating the effects of repeated exposure of EMR are limited. Therefore, we investigated the effects of repeated exposure of discrete frequencies of EMR in experimental animals. Male rats were exposed to EMR (900, 1800 and 2450 MHz) for 28 (1 h/day) days. Long term exposure of EMR (2450 MHz) induced anxiety like behavior. It deregulated the hypothalamic pituitary adrenal (HPA) axis in rats as observed by increase in plasma corticosterone levels apart from decreased corticotrophin releasing hormone-2 (CRH-2) and Glucocorticoid receptor (GR) expression in amygdala. Further, it impaired mitochondrial function and integrity. The expression of Bcl2 showed significant decrease while Bax and ratio of Bax: Bcl2 were increased in the mitochondria and vice versa in cytoplasm indicating altered regulation of apoptosis. EMR exposure caused release of cytochrome-c and expression of caspase-9 ensuing activation of apoptotic cell death. Additional set of experiments performed to estimate the pattern of cell death showed necrotic and apoptotic amygdalar cell death after EMR exposure. Histopathological studies also revealed a significant decrease in neuronal cells in amygdala. The above findings indicate that long-term exposure of EMR radiation (2450 MHz) acts as a stressor and induces anxiety-like behaviors with concomitant pathophysiological changes in EMR subjected rats. <https://doi.org/10.1016/j.neuint.2019.04.001>

Guxens, M., Vermeulen, R., Steenkamer, I., Beekhuizen, J., Vrijkotte, T. G. M., Kromhout, H., & Huss, A. 2019 Radiofrequency electromagnetic fields, screen time, and emotional and behavioural problems in 5-year-old children. *International Journal of Hygiene and Environmental Health*, 222(2), 188–194. BACKGROUND: Little is known about the exposure of young children to radiofrequency electromagnetic fields (RF-EMF) and potentially associated health effects. We assessed the relationship of RF-EMF exposure from different sources and screen time exposure with emotional and behavioural problems in 5-year-old children. METHODS: Cross-sectional study including 3102 children aged 5 years from the Amsterdam Born Children and their Development (ABCD) study, in the Netherlands. Residential RF-EMF exposure from mobile phone base stations was estimated with a 3D geospatial radio wave propagation model. Residential presence of RF-EMF indoor sources (cordless phone base stations and Wireless Fidelity (Wi-Fi)), children's mobile phone and cordless phone calls and screen time exposure (computer/video game and television watching) was reported by the mother. Teachers (n = 2617) and mothers (n = 3019) independently reported child emotional and behavioural problems using the Strengths and Difficulties Questionnaire. RESULTS: No associations were found between mobile phone and cordless phone calls and emotional and behavioural problems. Children exposed to higher RF-EMF levels from mobile phone base stations showed higher odds of maternal-reported emotional symptoms (OR 1.82, 95%CI 1.07 to 3.09). Children with cordless phone at home had lower odds of teacher-reported problematic prosocial behaviour (OR 0.68, 95%CI 0.48 to 0.97) and of maternal-reported peer relationship problems (OR 0.61, 95% CI 0.39 to 0.96). Children who watched television  $\geq 1.5$  h/day had higher odds of maternal-reported hyperactivity/inattention (OR 3.13, 95%CI 1.43 to 6.82). CONCLUSION: Mobile phone and cordless phone calls, which lead to peak RF-EMF exposures to the head, were not associated with any emotional and behavioural problems in 5-year-old children. Environmental RF-EMF exposure from mobile phone base stations and from indoor sources and television watching, which both contribute very little to RF-EMF exposure, were associated with specific emotional and behavioural problems but mainly when reported by the mothers. We cannot, however, discard residual confounding or reverse causality. Further longitudinal research in particular as children will increase the use of telecommunication devices with the age may help to better understand the exact contribution of the different RF-EMF exposure sources if any. Moreover, a thorough control for confounding is essential for a correct interpretation of the studies on screen time and emotional and behavioural problems. <https://doi.org/10.1016/j.ijheh.2018.09.006>

Hutton, J. S., Dudley, J., Horowitz-Kraus, T., DeWitt, T., & Holland, S. K. 2019 Associations Between Screen-Based Media Use and Brain White Matter Integrity in Preschool-Aged Children. *JAMA Pediatrics*, e193869. Importance: The American Academy of Pediatrics (AAP) recommends limits on screen-based media use, citing its cognitive-behavioral risks. Screen use by young children is prevalent and increasing, although its implications for brain development are unknown. Objective: To explore the associations between screen-based media use and integrity of brain white matter tracts supporting language and literacy skills in preschool-aged children. Design, Setting, and Participants: This cross-sectional study of healthy children aged 3 to 5 years (n = 47) was conducted from August 2017 to November 2018. Participants were recruited at a US children's hospital and community primary care clinics. Exposures: Children completed cognitive testing followed by diffusion tensor imaging (DTI), and their parent completed a ScreenQ survey. Main Outcomes and Measures: ScreenQ is a 15-item measure of screen-based media use reflecting the domains in the AAP recommendations: access to screens, frequency of use, content viewed, and covieing. Higher scores reflect greater use. ScreenQ scores were applied as the independent variable in 3 multiple linear regression models, with scores in 3 standardized assessments as the dependent variable, controlling for child age and household income: Comprehensive Test of Phonological Processing, Second Edition (CTOPP-2; Rapid Object Naming subtest); Expressive Vocabulary Test, Second Edition (EVT-2; expressive language); and Get Ready to Read! (GRTR; emergent literacy skills). The DTI measures included fractional anisotropy (FA) and radial diffusivity (RD), which estimated microstructural organization and myelination of white matter tracts. ScreenQ was applied as a factor associated with FA and RD in whole-brain regression analyses, which were then narrowed to 3 left-sided tracts supporting language and emergent literacy abilities. Results: Of the 69 children recruited, 47 (among whom 27 [57%] were girls, and the mean [SD] age was 54.3 [7.5] months) completed DTI. Mean (SD; range) ScreenQ score was 8.6 (4.8; 1-19) points. Mean (SD; range) CTOPP-2 score was 9.4 (3.3; 2-15) points, EVT-2 score was 113.1 (16.6; 88-144) points, and GRTR score was 19.0 (5.9; 5-25) points. ScreenQ scores were negatively correlated with EVT-2 ( $F_{2,43} = 5.14$ ;  $R^2 = 0.19$ ;  $P < .01$ ), CTOPP-2 ( $F_{2,35} = 6.64$ ;  $R^2 = 0.28$ ;  $P < .01$ ), and GRTR ( $F_{2,44} = 17.08$ ;  $R^2 = 0.44$ ;  $P < .01$ ) scores, controlling for child age. Higher ScreenQ scores were correlated with lower FA and higher RD in tracts involved with language, executive function, and emergent literacy abilities ( $P < .05$ , familywise error-corrected), controlling for child age and household income. Conclusions and Relevance: This study found an association between increased screen-based media use, compared with the AAP guidelines, and lower microstructural integrity of brain white matter tracts supporting language and emergent literacy skills in prekindergarten children. The findings suggest further study is needed, particularly during the rapid early stages of brain development. <https://doi.org/10.1001/jamapediatrics.2019.3869>

Ismail, L. A., Joumaa, W. H., & Moustafa, M. E. 2019a Selenium decreases triglycerides and VLDL-c in diabetic rats exposed to electromagnetic radiation from mobile phone base stations. *Journal of Taibah University for Science*, 13(1), 844–849. This study investigated the effects of exposure of diabetic rats to electromagnetic radiation (EMR) of 900 MHz from cell phone base stations antenna for four weeks on plasma triglycerides and cholesterol. We also examined whether selenium administration into these rats affects the levels of these parameters. Our results showed that the exposure of diabetic rats to this EMR increased the plasma triglycerides, total cholesterol and VLDL-c. The daily intraperitoneally injection of 2.0 µg selenium/kg body weight as sodium selenite into these rats decreased the triglycerides and VLDL-c levels compared to diabetic rats with EMR exposure. Selenium also restored the normal levels of plasma triglycerides, total cholesterol and HDL-c as compared to control rats. In conclusion, selenium decreased the elevated levels of triglycerides and cholesterol in diabetic rats exposed to EMR from cell phone base stations and hence it may decrease the development of some diabetic complications. <https://doi.org/10.1080/16583655.2019.1649881>

Ismail, L. A., Joumaa, W. H., & Moustafa, M. E. 2019b The impact of exposure of diabetic rats to 900 MHz electromagnetic radiation emitted from mobile phone antenna on hepatic oxidative stress. *Electromagnetic Biology and Medicine*, 38(4), 287–296. The excessive exposure of patients with type 2 diabetes mellitus (T2DM) to electromagnetic radiation (EMR) from mobile phones or their base stations antenna may influence oxidative stress and development of diabetic complications. Here, we investigated the effects of exposing type 2 diabetic rats to EMR of 900 MHz emitted from GSM mobile phone antenna for 24 hours/day over a period of 28 days on hyperglycemia and hepatic oxidative stress. Male Sprague-Dawley rats were divided into 4 groups (12 rats/group): control rats, normal rats exposed to EMR, T2DM rats generated by nicotinamide/streptozotocin administration, and T2DM rats exposed to EMR. Our results showed that the exposure of T2DM rats to EMR nonsignificantly reduced the hyperglycemia and hyperinsulinemia compared to unexposed T2DM rats. The exposure of T2DM rats to EMR for 28 days increased the hepatic levels of MDA and Nrf-2 as well as the activities of superoxide dismutase (SOD) and catalase but decreased phosphorylated Akt-2 (pAkt-2) as compared to unexposed T2DM rats. Therefore, the decrease in the hepatic pAkt-2 in T2DM rats after the exposure to EMR may result in elevated level of hepatic MDA, even though the level of Nrf-2 and the activities of SOD and catalase were increased. Abbreviations: BGL: blood glucose level; EMR: electromagnetic radiation; GSM: global system for mobile communication; H<sub>2</sub>O<sub>2</sub>: hydrogen peroxide; LSD: least significance difference; MDA: malondialdehyde; Nrf-2: nuclear factor erythroid 2- related factor 2; PI3K: phosphoinositide-3-kinase; pAkt-2: phosphorylated Akt-2; Akt-2: protein kinase; ROS: reactive oxygen species; SEM: standard error of the mean; STZ: streptozotocin; SOD: superoxide dismutase ; O<sub>2</sub><sup>-</sup>: superoxide radical; CT: threshold cycle; T2DM: type 2 diabetes mellitus.

Jadidi M, Bokharaeian M, Esmaili MH, Hasanzadeh H, & Ghorbani R. 2019 Cell Phone EMF Affects Rat Pulmonary Tc-MIBI Uptake and Oxidative Stress. Iran J Sci Technol Trans A Sci, 43, 1491–1497. 99mTc-MIBI is a radiopharmaceutical which has trend to accumulate in the heart, but its absorption in pulmonary system may alter heart accumulation and so affect the heart imaging. We aimed to assess the effects of cell phone EMF on lung accumulation of 99mTc-MIBI and oxidative stress. Male albino Wistar rats were randomly divided into 12 groups: four for 99mTc and 99mTc-MIBI control, four for 99mTc 900 and 1800 MHz, four for 99mTc-MIBI 900 and 1800 MHz. After injection of radiopharmaceutical in rats' tail vein, the animals were housed in standard cages for expose to 900 or 1800 MHz in time of 15 or 30 min. Activity of 99mTc and 99mTc-MIBI in the lungs was being assayed using a dose calibrator. Concentration of malondialdehyde (MDA) and catalase (CAT) was measured in serum. After 15 and 30 min EMF radiation, in both groups of 900 and 1800 MHz, lung specific activity was increased the same as control group; meanwhile, in 15 min 900 MHz group, there was a significant increase in lung-to-heart specific activity ratio compared to other groups. Data showed a permanent increase in 900 MHz group CAT activity. MDA level had not any significant changes. The use of cell phone EMF during the preparation and imaging process could increase absorption of radiopharmaceutical by the pulmonary system and may affect lung-to-heart specific activity ratio, so affect to correct diagnosis by the physician. <https://doi.org/10.1007/s40995-019-00679-4>

Jakubowska, M., Urban-Malinga, B., Otremba, Z., & Andruliewicz, E. 2019 Effect of low frequency electromagnetic field on the behavior and bioenergetics of the polychaete *Hediste diversicolor*. Marine Environmental Research, 150, 104766. The aim of the present study was to determine the effect of an electromagnetic field (EMF) of value typically recorded in the vicinity of submarine cables (50 Hz, 1 mT) on the behavior and bioenergetics of the polychaete *Hediste diversicolor*. No avoidance or attraction behavior to EMF was shown, but the burrowing activity of *H. diversicolor* was enhanced in EMF treatment, indicating a stimulating effect on bioturbation potential. The polychaete maintained a positive energy balance and high amount (85% of assimilated energy) of energy available for individual production (scope for growth) after exposure to EMF. Food consumption and respiration rates were not affected but ammonia excretion rate was significantly reduced in EMF-exposed animals compared to the control conditions (geomagnetic field). The mechanisms behind this effect remain, however, unclear. This is the first study demonstrating the effects of environmentally realistic EMF value on the behavior and physiology of marine invertebrates, thus there is a need for more research. <https://doi.org/10.1016/j.marenvres.2019.104766>

Jooyan, N., Goliaei, B., Bigdeli, B., Faraji-Dana, R., Zamani, A., Entezami, M., & Mortazavi, S. M. J. 2019 Direct and indirect effects of exposure to 900 MHz GSM radiofrequency electromagnetic fields on CHO cell line: Evidence of bystander effect by non-ionizing radiation. Environmental Research, 174, 176–187. INTRODUCTION: The rapid rise in global concerns about the adverse health effects of exposure to radiofrequency radiation (RFR) generated by common devices such as mobile phones has prompted scientists to further investigate the biological effects of these environmental exposures. Non-targeted effects (NTEs) are responses which do not need a direct exposure to be expressed and are particularly significant at low energy radiations. Although NTEs of ionizing radiation are well documented, there are scarcely any studies on non-targeted responses such as bystander effect (BE) after exposure to non-ionizing radiation. The main goal of this research is to study possible RFR-induced BE. MATERIAL AND METHODS: Chinese hamster ovary cells were exposed to 900 MHz GSM RFR at an average specific absorption rate (SAR) of 2 W/kg for 4, 12 and 24 hours (h). To generate a uniformly distributed electromagnetic field and avoid extraneous RF exposures a cavity was designed and used. Cell membrane permeability, cell redox activity, metabolic and mitotic cell death and DNA damages were analyzed. Then the most effective exposure durations and statistically significant altered parameters were chosen to assess the induction of BE through medium transfer procedure. Furthermore, intra and extra cellular reactive oxygen species (ROS) levels were measured to assess the molecular mechanism of BE induced by non-ionizing radiation. RESULTS: No statistically significant alteration was found in cell membrane permeability, cell redox activity, metabolic cell activity and micronuclei (MN) frequency in the cells directly exposed to RFR for 4, 12, or 24 h. However, RFR exposure for 24 h caused a statistically significant decrease in clonogenic ability as well as a statistically significant increase in olive moment in both directly exposed and bystander cells which received media from RFR-exposed cells (conditioned culture medium; CCM). Exposure to RFR also statistically significant elevated both intra and extra cellular levels of ROS. CONCLUSION: Our observation clearly indicated the induction of BE in cells treated with CCM. To our knowledge, this is the first report that a non-ionizing radiation (900 MHz GSM RFR) can induce bystander effect. As reported for ionizing radiation, our results proposed that ROS can be a potential molecule in indirect effect of RFR. On the other hand, we found the importance of ROS in direct effect of RFR but in different ways. <https://doi.org/10.1016/j.envres.2019.03.063>

Kalanjati, V. P., Purwantari, K. E., & Prasetiowati, L. 2019 Aluminium foil dampened the adverse effect of 2100 MHz mobile phone-induced radiation on the blood parameters and myocardium in rats. Environmental Science and Pollution Research International, 26(12), 11686–11689. Mobile phones emit a radiofrequency radiation (RFR) that might have



adverse health effects. We aimed to investigate the possible protective effects of aluminium foil (AF) as a physical shield against the RFR from mobile phones on the blood parameters and the myocardium in rats. The effects of whole body 2100 MHz with 0.84-1.86 W/kg of SAR, 4 h/day for 30 days Global System for Mobile Communications (GSM)-RFR exposure for 4 h/day for 30 days on blood parameters (i.e. haemoglobin, leucocytes, thrombocytes, erythrocyte sedimentation rate, white blood cell differential count, corticosterone, CKMB), and the histology of myocardium were investigated. Three-month-old male rats (n = 32) were studied and randomised equally in the following four groups: K1 (non-AF non-RFR control), K2 (AF non-RFR control), P1 (non-AF RFR-exposed), P2 (AF RFR-exposed). Data were analysed with level of significance of  $p < 0.05$ . In P1, lower leucocytes and neutrophils counts with high corticosterone levels were found compared with the control groups, whilst a significantly higher CKMB was observed compared with P2 ( $p = 0.034$ ). Lower cardiomyocyte counts congruent to the area fraction of the non-fibrotic myocardium were observed in P1 compared with the other groups ( $p < 0.01$ ). AF might decrease the inflammatory-oxidative stress on rodent's blood cells and myocardium induced by the exposures of radiofrequency radiation of the mobile phones. <https://doi.org/10.1007/s11356-019-04601-8>

Keleş, A. İ., Nyengaard, J. R., & Odacı, E. 2019 Changes in pyramidal and granular neuron numbers in the rat hippocampus 7 days after exposure to a continuous 900-MHz electromagnetic field during early and mid-adolescence. *Journal of Chemical Neuroanatomy*, 101, 101681. The aim of this study was to investigate qualitative and quantitative changes in pyramidal and granule neurons in the male rat hippocampus after exposure to a continuous 900-megahertz (MHz) electromagnetic field (EMF) for 25 days during early and mid-adolescence. Three-week-old (21 day) healthy Sprague Dawley male rats were divided equally into control (CON), pseudo-exposed (PEX) and EMF groups. EMF rats were exposed to a 900-MHz EMF in an EMF-application cage, while the PEX rats were placed in the same cage without being exposed to EMF. No procedure was performed in CON. EMF was applied for 1 h/day, every day for 25 days. Following the 900-MHz EMF and pseudo-exposed applications, behavioral tests were performed for seven days. Then, all animals were euthanized and their brains were removed. Following histological tissue procedures, sections were taken from tissues and stained with toluidine blue. The optical fractionation technique was performed to estimate the pyramidal neuron numbers in the CA1, CA2-3 and hilus regions of the hippocampus and granule neuron numbers in the dentate gyrus region. Our findings indicated that the number of pyramidal and granule neurons in the hippocampus of the EMF group was statistically higher than PEX. Furthermore, the histopathological results showed that the cytoplasm of pyramidal (in the hilus, CA1, CA2 and CA3 region) and granular (in the dentate gyrus region) cells at the hippocampus were disrupted, as evident by intensive staining around cytoplasm and some artifacts were detected in the EMF group. In addition, statistical comparisons of the mean body weights and brain weights of the study groups revealed no significant differences. There was no statistically significant difference between the PEX and EMF groups in terms of temperature ( $p > 0.05$ ) or humidity ( $p > 0.05$ ) in the cages. In conclusion, higher numbers of both pyramidal and granule neurons were found in the male rat hippocampus after continuous 900-MHz EMF treatment. <https://doi.org/10.1016/j.jchemneu.2019.101681>

Kumar, R., Deshmukh, P. S., Sharma, S., & Banerjee, B. 2019 Activation of endoplasmic reticulum stress in rat brain following low-intensity microwave exposure. *Environmental Science and Pollution Research International*, 26(9), 9314–9321. The present study was designed to explore the effects of low-intensity microwave radiation on endoplasmic reticulum stress and unfolded protein response. Experiments were performed on male Wistar rats exposed to microwave radiation for 30 days at 900 MHz, 1800 MHz, and 2450 MHz frequencies on four groups of animal: sham-exposed group, 900 MHz exposed (SAR  $5.84 \times 10^{-4}$  W/kg), 1800 MHz exposed (SAR  $5.94 \times 10^{-4}$  W/kg), and 2450 MHz exposed (SAR  $6.7 \times 10^{-4}$  W/kg) groups. Expressions of mRNA were estimated at the end of exposure in rat brain by real-time quantitative PCR. Microwave exposure at 900, 1800, and 2450 MHz with respective SAR values as mentioned above significantly ( $< 0.05$ ) altered mRNA expression of transcription factors ATF4, CHOP, and XBP1 in accordance with increasing microwave frequency. The result of the present study reveals that low-intensity microwave exposure at frequencies 900, 1800, and 2450 MHz induces endoplasmic reticulum stress and unfolded protein response. <https://doi.org/10.1007/s11356-019-04377-x>

Miller, A. B., Sears, M. E., Morgan, L. L., Davis, D. L., Hardell, L., Oremus, M., & Soskolne, C. L. 2019 Risks to Health and Well-Being From Radio-Frequency Radiation Emitted by Cell Phones and Other Wireless Devices. *Frontiers in Public Health*, 7. Radiation exposure has long been a concern for the public, policy makers and health researchers. Beginning with radar during World War II, human exposure to radio-frequency radiation (RFR) technologies has grown more than 100,000-fold over time. In 2011, the International Agency for Research on Cancer (IARC) reviewed the published literature and categorized RFR as a 'possible' (Group 2B) human carcinogen. A broad range of adverse human health effects associated with RFR have been reported since the IARC review. In addition, three large-scale carcinogenicity studies in rodents exposed to levels of RFR that mimic lifetime human exposures have shown significantly increased rates of Schwannomas and malignant gliomas, as well as chromosomal DNA damage. Of particular concern are the effects of RFR exposure on the developing brain in children. Compared with an adult male, a cell phone held against the head of a child exposes deeper brain structures to greater radiation doses per unit volume, and the young, thin skull's bone marrow absorbs a roughly 10-fold higher local dose. Recent reports also suggest

that men who keep cell phones in their trouser pockets have significantly lower sperm counts and significantly impaired sperm motility and morphology, including mitochondrial DNA damage. Based on the accumulated evidence, we recommend that IARC re-evaluate its 2011 classification of the human carcinogenicity of RFR, and that WHO complete a systematic review of multiple other health effects such as sperm damage. In the interim, current knowledge provides justification for governments, public health authorities, and physicians/allied health professionals to warn the population that having a cell phone next to the body is harmful, and to support measures to reduce all exposures to RFR. <https://doi.org/10.3389/fpubh.2019.00223>

Movahedi, M. M., Nouri, F., Tavakoli Golpaygani, A., Ataee, A., Amani, S., & Taheri, M. 2019 Antibacterial Susceptibility Pattern of the *Pseudomonas aeruginosa* and *Staphylococcus aureus* after Exposure to Electromagnetic Waves Emitted from Mobile Phone Simulator. *Journal of Biomedical Physics and Engineering*. Background: The increasing use of telecommunication devices such as Wi-Fi modems and mobile phones in the recent years can change the cellular structure of microorganisms so the generation of electromagnetic waves has led to concern in the community whenever be exposed to these fields and may have harmful effects on human health. Material and Methods: In this experimental study, standard strains of bacteria were prepared on Mueller-Hinton agar for bacterial growth to obtain 0.5 McFarland turbidity ( $1.5 \times 10^8$  CFU) of bacteria. Antibiotic susceptibility test using the Kirby-Bauer disk diffusion method was done. For *Staphylococcus aureus* and *Pseudomonas aeruginosa*, antibiotics susceptibility test was conducted. The test group was exposed to electromagnetic waves emitted by mobile phone simulator with a frequency of 900 MHz and the control group were not exposed. Results: The results revealed that increasing duration of exposure to electromagnetic waves emitted by the mobile simulators with a frequency of 900 MHz especially after 24 h of exposure, can increase bacterial resistance in *S. aureus*, and *P. aeruginosa*. Conclusion: Several factors can cause bacterial resistance against antibiotics. One of these factors is the electromagnetic waves emitted from mobile simulator with a frequency of 900 MHz, which can increase the permeability of the cell wall of bacteria. <https://doi.org/10.31661/jbpe.v0i0.1107>

Odemer, R., & Odemer, F. 2019 Effects of radiofrequency electromagnetic radiation (RF-EMF) on honey bee queen development and mating success. *The Science of the Total Environment*, 661, 553–562. Mobile phones can be found almost everywhere across the globe, upholding a direct point-to-point connection between the device and the broadcast tower. The emission of radiofrequency electromagnetic fields (RF-EMF) puts the surrounding environment inevitably into contact with this radiation. We have therefore exposed honey bee queen larvae to the radiation of a common mobile phone device (GSM band at 900 MHz) during all stages of their pre-adult development including pupation. After 14 days of exposure, hatching of adult queens was assessed and mating success after further 11 days, respectively. Moreover, full colonies were established of five of the untreated and four of the treated queens to contrast population dynamics. We found that mobile phone radiation had significantly reduced the hatching ratio but not the mating success. If treated queens had successfully mated, colony development was not adversely affected. We provide evidence that mobile phone radiation may alter pupal development, once succeeded this point, no further impairment has manifested in adulthood. Our results are discussed against the background of long-lasting consequences for colony performance and the possible implication on periodic colony losses. <https://doi.org/10.1016/j.scitotenv.2019.01.154>

Okatan, D. Ö., Kulaber, A., Kerimoglu, G., & Odaci, E. 2019 Altered morphology and biochemistry of the female rat liver following 900 megahertz electromagnetic field exposure during mid to late adolescence. *Biotechnic & Histochemistry: Official Publication of the Biological Stain Commission*, 94(6), 420–428. Despite their benefits, technological devices such as cell phones may also have deleterious effects on human health. Considerable debate continues concerning the effects of the electromagnetic field (EMF) emitted during cell phone use on human health. We investigated the effects of exposure to 900 megahertz (MHz) EMF during mid to late adolescence on the rat liver. Control (ContGr), sham (ShmGr) and EMF (EMFGr) groups of female rats were established. We exposed the EMFGr rats daily to 900 MHz EMF on postnatal days 35-59. ShmGr rats underwent sham procedures. No procedure was performed on ContGr rats. Rats were sacrificed on postnatal day 60 and the livers were extracted. One part of the liver was stained with Masson's trichrome or hematoxylin and eosin. The remaining tissue was used to measure oxidative stress markers including malondialdehyde, glutathione, catalase, superoxide dismutase, 8-hydroxydeoxyguanosine (8-OHdG) and nitrotyrosine. Total antioxidant status and total oxidant status were used to calculate the oxidative stress index. We found normal hepatic morphology in the ContGr and ShmGr groups. The EMFGr group exhibited occasional irregularities in the radial arrangement of hepatocytes, cytoplasmic vacuolization, hemorrhage, sinusoid expansion, hepatocyte morphology and edema. Biochemical analysis revealed that 8-OHdG and SOD levels in EMFGr decreased significantly compared to the ContGr and ShmGr groups. Exposure to a continuous 900 MHz EMF for 1 h daily during mid to late adolescence may cause histopathological and biochemical alterations in hepatic tissue. <https://doi.org/10.1080/10520295.2019.1580767>

Panagopoulos, D. J. 2019 Comparing DNA damage induced by mobile telephony and other types of man-made electromagnetic fields. *Mutation Research/Reviews in Mutation Research*, 781, 53–62. The number of studies showing adverse effects on living organisms induced by different types of man-made Electromagnetic Fields (EMFs) has increased

tremendously. Hundreds of peer reviewed published studies show a variety of effects, the most important being DNA damage which is linked to cancer, neurodegenerative diseases, reproductive declines etc. Those studies that are far more effective in showing effects employ real-life Mobile Telephony (MT) exposures emitted by commercially available mobile phones. The present review - of results published by my group from 2006 until 2016 - compares DNA fragmentation induced by six different EMFs on the same biological system - the oogenesis of *Drosophila melanogaster* - under identical conditions and procedures. Such a direct comparison between different EMFs - especially those employed in daily life - on the same biological endpoint, is very useful for drawing conclusions on their bioactivity, and novel. It shows that real MT EMFs are far more damaging than 50 Hz alternating magnetic field (MF) - similar or much stronger to those of power lines - or a pulsed electric field (PEF) found before to increase fertility. The MT EMFs were significantly more bioactive even for much shorter exposure durations than the other EMFs. Moreover, they were more damaging than previously tested cytotoxic agents like certain chemicals, starvation, dehydration. Individual parameters of the real MT EMFs like intensity, frequency, exposure duration, polarization, pulsing, modulation, are discussed in terms of their role in bioactivity. The crucial parameter for the intense bioactivity seems to be the extreme variability of the polarized MT signals, mainly due to the large unpredictable intensity changes.

<https://doi.org/10.1016/j.mrrev.2019.03.003>

Puri, B. K., Segal, D. R., & Monro, J. A. 2019 The effect of successful low-dose immunotherapy ascertained by provocation neutralization on lymphocytic calcium ion influx following electric field exposure. *Journal of Complementary & Integrative Medicine*. Background Low-dose immunotherapy affects baseline levels of intracellular calcium. However, the effect of background electric fields is yet to be ascertained. The aim of this study was to test the following hypotheses: desensitization by low-dose immunotherapy is associated with reduced calcium ion influx during electric field exposure; the effect of low-dose immunotherapy on intracellular calcium ion concentration does not depend on electric field exposure; and the intracellular calcium ion concentration is amplified by electric field exposure. Methods The experimental design was balanced and orthogonal. Intracellular lymphocytic calcium ion concentrations were assayed in 47 patients, following incubation with picogram amounts of 12 test allergens, using a cell-permeable calcium-sensing ratiometric fluorescent dye and fluorescence spectroscopy, both at baseline and following successful provocation neutralization treatment with low-dose immunotherapy. Duplicates were also exposed to an electric field which replicated the frequency spectrum measured in a non-Faraday shielded room. Results A significant or trend-level main effect was found for low-dose immunotherapy for: benzoate; formaldehyde; metabisulfite; natural gas; nitrosamines; organophosphates; salicylate; azo-dyes and precursors; nickel; and petrol (gasoline) exhaust. Significant or trend-level main effects for electric field exposure were observed for: formaldehyde; mercury (inorganic); natural gas; nickel; nitrosamines; petrol exhaust; salicylate; benzoate; and metabisulfite. There was no evidence of a statistical interaction between these two factors. Electric field exposure was associated with a higher intracellular calcium ion concentration. Conclusion There was support for all three hypotheses. The results suggest that patients may experience increased sensitivity to allergens as a result of exposure to everyday electric fields. <https://doi.org/10.1515/jcim-2017-0156>

Salas-Sánchez, A. A., López-Furelos, A., Rodríguez-González, J. A., Ares-Pena, F. J., & López-Martín, M. E. 2019 Validation of Potential Effects on Human Health of in Vivo Experimental Models Studied in Rats Exposed to Sub-Thermal Radiofrequency. Possible Health Risks Due to the Interaction of Electromagnetic Pollution and Environmental Particles. *IEEE Access*, 7, 79186–79198. Studies are based on the exposure of Sprague-Dawley rats (250 male and 250 female rats) to electromagnetic fields (EMF) at different frequencies in standing and travelling wave chambers. Values of specific absorption rate (SAR) for all of these experiments were obtained from commercially available FDTD-based simulation software based on numerical phantom animals. An experimental radiation system was developed with a standing-wave cavity which keeps electromagnetic parameters constant while facilitating stress-free exposure of animals to non-thermal radiation. This makes it possible to directly measure the power absorbed by the animal and determine whole-body mean SAR according to weight. All studies using this setup were performed with global system for mobile communication (GSM) radiation at 900 MHz. The simple picrotoxin model made allow to identify morphological signs of neurotoxicity in rat brain tissue. Experiments involving travelling waves were done in a commercial Gigahertz Transverse ElectroMagnetic (GTEM) chamber connected to one or two vector signal generators (to carry single or multiple EMF exposure frequencies). In the diathermy model, rat thyroid and thymus exposed to 2.45 GHz radiation showed visible morphological and immune effects. Cellular stress in the cerebral cortex, the cerebellum or both seems to be more associated with the type of signal than with additive effects of combined frequencies. Finally, some hypothesis related with the future models about the ElectroMagnetic (EM) pollution are established. In an urban environmental that combines the electromagnetic and chemical pollution of environmental particles, cortical excitability, inflammatory response, and cell injury can be modified.

<https://doi.org/10.1109/ACCESS.2019.2923581>

Shahin, N. N., El-Nabarawy, N. A., Gouda, A. S., & Mégarbane, B. 2019 The protective role of spermine against male reproductive aberrations induced by exposure to electromagnetic field - An experimental investigation in the rat. *Toxicology and Applied Pharmacology*, 370, 117–130.

The exponentially increasing use of electromagnetic field (EMF)-emitting devices imposes substantial health burden on modern societies with particular concerns of male infertility. Limited studies have addressed the modulation of this risk by protective agents. We investigated the hazardous effects of rat exposure to EMF (900 MHz, 2 h/day for 8 weeks) on male fertility and evaluated the possible protective effect of the polyamine, spermine, against EMF-induced alterations. Exposure to EMF significantly decreased sperm count, viability and motility, and increased sperm deformities. EMF-exposed rats exhibited significant reductions in serum inhibin B and testosterone along with elevated activin A, follicle-stimulating hormone, luteinizing hormone and estradiol concentrations. Testicular steroidogenic acute regulatory protein (StAR), c-kit mRNA expression and testicular activities of the key androgenic enzymes 3 $\beta$ - and 17 $\beta$ -hydroxysteroid dehydrogenases were significantly attenuated following exposure to EMF. Exposure led to testicular lipid peroxidation, decreased catalase and glutathione peroxidase activities and triggered nuclear factor-kappa B p65, inducible nitric oxide synthase, cyclooxygenase-2 and caspase-3 overexpression. EMF-exposed rats showed testicular DNA damage as indicated by elevated comet parameters. Spermine administration (2.5 mg/Kg/day intraperitoneally for 8 weeks) prevented EMF-induced alterations in the sperm and hormone profiles, StAR and c-kit expression and androgenic enzyme activities. Spermine hampered EMF-induced oxidative, inflammatory, apoptotic and DNA perturbations. Histological and histomorphometric analysis of the testes supported all biochemical findings. In conclusion, rat exposure to EMF disrupts sperm and hormone profiles with underlying impairment of steroidogenesis and spermatogenesis. Spermine confers protection against EMF-associated testicular and reproductive aberrations, at least in part, via antioxidant, anti-inflammatory and anti-apoptotic mechanisms.

<https://doi.org/10.1016/j.taap.2019.03.009>

Simkó, M., & Mattsson, M.-O. 2019a 5G Wireless Communication and Health Effects—A Pragmatic Review Based on Available Studies Regarding 6 to 100 GHz. *International Journal of Environmental Research and Public Health*, 16(18), 3406. The introduction of the fifth generation (5G) of wireless communication will increase the number of high-frequency-powered base stations and other devices. The question is if such higher frequencies (in this review, 6–100 GHz, millimeter waves, MMW) can have a health impact. This review analyzed 94 relevant publications performing in vivo or in vitro investigations. Each study was characterized for: study type (in vivo, in vitro), biological material (species, cell type, etc.), biological endpoint, exposure (frequency, exposure duration, power density), results, and certain quality criteria. Eighty percent of the in vivo studies showed responses to exposure, while 58% of the in vitro studies demonstrated effects. The responses affected all biological endpoints studied. There was no consistent relationship between power density, exposure duration, or frequency, and exposure effects. The available studies do not provide adequate and sufficient information for a meaningful safety assessment, or for the question about non-thermal effects. There is a need for research regarding local heat developments on small surfaces, e.g., skin or the eye, and on any environmental impact. Our quality analysis shows that for future studies to be useful for safety assessment, design and implementation need to be significantly improved. <https://doi.org/10.3390/ijerph16183406>

Simkó, M., & Mattsson, M.-O. 2019b SUPPLEMENTAL MATERIAL. 5G Wireless Communication and Health Effects—A Pragmatic Review Based on Available Studies Regarding 6 to 100 GHz. *International Journal of Environmental Research and Public Health*, 16(18), 3406. Extensive Supplementary Material for 5G review. <https://doi.org/10.3390/ijerph16183406>

Van Huizen, A. V., Morton, J. M., Kinsey, L. J., Von Kannon, D. G., Saad, M. A., Birkholz, T. R., ... Beane, W. S. 2019 Weak magnetic fields alter stem cell-mediated growth. *Science Advances*, 5(1), eaau7201. Biological systems are constantly exposed to electromagnetic fields (EMFs) in the form of natural geomagnetic fields and EMFs emitted from technology. While strong magnetic fields are known to change chemical reaction rates and free radical concentrations, the debate remains about whether static weak magnetic fields (WMFs; <1 mT) also produce biological effects. Using the planarian regeneration model, we show that WMFs altered stem cell proliferation and subsequent differentiation via changes in reactive oxygen species (ROS) accumulation and downstream heat shock protein 70 (Hsp70) expression. These data reveal that on the basis of field strength, WMF exposure can increase or decrease new tissue formation in vivo, suggesting WMFs as a potential therapeutic tool to manipulate mitotic activity. <https://doi.org/10.1126/sciadv.aau7201>

Vanbergen, A. J., Potts, S. G., Vian, A., Malkemper, E. P., Young, J., & Tscheulin, T. 2019 Risk to pollinators from anthropogenic electro-magnetic radiation (EMR): Evidence and knowledge gaps. *The Science of the Total Environment*, 695, 133833. Worldwide urbanisation and use of mobile and wireless technologies (5G, Internet of Things) is leading to the proliferation of anthropogenic electromagnetic radiation (EMR) and campaigning voices continue to call for the risk to human health and wildlife to be recognised. Pollinators provide many benefits to nature and humankind, but face multiple anthropogenic threats. Here, we assess whether artificial light at night (ALAN) and anthropogenic radiofrequency electromagnetic radiation (AREMR), such as used in wireless technologies (4G, 5G) or emitted from power lines, represent an additional and growing threat to pollinators. A lack of high quality scientific studies means that knowledge of the risk to pollinators from anthropogenic EMR is either inconclusive, unresolved, or only partly established. A handful of studies provide evidence that ALAN can alter pollinator communities, pollination and fruit set. Laboratory experiments provide some, albeit

variable, evidence that the honey bee *Apis mellifera* and other invertebrates can detect EMR, potentially using it for orientation or navigation, but they do not provide evidence that AREMR affects insect behaviour in ecosystems. Scientifically robust evidence of AREMR impacts on abundance or diversity of pollinators (or other invertebrates) are limited to a single study reporting positive and negative effects depending on the pollinator group and geographical location. Therefore, whether anthropogenic EMR (ALAN or AREMR) poses a significant threat to insect pollinators and the benefits they provide to ecosystems and humanity remains to be established. <https://doi.org/10.1016/j.scitotenv.2019.133833>

Wyszkowska, Joanna, Grodzicki, Przemysław, & Szczygiel, Marcin. 2019 Electromagnetic Fields and Colony Collapse Disorder of the Honeybee. *Przegląd Elektrotechniczny*, 95, 137–140. The abrupt disappearance of the bees that pollinate crops is a significant subject of recent study. One theory points to the development of telecommunications technology and an increasing number of electromagnetic field sources as a possible cause of the phenomenon. This paper presents the results of preliminary studies of honeybee exposure to extremely low frequency electromagnetic field (50 Hz; 1 mT, 7 mT) Streszczenie. Nagłe znikanie pszczół, które zapylają uprawy, jest jednym z istotnych tematów ostatnich badań. Jedną z teorii wskazuje na rozwój telekomunikacji i zwiększenie liczby źródeł pola elektromagnetycznego jako możliwą przyczynę tego zjawiska. Artykuł prezentuje wyniki wstępnych badań nad ekspozycją pszczół miodnych na pole elektromagnetyczne o wyjątkowo niskiej częstotliwości (50 Hz; 1 mT 7 mT) (Pola elektromagnetyczne i zespół masowego ginięcia pszczoły miodnej). <http://dx.doi.org/10.15199/48.2019.01.35>

Yahyazadeh, A., & Altunkaynak, B. Z. 2019 Protective effects of luteolin on rat testis following exposure to 900 MHz electromagnetic field. *Biotechnic & Histochemistry: Official Publication of the Biological Stain Commission*, 94(4), 298–307. Increasing cell phone use calls for clarification of the consequences of long term exposure to electromagnetic fields (EMF). We investigated the effects of EMF on the testes of 12-week-old rats as well as possible protective effects of luteolin on testis tissue. Twenty-four Wistar albino rats were randomly divided into four groups: control, EMF, luteolin, and EMF + luteolin. The number of Leydig cells, primary spermatocytes and spermatids were reduced in the EMF group compared to the control group. In the EMF + luteolin group, the number of Leydig cells, primary spermatocytes and spermatids was significantly greater than the EMF group. We found an increase in superoxide dismutase (SOD) activity in the EMF group compared to the control group. In the EMF group, we found decreased wet weight of testes and serum testosterone levels compared to the control group. Decreased SOD enzyme activity, and increased serum testosterone levels and weight of the testes were observed in the EMF + luteolin group compared to the EMF group. EMF also affected sperm morphology. We found that in rat testis repeated exposure to 900 MHz EMF caused changes in testicular tissue and that the antioxidant, luteolin, substantially reduced the deleterious effects of EMF. <https://doi.org/10.1080/10520295.2019.1566568>

Yahyazadeh, Ahmad, & Altunkaynak, B. Z. 2019 Investigation of the neuroprotective effects of thymoquinone on rat spinal cord exposed to 900 MHz electromagnetic field. *Journal of Chemical Neuroanatomy*, 100, 101657. Exposure to electromagnetic field in long-term use of cell phones has increased concerns about serious health problems. Our aim was to survey the possible effects of electromagnetic field radiation (60 min/day for 28 days) on the spinal cords of 12 weeks old rats. Further, we investigated whether the administration of thymoquinone (10 mg/kg/day) would protect the spinal cord tissue against the adverse effects of electromagnetic field or not. Twenty-four adult male Wistar albino rats were assigned randomly into four groups: control, electromagnetic field, thymoquinone and electromagnetic field + thymoquinone. The cervical spinal cords of all rats was evaluated using the stereological, biochemical and histological methods. The number of motor neurons were reduced in the electromagnetic field group compared to the control group ( $p < 0.05$ ). Superoxide dismutase level was higher in the electromagnetic field group compared to the control group ( $p < 0.05$ ). In the electromagnetic field + thymoquinone group, we found an increase in the number of motor neurons and decrease in superoxide dismutase activity compared to the electromagnetic field group ( $p < 0.05$ ). Our histological findings also exhibit the remarkable architectural alterations. We speculated that electromagnetic field radiation induced the morphological and biochemical damage to the spinal cord tissue of rats. Administration of antioxidant, thymoquinone, also ameliorated such complications caused by electromagnetic field. <https://doi.org/10.1016/j.jchemneu.2019.101657>

Zha, X.-D., Wang, W.-W., Xu, S., & Shang, X.-J. 2019 [Impacts of electromagnetic radiation from cellphones and Wi-Fi on spermatogenesis]. *Zhonghua Nan Ke Xue* National Journal of Andrology, 25(5), 451–455. [article in Chinese] With the development of Wi-Fi technology and widespread exposure to electromagnetic radiation (EMR), people are increasingly concerned about the health hazards caused by radiofrequency electromagnetic fields as from cellphones and Wi-Fi, particularly about the current decline in sperm concentration and increase in male infertility. Long-term exposure to EMR not only damages male reproductive organs, but also affects the number, morphology, motility and oocyte-binding ability of sperm, and indirectly increases the risk of infertility. However, EMR is not unavoidable. Low-intensity short-term or intermittent exposure to EMR has little adverse effect on reproductive organs and sperm. And many antioxidant and anti-free radical agents, such as vitamin E and

melatonin, can protect some special populations from EMR. This review presents an overview of the impacts of EMR from cellphones and Wi-Fi on sperm, some countermeasures, and prospects of EMR protection.  
<https://pubmed.ncbi.nlm.nih.gov/32216233/>

Zong, L., Gao, Z., Xie, W., Tong, J., & Cao, Y. 2019 Role of NF- $\kappa$ B activation in mouse bone marrow stromal cells exposed to 900 MHz radiofrequency fields (RF). *Journal of Toxicology and Environmental Health. Part A*, 82(3), 157–162. Nuclear factor kappa-light-chain-enhancer of activated B cells (NF- $\kappa$ B) is a primary transcription factor which plays a key role in several cellular processes including proliferation and survival. It is well-known that exposure to non-ionizing radiofrequency fields (RF), which are ubiquitous, interact with cellular components. The aim of the study was thus to examine whether exposure of mouse bone marrow stromal cells (BMSC) to RF also resulted in cellular interactions. BMSC were exposed to 900 MHz RF at 120  $\mu$ W/cm<sup>2</sup> power intensity for 4 hr/day for 5 consecutive days. The relative protein expression levels of NF- $\kappa$ B in the cytoplasm and nucleus of RF-exposed cells were compared to non-RF-exposed controls. At 30 min post-RF exposure a significant decrease in protein expression of NF- $\kappa$ B in the cytoplasm was accompanied by a concomitant increase in nuclear NF- $\kappa$ B protein expression levels. Similar responses were noted in the cytoplasm and nuclear NF- $\kappa$ B levels at 2 hr with a return to control concentrations in primary transcription factor at 24 hr post-RF treatment. Daily incubation of BAY 11-7082 an inhibitor of NF- $\kappa$ B for 90 min for 5 days followed by RF each day prevented the fall in cytoplasmic NF- $\kappa$ B and rise in nuclear primary transcription factor at 30 min and 2 hr. There were no marked alterations at 24 hr. Data showed that the effects of RF treatment on BMSC involved transient activation of NF- $\kappa$ B which may be attributed to RF-mediated cellular perturbation as evidenced by consequences of BAY 11-7082 inhibition. <https://doi.org/10.1080/15287394.2018.1564196>

## 2018

Ahmadi, S., Alavi, S. S., Jadidi, M., & Ardjmand, A. 2018 Exposure to GSM 900-MHz mobile radiation impaired inhibitory avoidance memory consolidation in rat: Involvements of opioidergic and nitrenergic systems. *Brain Research*, 1701, 36–45. The use of mobile phones is increasing, and the main health concern is the possible deleterious effects of radiation on brain functioning. The present study aimed to examine the effects of exposure to a global system for mobile communication (GSM) with mobile phones on inhibitory avoidance (IA) memory performance as well as the involvement of endogenous opioids and nitric oxide (NO) in this task. Male Wistar rats, 10-12 weeks old, were used. The results showed that four weeks of mobile phone exposure impaired IA memory performance in rats. The results also revealed that post-training, but not pre-training, as well as pre-test intracerebroventricular (i.c.v.) injections of naloxone (0.4, 4 and 40 ng/rat), dose-dependently recovered the impairment of IA memory performance induced by GSM radiation. Additionally, the impairment of IA memory performance was completely recovered in the exposed animals with post-training treatment of naloxone (40 ng/rat) plus pre-test i.c.v. injections of L-arginine (100 and 200 nmol/rat). However, pre-test i.c.v. injections of L-NAME (10 and 20 nmol/rat), impaired IA memory performance in the animals receiving post-training naloxone (40 ng/rat). In the animals receiving post-training naloxone treatment, the impairment of IA memory performance due to pre-test i.c.v. injections of L-NAME was recovered by the pre-test co-administration of L-arginine. It was concluded that the recovery from impairment of IA memory in GSM-exposed animals with post-training naloxone treatment was the result of blockade of the opioidergic system in early memory consolidation as well as activation of the nitrenergic system in the retrieval phase of memory. <https://doi.org/10.1016/j.brainres.2018.07.016>

Akdag, M., Dasdag, S., Canturk, F., & Akdag, M. Z. 2018 Exposure to non-ionizing electromagnetic fields emitted from mobile phones induced DNA damage in human ear canal hair follicle cells. *Electromagnetic Biology and Medicine*, 37(2), 66–75. The aim of this study was to investigate effect of radiofrequency radiation (RFR) emitted from mobile phones on DNA damage in follicle cells of hair in the ear canal. The study was carried out on 56 men (age range: 30–60 years old) in four treatment groups with n = 14 in each group. The groups were defined as follows: people who did not use a mobile phone (Control), people use mobile phones for 0–30 min/day (second group), people use mobile phones for 30–60 min/day (third group) and people use mobile phones for more than 60 min/day (fourth group). Ear canal hair follicle cells taken from the subjects were analyzed by the Comet Assay to determine DNA damages. The Comet Assay parameters measured were head length, tail length, comet length, percentage of head DNA, tail DNA percentage, tail moment, and Olive tail moment. Results of the study showed that DNA damage indicators were higher in the RFR exposure groups than in the control subjects. In addition, DNA damage increased with the daily duration of exposure. In conclusion, RFR emitted from mobile phones has a potential to produce DNA damage in follicle cells of hair in the ear canal. Therefore, mobile phone users have to pay more attention when using wireless phones. <https://doi.org/10.1080/15368378.2018.1463246>

Alimohammadi, I., Ashtarinezhad, A., Asl, B. M., Masruri, B., & Moghadasi, N. 2018 The effects of radiofrequency radiation on mice fetus weight, length and tissues. *Data in Brief*, 19, 2189–2194. The public concern of harmful effects of radiofrequency radiation exposure, especially with rapid increase in the use of wireless and telecommunication devices, is increasing. Some studies show fetal and developmental abnormalities as the result of radiofrequency radiation exposure. We aimed to investigate possible teratogenic effects of radiofrequency in 915 MHz on mice fetus and protective role of vitamin C. 21 RF-EMR References 2017 to mid-2022

pregnant mice were divided into 3 groups. Control group was in normal condition without any stressor agent. Exposure group was exposed to 915 MHz RFR (8 h/day for 10 days) and 0.045  $\mu\text{W}/\text{cm}^2$  power density. The exposure plus vitamin C group received 200 mg/kg vitamin C by gavage and was exposed to 915 MHz RFR (8 h/day for 10 days) and 0.045  $\mu\text{W}/\text{cm}^2$  power density. The fetus weight, C-R length were measured by digital balance and caliper. Tissues were assessed after staining with H & E. Our results showed significant increase in fetus weight and C-R length and also enlarged liver, tail deformation in mice fetus in exposure group. Although usage of vitamin C caused significant decrease in mentioned parameters. The outcome of this study confirms the effects of radiofrequency radiation on growth parameters such as body weight, length and some tissues in mice fetuses and protective effect of vitamin C. However more studies on non-ionization radiation in different frequencies and severity, during pregnancy are needed to clarify the exact mechanisms of these changes and better protection.

<https://doi.org/10.1016/j.dib.2018.06.107>

Bahreyni Toossi, M. H., Sadeghnia, H. R., Mohammad Mahdizadeh Feyzabadi, M., Hosseini, M., Hedayati, M., Mosallanejad, R., ... Alizadeh Rahvar, Z. 2018 Exposure to mobile phone (900-1800 MHz) during pregnancy: tissue oxidative stress after childbirth. *The Journal of Maternal-Fetal & Neonatal Medicine: The Official Journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians*, 31(10), 1298–1303. 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.

<https://doi.org/10.1080/14767058.2017.1315657>

Bandara, P., & Carpenter, D. O. 2018 Planetary electromagnetic pollution: it is time to assess its impact. *The Lancet Planetary Health*, 2(12), e512–e514. As the Planetary Health Alliance moves forward after a productive second annual meeting, a discussion on the rapid global proliferation of artificial electromagnetic fields would now be apt. The most notable is the blanket of radiofrequency electromagnetic radiation, largely microwave radiation generated for wireless communication and surveillance technologies, as mounting scientific evidence suggests that prolonged exposure to radiofrequency electromagnetic radiation has serious biological and health effects. However, public exposure regulations in most countries continue to be based on the guidelines of the International Commission on Non-Ionizing Radiation Protection<sup>1</sup> and Institute of Electrical and Electronics Engineers, which were established in the 1990s on the belief that only acute thermal effects are hazardous. Prevention of tissue heating by radiofrequency electromagnetic radiation is now proven to be ineffective in preventing biochemical and physiological interference. For example, acute non-thermal exposure has been shown to alter human brain metabolism by NIH scientists, electrical activity in the brain,<sup>4</sup> and systemic immune responses. Chronic exposure has been associated with increased oxidative stress and DNA damage and cancer risk.<sup>8</sup> Laboratory studies, including large rodent studies by the US National Toxicology Program<sup>9</sup> and Ramazzini Institute of Italy, confirm these biological and health effects in vivo. As we address the threats to human health from the changing environmental conditions due to human activity, the increasing exposure to artificial electromagnetic radiation needs to be included in this discussion. Due to the exponential increase in the use of wireless personal communication devices (e.g., mobile or cordless phones and WiFi or Bluetooth-enabled devices) and the infrastructure facilitating them, levels of exposure to radiofrequency electromagnetic radiation around the 1 GHz frequency band, which is mostly used for modern wireless communications, have increased from extremely low natural levels by about 10<sup>18</sup> times (figure). Radiofrequency electromagnetic radiation is also used for radar, security scanners, smart meters, and medical equipment (MRI, diathermy, and radiofrequency ablation). It is plausibly the most rapidly increasing anthropogenic environmental exposure since the mid-20th century, and levels will surge considerably again, as technologies like the Internet of Things and 5G add millions more radiofrequency transmitters around us.

[https://doi.org/10.1016/S2542-5196\(18\)30221-3](https://doi.org/10.1016/S2542-5196(18)30221-3)

Bektas, H., Bektas, M. S., & Dasdag, S. 2018 Effects of mobile phone exposure on biochemical parameters of cord blood: A preliminary study. *Electromagnetic Biology and Medicine*, 37(4), 184–191. The purpose of this study is to investigate foetal impact of radiofrequencies (RFs) emitted from mobile phones in postnatal cord blood. The study carried on 149 pregnant women divided into four groups such as nonusers of mobile phone (n: 37; control group), 2-15 min/d (n: 39; group 1), 15-60 min/d (n: 37; group 2) and participants using mobile phone for more than 60 min/d (n: 36; group 3). Cord blood of the infants was taken in all groups for biochemical analyses immediately after birth. The results of the study showed that the biggest foetal impact was observed in the third study group which was pregnant exposed RFRs (RF radiation) more than 1 h/d (1 hour per

day). AST (aspartat aminotransferaz), ALT (alanine aminotransferase), LDH (lactate dehydrogenase), CK (creatin kinase), CK-MB (creatin kinase-miyocardial band), CRP (c-reactive protein), PCT (procalcitonin), TnT (troponin T), uric acid and lactate levels of third group were found higher than the other groups ( $p < 0.001$ ). However, Mean platelet volume values of third group were found lower than the other groups ( $p < 0.001$ ). Finally, this is the first human study which was performed on pregnant and infants because there is no previous work in this area. However, the results of this study revealed that long-term RFR exposure of pregnant may result in some biochemical changes in the infants. Therefore, our suggestion to pregnant is to avoid from RFR exposure emitted from mobile phones at least during pregnancy.  
<https://doi.org/10.1080/15368378.2018.1499033>

Belpomme, D., Hardell, L., Belyaev, I., Burgio, E., & Carpenter, D. O. 2018 Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective. *Environmental Pollution*, 242, 643–658. Exposure to low frequency and radiofrequency electromagnetic fields at low intensities poses a significant health hazard that has not been adequately addressed by national and international organizations such as the World Health Organization. There is strong evidence that excessive exposure to mobile phone-frequencies over long periods of time increases the risk of brain cancer both in humans and animals. The mechanism(s) responsible include induction of reactive oxygen species, gene expression alteration and DNA damage through both epigenetic and genetic processes. In vivo and in vitro studies demonstrate adverse effects on male and female reproduction, almost certainly due to generation of reactive oxygen species. There is increasing evidence the exposures can result in neurobehavioral decrements and that some individuals develop a syndrome of “electro-hypersensitivity” or “microwave illness”, which is one of several syndromes commonly categorized as “idiopathic environmental intolerance”. While the symptoms are non-specific, new biochemical indicators and imaging techniques allow diagnosis that excludes the symptoms as being only psychosomatic. Unfortunately standards set by most national and international bodies are not protective of human health. This is a particular concern in children, given the rapid expansion of use of wireless technologies, the greater susceptibility of the developing nervous system, the hyperconductivity of their brain tissue, the greater penetration of radiofrequency radiation relative to head size and their potential for a longer lifetime exposure.  
<https://doi.org/10.1016/j.envpol.2018.07.019>

Bertrand, E., Pasquier, C., Duchez, D., Girard, S., Pons, A., Bonnet, P., ... Dussap, C.-G. 2018 High-frequency, high-intensity electromagnetic field effects on *Saccharomyces cerevisiae* conversion yields and growth rates in a reverberant environment. *Bioresource Technology*, 260, 264–272. Studies of the effects of electromagnetic waves on *Saccharomyces cerevisiae* emphasize the need to develop instrumented experimental systems ensuring a characterization of the exposition level to enable unambiguous assessment of their potential effects on living organisms. A bioreactor constituted with two separate compartments has been designed. The main element (75% of total volume) supporting all measurement and control systems (temperature, pH, agitation, and aeration) is placed outside the exposure room whereas the secondary element is exposed to irradiation. Measurements of the medium dielectric properties allow the determination of the electromagnetic field at any point inside the irradiated part of the reactor and are consistent with numerical simulations. In these conditions, the growth rate of *Saccharomyces cerevisiae* and the ethanol yield in aerobic conditions are not significantly modified when submitted to an electromagnetic field of 900 and 2400 MHz with an average exposition of 6.11 V.m<sup>-1</sup> and 3.44 V.m<sup>-1</sup> respectively.  
<https://doi.org/10.1016/j.biortech.2018.03.130>

Betzalel, N., Ben Ishai, P., & Feldman, Y. 2018 The human skin as a sub-THz receiver - Does 5G pose a danger to it or not? *Environmental Research*, 163, 208–216. In the interaction of microwave radiation and human beings, the skin is traditionally considered as just an absorbing sponge stratum filled with water. In previous works, we showed that this view is flawed when we demonstrated that the coiled portion of the sweat duct in upper skin layer is regarded as a helical antenna in the sub-THz band. Experimentally we showed that the reflectance of the human skin in the sub-THz region depends on the intensity of perspiration, i.e. sweat duct’s conductivity, and correlates with levels of human stress (physical, mental and emotional). Later on, we detected circular dichroism in the reflectance from the skin, a signature of the axial mode of a helical antenna. The full ramifications of what these findings represent in the human condition are still unclear. We also revealed correlation of electrocardiography (ECG) parameters to the sub-THz reflection coefficient of human skin. In a recent work, we developed a unique simulation tool of human skin, taking into account the skin multi-layer structure together with the helical segment of the sweat duct embedded in it. The presence of the sweat duct led to a high specific absorption rate (SAR) of the skin in extremely high frequency band. In this paper, we summarize the physical evidence for this phenomenon and consider its implication for the future exploitation of the electromagnetic spectrum by wireless communication. Starting from July 2016 the US Federal Communications Commission (FCC) has adopted new rules for wireless broadband operations above 24 GHz (5 G). This trend of exploitation is predicted to expand to higher frequencies in the sub-THz region. One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned. We are  
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raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored.

<https://doi.org/10.1016/j.envres.2018.01.032>

Di Ciaula, A. 2018 Towards 5G communication systems: Are there health implications? *International Journal of Hygiene and Environmental Health*, 221(3), 367–375. The spread of radiofrequency electromagnetic fields (RF-EMF) is rising and health effects are still under investigation. RF-EMF promote oxidative stress, a condition involved in cancer onset, in several acute and chronic diseases and in vascular homeostasis. Although some evidences are still controversial, the WHO IARC classified RF-EMF as “possible carcinogenic to humans”, and more recent studies suggested reproductive, metabolic and neurologic effects of RF-EMF, which are also able to alter bacterial antibiotic resistance. In this evolving scenario, although the biological effects of 5G communication systems are very scarcely investigated, an international action plan for the development of 5G networks has started, with a forthcoming increment in devices and density of small cells, and with the future use of millimeter waves (MMW). Preliminary observations showed that MMW increase skin temperature, alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes, could generate ocular damages, affect neuro-muscular dynamics. Further studies are needed to better and independently explore the health effects of RF-EMF in general and of MMW in particular. However, available findings seem sufficient to demonstrate the existence of biomedical effects, to invoke the precautionary principle, to define exposed subjects as potentially vulnerable and to revise existing limits. An adequate knowledge of pathophysiological mechanisms linking RF-EMF exposure to health risk should also be useful in the current clinical practice, in particular in consideration of evidences pointing to extrinsic factors as heavy contributors to cancer risk and to the progressive epidemiological growth of noncommunicable diseases. <https://doi.org/10.1016/j.ijheh.2018.01.011>

Ertilav, K., Uslusoy, F., Ataizi, S., & Naziroğlu, M. 2018 Long term exposure to cell phone frequencies (900 and 1800 MHz) induces apoptosis, mitochondrial oxidative stress and TRPV1 channel activation in the hippocampus and dorsal root ganglion of rats. *Metabolic Brain Disease*, 33(3), 753–763. Mobile phone providers use electromagnetic radiation (EMR) with frequencies ranging from 900 to 1800 MHz. The increasing use of mobile phones has been accompanied by several potentially pathological consequences, such as neurological diseases related to hippocampal (HIPPO) and dorsal root ganglion neuron (DRGN). The TRPV1 channel is activated different stimuli, including CapN, high temperature and oxidative stress. We investigated the contribution TRPV1 to mitochondrial oxidative stress and apoptosis in HIPPO and DRGN following long term exposure to 900 and 1800 MHz in a rat model. Twenty-four adult rats were equally divided into the following groups: (1) control, (2) 900 MHz, and (3) 1800 MHz exposure. Each experimental group was exposed to EMR for 60 min/ 5 days of the week during the one year. The 900 and 1800 MHz EMR exposure induced increases in TRPV1 currents, intracellular free calcium influx (Ca<sup>2+</sup>), reactive oxygen species (ROS) production, mitochondrial membrane depolarization (JC-1), apoptosis, and caspase 3 and 9 activities in the HIPPO and DRGN. These deleterious processes were further increased in the 1800 MHz experimental group compared to the 900 MHz exposure group. In conclusion, mitochondrial oxidative stress, programmed cell death and Ca<sup>2+</sup> entry pathway through TRPV1 activation in the HIPPO and DRGN of rats were increased in the rat model following exposure to 900 and 1800 MHz cell frequencies. Our results suggest that exposure to 900 and 1800 MHz EMR may induce a dose-associated, TRPV1-mediated stress response. <https://doi.org/10.1007/s11011-017-0180-4>

Falcioni, L., Bua, L., Tibaldi, E., Lauriola, M., De Angelis, L., Gnudi, F., ... Belpoggi, F. 2018 Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission. *Environmental Research*. Background: In 2011, IARC classified radiofrequency radiation (RFR) as possible human carcinogen (Group 2B). According to IARC, animals studies, as well as epidemiological ones, showed limited evidence of carcinogenicity. In 2016, the NTP published the first results of its long-term bioassays on near field RFR, reporting increased incidence of malignant glial tumors of the brain and heart Schwannoma in rats exposed to GSM – and CDMA –modulated cell phone RFR. The tumors observed in the NTP study are of the type similar to the ones observed in some epidemiological studies of cell phone users.Objectives: The Ramazzini Institute (RI) performed a life-span carcinogenic study on Sprague-Dawley rats to evaluate the carcinogenic effects of RFR in the situation of far field, reproducing the environmental exposure to RFR generated by 1.8 GHz GSM antenna of the radio base stations of mobile phone. This is the largest long-term study ever performed in rats on the health effects of RFR, including 2448 animals. In this article, we reported the final results regarding brain and heart tumors.Methods: Male and female Sprague-Dawley rats were exposed from prenatal life until natural death to a 1.8 GHz GSM far field of 0, 5, 25, 50 V/m with a whole-body exposure for 19 h/day.Results: A statistically significant increase in the incidence of heart Schwannomas was observed in treated male rats at the highest dose (50 V/m). Furthermore, an increase in the incidence of heart Schwann cells hyperplasia was observed in treated male and female rats at the highest dose (50 V/m), although this was not statistically significant. An increase in the incidence of malignant glial tumors was observed in treated female rats at the highest dose (50 V/m), although not statistically significant.Conclusions: The RI findings on far field exposure to RFR are consistent with and reinforce the results of the NTP study on near field exposure, as both

reported an increase in the incidence of tumors of the brain and heart in RFR-exposed Sprague-Dawley rats. These tumors are of the same histotype of those observed in some epidemiological studies on cell phone users. These experimental studies provide sufficient evidence to call for the reevaluation of IARC conclusions regarding the carcinogenic potential of RFR in humans. <https://doi.org/10.1016/j.envres.2018.01.037>

Fernández, C., de Salles, A. A., Sears, M. E., Morris, R. D., & Davis, D. L. 2018 Absorption of wireless radiation in the child versus adult brain and eye from cell phone conversation or virtual reality. *Environmental Research*, 167, 694–699. Children’s brains are more susceptible to hazardous exposures, and are thought to absorb higher doses of radiation from cell phones in some regions of the brain. Globally the numbers and applications of wireless devices are increasing rapidly, but since 1997 safety testing has relied on a large, homogenous, adult male head phantom to simulate exposures; the “Standard Anthropomorphic Mannequin” (SAM) is used to estimate only whether tissue temperature will be increased by more than 1 Celsius degree in the periphery. The present work employs anatomically based modeling currently used to set standards for surgical and medical devices, that incorporates heterogeneous characteristics of age and anatomy. Modeling of a cell phone held to the ear, or of virtual reality devices in front of the eyes, reveals that young eyes and brains absorb substantially higher local radiation doses than adults’. Age-specific simulations indicate the need to apply refined methods for regulatory compliance testing; and for public education regarding manufacturers’ advice to keep phones off the body, and prudent use to limit exposures, particularly to protect the young. <https://doi.org/10.1016/j.envres.2018.05.013>

Golomb, B. A. 2018 Diplomats’ Mystery Illness and Pulsed Radiofrequency/Microwave Radiation. *Neural Computation*, 30(11), 2882–2985. Importance: A mystery illness striking U.S. and Canadian diplomats to Cuba (and now China) “has confounded the FBI, the State Department and US intelligence agencies” (Lederman, Weissenstein, & Lee, 2017). Sonic explanations for the so-called health attacks have long dominated media reports, propelled by peculiar sounds heard and auditory symptoms experienced. Sonic mediation was justly rejected by experts. We assessed whether pulsed radiofrequency/microwave radiation (RF/MW) exposure can accommodate reported facts in diplomats, including unusual ones. Observations: (1) Noises: Many diplomats heard chirping, ringing or grinding noises at night during episodes reportedly triggering health problems. Some reported that noises were localized with laser-like precision or said the sounds seemed to follow them (within the territory in which they were perceived). Pulsed RF/MW engenders just these apparent “sounds” via the Frey effect. Perceived “sounds” differ by head dimensions and pulse characteristics and can be perceived as located behind in or above the head. Ability to hear the “sounds” depends on high-frequency hearing and low ambient noise. (2) Signs/symptoms: Hearing loss and tinnitus are prominent in affected diplomats and in RF/MW-affected individuals. Each of the protean symptoms that diplomats report also affect persons reporting symptoms from RF/MW: sleep problems, headaches, and cognitive problems dominate in both groups. Sensations of pressure or vibration figure in each. Both encompass vision, balance, and speech problems and nosebleeds. Brain injury and brain swelling are reported in both. (3) Mechanisms: Oxidative stress provides a documented mechanism of RF/MW injury compatible with reported signs and symptoms; sequelae of endothelial dysfunction (yielding blood flow compromise), membrane damage, blood-brain barrier disruption, mitochondrial injury, apoptosis, and autoimmune triggering afford downstream mechanisms, of varying persistence, that merit investigation. (4) Of note, microwaving of the U.S. embassy in Moscow is historically documented. Conclusions and relevance: Reported facts appear consistent with pulsed RF/MW as the source of injury in affected diplomats. Nondiplomats citing symptoms from RF/MW, often with an inciting pulsed-RF/MW exposure, report compatible health conditions. Under the RF/MW hypothesis, lessons learned for diplomats and for RF/MW-affected civilians may each aid the other. [https://doi.org/10.1162/neco\\_a\\_01133](https://doi.org/10.1162/neco_a_01133)

Gupta, S. K., Mesharam, M. K., & Krishnamurthy, S. 2018 Electromagnetic radiation 2450 MHz exposure causes cognition deficit with mitochondrial dysfunction and activation of intrinsic pathway of apoptosis in rats. *Journal of Biosciences*, 43(2), 263–276. Electromagnetic radiation (EMR) can induce or modulate several neurobehavioral disorders. Duration and frequency of exposure of EMR is critical to develop cognitive disorders. Even though EMR-2450 is widely used, its effects on cognition in relation to mitochondrial function and apoptosis would provide better understanding of its pathophysiological effects. Therefore, a comparative study of different frequencies of EMR exposure would give valuable information on effects of discrete frequencies of EMR on cognition. Male rats were exposed to EMR (900, 1800 and 2450 MHz) every day for 1 h for 28 consecutive days. The cognitive behavior in terms of novel arm entries in Y-maze paradigm was evaluated every week after 1 h to last EMR exposure. Animals exposed to EMR-2450 MHz exhibited significant cognitive deficits. EMR- 2450 MHz caused loss of mitochondrial function and integrity, an increase in amyloid beta expression. There was release of cytochrome-c and activation of apoptotic factors such as caspase-9 and -3 in the hippocampus. Further, there was decrease in levels of acetylcholine, and increase in activity of acetyl cholinesterase, indicating impairment of cholinergic system. Therefore, exposure of EMR-2450 in rats caused cognitive deficit with related pathophysiological changes in mitochondrial and cholinergic function, and amyloidogenesis. <http://dx.doi.org/10.1007/s12038-018-9744-7>

- Hancı, H., Kerimoğlu, G., Mercantepe, T., & Odacı, E. 2018 Changes in testicular morphology and oxidative stress biomarkers in 60-day-old Sprague Dawley rats following exposure to continuous 900-MHz electromagnetic field for 1 h a day throughout adolescence. *Reproductive Toxicology* (Elmsford, N.Y.), 81, 71–78. The purpose of this study was to investigate the 60-day-old male rat testis following exposure to continuous 900-megahertz (MHz) electromagnetic field (EMF) throughout the adolescent period using histopathological and biochemical analysis methods. Twenty-four Sprague Dawley rats aged 21 days were randomly and equally (n = 8) divided into three groups. No procedure was performed on the control group rats. The sham group rats were held in an EMF-cage without exposure to EMF. The EMF group rats were exposed to continuous 900-MHz EMF for 1 h each day inside the EMF-cage during adolescence. On postnatal day 60 the testes were extracted and divided into right and left halves. The right half was used for histopathological evaluation and the left half for biochemical analyses. Our results show that changes may occur in morphology and oxidative stress biomarkers in the rat testis following exposure to continuous 900-MHz EMF throughout the adolescent period. <https://doi.org/10.1016/j.reprotox.2018.07.002>
- Hardell, L., & Carlberg, M. 2018 Comments on the US National Toxicology Program technical reports on toxicology and carcinogenesis study in rats exposed to whole-body radiofrequency radiation at 900 MHz and in mice exposed to whole-body radiofrequency radiation at 1,900 MHz. *International Journal of Oncology*. During the use of handheld mobile and cordless phones, the brain is the main target of radiofrequency (RF) radiation. An increased risk of developing glioma and acoustic neuroma has been found in human epidemiological studies. Primarily based on these findings, the International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) classified in May, 2011 RF radiation at the frequency range of 30 kHz 300 GHz as a “possible” human carcinogen, Group 2B. A carcinogenic potential for RF radiation in animal studies was already published in 1982. This has been confirmed over the years, more recently in the Ramazzini Institute rat study. An increased incidence of glioma in the brain and malignant schwannoma in the heart was found in the US National Toxicology Program (NTP) study on rats and mice. The NTP final report is to be published; however, the extended reports are published on the internet for evaluation and are reviewed herein in more detail in relation to human epidemiological studies. Thus, the main aim of this study was to compare earlier human epidemiological studies with NTP findings, including a short review of animal studies. We conclude that there is clear evidence that RF radiation is a human carcinogen, causing glioma and vestibular schwannoma (acoustic neuroma). There is some evidence of an increased risk of developing thyroid cancer, and clear evidence that RF radiation is a multi site carcinogen. Based on the Preamble to the IARC Monographs, RF radiation should be classified as carcinogenic to humans, Group 1. <https://doi.org/10.3892/ijo.2018.4606>
- Him A, Deniz NB, & Onger ME. 2018 The effect of caffeine on neuron number of rats exposed to 900-MHz electromagnetic field. *Turk J Vet Anim Sci*, 42(3), 198–204. Previous studies have shown that the electromagnetic field (EMF) emitted by cell phones decreased the number of neurons in some parts of the brain. It was also shown that caffeine protects the nerve cells. This study examines if caffeine has any effects on preventing neuron loss in rats exposed to EMF. Rats were exposed to a 900-MHz EMF for 60 min a day for 28 days. The rats that were exposed to EMF were fed 1 mg/L caffeinated water instead of tap water. The rats in the sham group were put inside the exposure chamber but were not exposed to EMF. The changes in the hippocampal and cerebellar neuron numbers were examined with stereological histological methods. EMF application caused a significant decrease in the number of the cerebellar Purkinje neurons and the hippocampal pyramidal neurons. In the group that received caffeine with EMF exposure, the decrease in neuron number was prevented in both the hippocampus and the cerebellum. The results show that caffeine protects the cerebellum and the hippocampus from neural damage induced by EMF exposure. <https://doi.org/10.3906/vet-1802-31>
- Keleş, A. İ., Yıldırım, M., Gedikli, Ö., Çolakoğlu, S., Kaya, H., Baş, O., ... Odacı, E. 2018 The effects of a continuous 1-h a day 900-MHz electromagnetic field applied throughout early and mid-adolescence on hippocampus morphology and learning behavior in late adolescent male rats. *Journal of Chemical Neuroanatomy*, 94, 46–53. The purpose of this study was to investigate hippocampus morphology and changes in learning behavior in male rats in late adolescence exposed to the effect of a continuous 1-h a day 900-megahertz (MHz) electromagnetic field (EMF). Twenty-four male Sprague Dawley rats aged 3-weeks were divided equally into control, sham and EMF groups. EMF group rats were exposed to a 900-MHz EMF inside an EMF cage, while the sham group rats were placed in the same cage but were not exposed to such an effect. No procedure was performed on the control group. Following 25-day application of EMF, passive avoidance, 8-arm radial maze and Y-maze tests were applied to determine rats’ learning and memory performances. Open field and rotarod tests were applied to assess locomotor activity. At the end of the tests, the animals’ brains were removed. Sections were taken and stained with toluidine blue. The regions of the hippocampus were subjected to histopathological evaluation. At histopathological examination, impairments of pyramidal and granular cell structures were observed in the EMF group hippocampus. No significant change was observed in learning, memory or locomotor behavior in any group. In conclusion, 900-MHz EMF applied in early and mid-adolescence causes no changes in learning, memory or locomotor behavior. <https://doi.org/10.1016/j.jchemneu.2018.08.006>

Kerimoğlu, G., Güney, C., Ersöz, Ş., & Odacı, E. 2018 A histopathological and biochemical evaluation of oxidative injury in the sciatic nerves of male rats exposed to a continuous 900-megahertz electromagnetic field throughout all periods of adolescence. *Journal of Chemical Neuroanatomy*, 91, 1–7. The effects on human health of the electromagnetic field (EMF) emitted by mobile phones, used by approximately 7 billion people worldwide, have become an important subject for scientific research. Studies have suggested that the EMF emitted by mobile phones can cause oxidative stress in different tissues and age groups. Young people in adolescence, a time period when risky behaviors and dependences increase, use mobile phones more than adults. The EMF emitted by mobile phones, which are generally carried in the pocket or in bags when not in use, will very probably affect the sciatic nerve. No previous study has investigated the effect of mobile phone use in adolescence on peripheral nerve. This study was planned accordingly. Twenty-four male Sprague Dawley rats aged 21 days were divided equally into control (CGr), Sham (SGr) and EMF (EMFGr) groups. No procedure was performed on CGr rats. EMFGr were exposed to the effect of a 900-megahertz (MHz) EMF for 1 h at the same time every day between postnatal days 21-59 (the entire adolescent period) inside a cage in the EMF apparatus. SGr rats were placed inside the cage for 1 h every day without being exposed to EMF. All rats were sacrificed at the end of the study period, and 1 cm sections of sciatic nerve were extracted. Malondialdehyde (MDA), glutathione, catalase (CAT) superoxide dismutase (SOD) values were investigated biochemically in half of the right sciatic nerve tissues. The other halves of the nerve tissues were subjected to routine histopathological tissue procedures, sectioned and stained with hematoxylin and eosin (H&E) and Masson's trichrome. Histopathological evaluation of slides stained with Masson's trichrome and H&E revealed a normal appearance in Schwann cells and axons in all groups. However, there was marked thickening in the epineurium of sciatic nerves from EMFGr rats. MDA, SOD and CAT levels were higher in EMFGr than in CGr and SGr at biochemical analyses. Apoptotic index (AI) analysis revealed a significant increase in the number of TUNEL (+) cells when EMFGr was compared with CGr and SGr. In conclusion, our study results suggest that continuous exposure to a 900-MHz EMF for 1 h throughout adolescence can cause oxidative injury and thickening in the epineurium in the sciatic nerve in male rats. <https://doi.org/10.1016/j.jchemneu.2018.01.001>

Kesari, K. K., Agarwal, A., & Henkel, R. 2018 Radiations and male fertility. *Reproductive Biology and Endocrinology: RB&E*, 16(1), 118. During recent years, an increasing percentage of male infertility has to be attributed to an array of environmental, health and lifestyle factors. Male infertility is likely to be affected by the intense exposure to heat and extreme exposure to pesticides, radiations, radioactivity and other hazardous substances. We are surrounded by several types of ionizing and non-ionizing radiations and both have recognized causative effects on spermatogenesis. Since it is impossible to cover all types of radiation sources and their biological effects under a single title, this review is focusing on radiation deriving from cell phones, laptops, Wi-Fi and microwave ovens, as these are the most common sources of non-ionizing radiations, which may contribute to the cause of infertility by exploring the effect of exposure to radiofrequency radiations on the male fertility pattern. From currently available studies it is clear that radiofrequency electromagnetic fields (RF-EMF) have deleterious effects on sperm parameters (like sperm count, morphology, motility), affects the role of kinases in cellular metabolism and the endocrine system, and produces genotoxicity, genomic instability and oxidative stress. This is followed with protective measures for these radiations and future recommendations. The study concludes that the RF-EMF may induce oxidative stress with an increased level of reactive oxygen species, which may lead to infertility. This has been concluded based on available evidences from in vitro and in vivo studies suggesting that RF-EMF exposure negatively affects sperm quality. <https://doi.org/10.1186/s12958-018-0431-1>

Kocyigit, U. M., Taslimi, P., Gurses, F., Soyul, S., Durna Dastan, S., & Gulcin, İ. 2018 The effects of wireless electromagnetic fields on the activities of carbonic anhydrase and acetylcholinesterase enzymes in various tissues of rats. *Journal of Biochemical and Molecular Toxicology*, 32(3), e22031. The purpose of our study is to assist in understanding the effects of wireless electromagnetic waves on carbonic anhydrase (CA) and acetylcholinesterase (AChE) enzymes activities in the different tissues of the rats. For this purpose, two different groups each of which contains eight rats (n = 8) were formed as being control group and wireless electromagnetic wave-administered group. The rats were necropsied after 60 min from the injection of chemicals into the rats intraperitoneally. The different tissues of the rats were extracted. CA and AChE enzymes activities were measured for each tissue. All the experimental results were provided in mean  $\pm$  S.D. Statistical significance was identified to be  $P < 0.05$ . It was observed that there were significant changes of enzyme activities in wireless-administered group in salivary gland, stomach, colon, liver, and striated muscle tissues. <https://doi.org/10.1002/jbt.22031>

Kojima et al., M. 2018 Ocular Effects of Exposure to 40, 75, and 95 GHz Millimeter Waves. *Journal of Infrared, Millimeter, and Terahertz Waves*. 39(8). The objective of this study was to develop a model of ocular damage induced by 40, 75, and 95 GHz continuous millimeter waves (MMW), thereby allowing assessment of the clinical course of ocular damage resulting from exposure to thermal damage-inducing MMW. This study also examined the dependence of ocular damage on incident power density. Pigmented rabbit eyes were exposed to 40, 75, and 95 GHz MMW from a spot-focus-type lens antenna. Slight ocular damage was observed 10 min after MMW exposure, including reduced cornea thickness and reduced transparency. Diffuse fluorescein staining around the pupillary area indicated corneal epithelial injury. Slit-lamp examination 1 day after MMW exposure revealed a round area of opacity, accompanied by fluorescence staining, in the central pupillary zone. Corneal edema, indicative of corneal stromal damage, peaked 1 day after MMW exposure, with thickness gradually subsiding to normal. Three

days after exposure, ocular conditions had almost normalized, though corneal thickness was slightly greater than that before exposure. The 50% probability of ocular damage (DD50) was in the order  $40 > 95 \approx 75$  GHz at the same incident power densities. <https://link.springer.com/article/10.1007/s10762-018-0497-z>

Lamkowski, A., Kreitlow, M., Radunz, J., Willenbockel, M., Sabath, F., Schuh, W., ... Abend, M. 2018 Gene Expression Analysis in Human Peripheral Blood Cells after 900 MHz RF-EMF Short-Term Exposure. *Radiation Research*, 189(5), 529–540.

Radiofrequency electromagnetic fields (RF-EMF) are a basic requirement of modern wireless communication technology. Statutory thresholds of RF-EMF are established to limit relevant additional heat supply in human tissue. Nevertheless, to date, questions concerning nonthermal biological effects have yet to be fully addressed. New versions of microarrays (8 × 60K v2) provide a higher resolution of whole genome gene expression to display adaptive processes in cells after irradiation. In this ex vivo/ in vitro study, we irradiated peripheral blood cells from five donors with a continuous wave of 900 MHz RF-EMF for 0, 30, 60 and 90 min. Gene expression changes ( $P \leq 0.05$  and  $\geq$ twofold differences above or below the room temperature control exposed samples) were evaluated with microarray analysis. The results were compared with data from room temperature + 2°C samples. Verification of microarray results was performed using bioinformatic analyses and qRT-PCR. We registered a lack of an EMF-specific gene expression response after applying the false discovery rate adjustment (FDR), using a high-stringency approach. Low-stringency analysis revealed 483 statistically significant deregulated transcripts in all RF-EMF groups relative to the room temperature exposed samples without an association with their corresponding room temperature + 2°C controls. Nevertheless, these transcripts must be regarded as statistical artefacts due to the absence of a targeted biological response, including enrichment and network analyses administered to microarray expressed gene subset profiles. Correspondingly, 14 most promising candidate transcripts examined by qRT-PCR displayed an absence of correlation with respect to the microarray results. In conclusion, these findings indicate that 900 MHz EMF exposure establishing an average specific absorption rate of 9.3 W/kg to whole blood cells is insufficient to induce nonthermal effects in gene expression during short-time exposure up to 90 min.

<https://doi.org/10.1667/RR14909.1>

Lin, J. C. 2018 Clear Evidence of Cell Phone RF Radiation Cancer Risk [Health Matters]. *IEEE Microwave Magazine*, 19(6), 16–24. During 26-28 March 2018, the National Institute of Environmental Health Sciences (NIEHS) National Toxicology Program (NTP), a part of the U.S. National Institutes of Health, convened a three-day technical reports peer-review panel meeting in Research Triangle Park, North Carolina, to review the NTP's draft reports on its carcinogenesis studies of cell-phone RF radiation in mice and rats. <https://doi.org/10.1109/MMM.2018.2844058>

Lissak, G. 2018 Adverse physiological and psychological effects of screen time on children and adolescents: Literature review and case study. *Environmental Research*, 164, 149–157. A growing body of literature is associating excessive and addictive use of digital media with physical, psychological, social and neurological adverse consequences. Research is focusing more on mobile devices use, and studies suggest that duration, content, after-dark-use, media type and the number of devices are key components determining screen time effects. Physical health effects: excessive screen time is associated with poor sleep and risk factors for cardiovascular diseases such as high blood pressure, obesity, low HDL cholesterol, poor stress regulation (high sympathetic arousal and cortisol dysregulation), and Insulin Resistance. Other physical health consequences include impaired vision and reduced bone density. Psychological effects: internalizing and externalizing behavior is related to poor sleep. Depressive symptoms and suicidal are associated to screen time induced poor sleep, digital device night use, and mobile phone dependency. ADHD-related behavior was linked to sleep problems, overall screen time, and violent and fast-paced content which activates dopamine and the reward pathways. Early and prolonged exposure to violent content is also linked to risk for antisocial behavior and decreased prosocial behavior. Psychoneurological effects: addictive screen time use decreases social coping and involves craving behavior which resembles substance dependence behavior. Brain structural changes related to cognitive control and emotional regulation are associated with digital media addictive behavior. A case study of a treatment of an ADHD diagnosed 9-year-old boy suggests screen time induced ADHD-related behavior could be inaccurately diagnosed as ADHD. Screen time reduction is effective in decreasing ADHD-related behavior. CONCLUSIONS: Components crucial for psychophysiological resilience are none-wandering mind (typical of ADHD-related behavior), good social coping and attachment, and good physical health. Excessive digital media use by children and adolescents appears as a major factor which may hamper the formation of sound psychophysiological resilience. <https://doi.org/10.1016/j.envres.2018.01.015>

López-Furelos, A., Salas-Sánchez, A. A., Ares-Pena, F. J., Leiro-Vidal, J. M., & López-Martín, E. 2018 Exposure to radiation from single or combined radio frequencies provokes macrophage dysfunction in the RAW 264.7 cell line. *International Journal of Radiation Biology*, 94(6), 607–618. Purpose: The aim of this study was to determine whether exposure to radiation from single or multiple radio-frequency (RF) signals at 900 and 2450 MHz would induce effects in the RAW 264.7 cell line. Materials and methods: Cell cultures were exposed to single or combined RF for 4, 24, 48, or 72 h in a GTEM electromagnetic test chamber. At the end of the radiation exposure time, viability and cell growth were analyzed by flow cytometry, nitric oxide (NO) production was measured by colorimetry, the expression of HSP70 and TNF- $\alpha$  was ascertained by qPCR, and the phagocytic activity was observed by microscopy. Results: NO production increased after 48 h exposure at 2450 MHz, compared with controls. The group

subjected to the combined interaction of two RFs showed an increase of HSP70 after 48 h exposure and a significant increase of NO and TNF- $\alpha$  after 72 h. The phagocytic activity of macrophages decreased in all groups as exposure time increased. Conclusions: Our results indicated a decrease in phagocytic activity and an increase in inflammatory, cytoprotective, and cytotoxic responses in macrophages after continuous and combined exposure of multiple RF signals. Multiple RF interact in everyday life, the immune response in humans is unknown. <https://doi.org/10.1080/09553002.2018.1465610>

Melnick, R. L. 2018 Commentary on the utility of the National Toxicology Program study on cell phone radiofrequency radiation data for assessing human health risks despite unfounded criticisms aimed at minimizing the findings of adverse health effects. *Environmental Research*, 168, 1–6. The National Toxicology Program (NTP) conducted two-year studies of cell phone radiation in rats and mice exposed to CDMA- or GSM-modulated radiofrequency radiation (RFR) at exposure intensities in the brain of rats that were similar to or only slightly higher than potential, localized human exposures from cell phones held next to the head. This study was designed to test the (null) hypothesis that cell phone radiation at non-thermal exposure intensities could not cause adverse health effects, and to provide dose-response data for any detected toxic or carcinogenic effects. Partial findings released from that study showed significantly increased incidences and/or trends for gliomas and glial cell hyperplasias in the brain and schwannomas and Schwann cell hyperplasias in the heart of exposed male rats. These results, as well as the findings of significantly increased DNA damage (strand breaks) in the brains of exposed rats and mice, reduced pup birth weights when pregnant dams were exposed to GSM- or CDMA-modulated RFR, and the induction of cardiomyopathy of the right ventricle in male and female rats clearly demonstrate that the null hypothesis has been disproved. The NTP findings are most important because the International Agency for Research on Cancer (IARC) classified RFR as a “possible human carcinogen” based largely on increased risks of gliomas and acoustic neuromas (which are Schwann cell tumors on the acoustic nerve) among long term users of cell phones. The concordance between rats and humans in cell type affected by RFR strengthens the animal-to-human association. This commentary addresses several unfounded criticisms about the design and results of the NTP study that have been promoted to minimize the utility of the experimental data on RFR for assessing human health risks. In contrast to those criticisms, an expert peer-review panel recently concluded that the NTP studies were well designed, and that the results demonstrated that both GSM- and CDMA-modulated RFR were carcinogenic to the heart (schwannomas) and brain (gliomas) of male rats. <https://doi.org/10.1016/j.envres.2018.09.010>

Mendoza, J. S., Pody, B. C., Lee, S., Kim, M., & McDonough, I. M. 2018 The effect of cellphones on attention and learning: The influences of time, distraction, and nomophobia. *Computers in Human Behavior*, 86, 52–60. Excessive cellphone use impacts attention and learning in classrooms. Given that attention declines over time, we investigated when during lecture cellphones might impair learning. Across two experiments, participants watched a 20-min lecture under different cellphone conditions (keep or remove). Groups who kept their cellphones received distracting text messages during the lecture. Participants were quizzed on the lecture. Quiz questions were divided into four segments depending on when the material was presented. Lastly, participants’ nomophobia—the fear of being without access to one’s cellphone—was assessed. Participants who kept their cellphone performed worse on the quiz for material presented in the 3rd quarter of the lecture than those without cellphones. Distracted participants performed worse on the test for the same material than those who were not distracted. Participants higher in nomophobia, especially on subscales having to do with losing connectedness and giving up convenience, performed worse on the quiz for material that occurred in the 3rd quarter of the lecture. Findings indicate that having cellphones in a short lecture has its largest impact on attention and learning 10–15 min into the lecture. This study provides novel insights into the interactions between technology and learning to help educators and students optimize learning. <https://doi.org/10.1016/j.chb.2018.04.027>

Miller, A. B., Morgan, L. L., Udasin, I., & Davis, D. L. 2018 Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields (Monograph 102). *Environmental Research*, 167(673-683). Epidemiology studies (case-control, cohort, time trend and case studies) published since the International Agency for Research on Cancer (IARC) 2011 categorization of radiofrequency radiation (RFR) from mobile phones and other wireless devices as a possible human carcinogen (Group 2B) are reviewed and summarized. Glioma is an important human cancer found to be associated with RFR in 9 case-control studies conducted in Sweden and France, as well as in some other countries. Increasing glioma incidence trends have been reported in the UK and other countries. Non-malignant endpoints linked include acoustic neuroma (vestibular Schwannoma) and meningioma. Because they allow more detailed consideration of exposure, case-control studies can be superior to cohort studies or other methods in evaluating potential risks for brain cancer. When considered with recent animal experimental evidence, the recent epidemiological studies strengthen and support the conclusion that RFR should be categorized as carcinogenic to humans (IARC Group 1). Opportunistic epidemiological studies are proposed that can be carried out through cross-sectional analyses of high, medium, and low mobile phone users with respect to hearing, vision, memory, reaction time, and other indicators that can easily be assessed through standardized computer-based tests. As exposure data are not uniformly

available, billing records should be used whenever available to corroborate reported exposures.  
<https://doi.org/10.1016/j.envres.2018.06.043>

Narayanan, S. N., Mohapatra, N., John, P., K, N., Kumar, R. S., Nayak, S. B., & Bhat, P. G. 2018 Radiofrequency electromagnetic radiation exposure effects on amygdala morphology, place preference behavior and brain caspase-3 activity in rats. *Environmental Toxicology and Pharmacology*, 58, 220–229.

The purpose of the study was to evaluate the changes in amygdala morphology and emotional behaviors, upon exposure to chronic RF-EMR in adolescent rats. Four weeks old male albino Wistar rats were exposed to 900 MHz (power density: 146.60  $\mu\text{W}/\text{cm}^2$ ) from a mobile phone in silent-mode for 28 days. Amygdala morphology was studied using cresyl violet, TUNEL and Golgi-Cox staining. Place preference behavior was studied using light/dark chamber test and following this brain caspase-3 activity was determined. Number of healthy neurons was decreased in the basolateral amygdala and cortical amygdala but not in the central amygdala after RF-EMR exposure. It also induced apoptosis in the amygdala. RF-EMR exposure altered dendritic arborization pattern in basolateral amygdala but not in the central amygdala. Altered place preference and hyperactivity-like behavior was evident after RF-EMR exposure, but brain caspase-3 activity did not change. RF-EMR exposure perturbed normal cellular architecture of amygdala and this was associated with altered place preference.

<https://doi.org/10.1016/j.etap.2018.01.009>

Narayanan SN, Lukose ST, Arun G, Mohapatra N, Pamala J, Concessao PL, ... Bhat PG. 2018 Modulatory effect of 900 MHz radiation on biochemical and reproductive parameters in rats. *Bratisl Lek Listy*, 119(9), 581–587. In the present study, the effect of 900 MHz radiation exposure on blood biochemical and reproductive parameters was evaluated in adolescent rats. Male albino Wistar rats (8–10 weeks of age) were exposed to 900 MHz radiation (1hr/day, power density – 146.60  $\mu\text{W}/\text{cm}^2$ ) from a mobile phone for 28 days. On 29th day the animals were euthanized and malondialdehyde (MDA), total antioxidants (TA) levels and Glutathione-S transferase (GST) activity were studied in the blood. Reproductive parameters such as total sperm count, percentage of non-motile sperms, and sperm morphology were determined. Testes sections were stained with H(et)E staining and their cellular integrity was evaluated. Caspase-3 activity in the testes was also determined. MDA concentration was increased but TA levels and GST activity were not found to be different in 900 MHz group compared to controls. Sperm motility was found to be slightly reduced in 900 MHz group. Percentage of abnormal sperm was significantly elevated in 900 MHz group. Additionally, loss of germ cells particularly spermatocytes and spermatids was found in the testes of 900 MHz group. Testes caspase-3 activity was slightly elevated in 900 MHz exposed rats. Chronic 900 MHz exposure induced oxidative damage in the blood and lead to alterations in reproductive parameters in rats (Fig. 4, Ref. 33).

[https://doi.org/10.4149/BLL\\_2018\\_105](https://doi.org/10.4149/BLL_2018_105)

National Institute for Public Health and the Environment (RIVM). 2018 Comparison of international policies on electromagnetic fields. This document is an update of an earlier overview from May 2011 (RIVM 118/2011). It was prepared as part of a research project commissioned by the Ministry of Infrastructure and Water Management and the Ministry of Social Affairs and Employment of the Netherlands. The information that forms the basis for this summary was obtained from searches of governmental and scientific websites, scientific publications, policy summaries by other organisations and personal contacts with experts in the countries in question. The information was last updated in the period from January to July 2017. <https://www.rivm.nl/en/comparison-of-international-policies-on-electromagnetic-fields-2018>

National Toxicology Program, U.S. National Institute of Environmental Health Sciences. 2018 Toxicology and carcinogenesis studies in Hsd: Sprague Dawley SD rats exposed to whole-body radio frequency radiation at a frequency (900 MHz) and modulations (GSM and CDMA) used by cell phones. NTP Technical Report 595, 384. CONCLUSIONS: GSM-modulated RFR Under the conditions of this 2-year whole-body exposure study, there was clear evidence of carcinogenic activity (see a summary of the peer review panel comments and the public discussion on this Technical Report in Appendix L) of GSM-modulated cell phone RFR at 900 MHz in male Hsd: Sprague Dawley SD rats based on the incidences of malignant schwannoma of the heart. The incidences of malignant glioma of the brain and benign, malignant, or complex pheochromocytoma (combined) of the adrenal medulla were also related to RFR exposure. The incidences of benign or malignant granular cell tumors of the brain, adenoma or carcinoma (combined) of the prostate gland, adenoma of the pars distalis of the pituitary gland, and pancreatic islet cell adenoma or carcinoma (combined) may have been related to RFR exposure. There was equivocal evidence of carcinogenic activity of GSM-modulated cell phone RFR at 900 MHz in female Hsd: Sprague Dawley SD rats based on the incidences of schwannomas of the heart. Increases in nonneoplastic lesions of the heart, brain, and prostate gland in male rats, and of the heart, thyroid gland, and adrenal gland in female rats occurred with exposures to GSM-modulated RFR at 900 MHz. CDMA-modulated RFR Under the conditions of this 2-year whole-body exposure study, there was clear evidence of carcinogenic activity (see a summary of the Peer Review Panel comments and the public discussion on this Technical Report in Appendix L) of CDMA-modulated cell phone RFR at 900 MHz in male Hsd: Sprague Dawley SD rats based on the incidences of malignant schwannoma of the heart. The incidences of malignant glioma of the brain were also related to RFR exposure. The incidences of adenoma of the

pars distalis of the pituitary gland and adenoma or carcinoma (combined) of the liver may have been related to RFR exposure. There was equivocal evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 900 MHz in female Hsd:Sprague Dawley SD rats based on the incidences of malignant schwannoma of the heart, malignant glioma of the brain, and benign, malignant, or complex pheochromocytoma (combined) of the adrenal medulla. Increases in nonneoplastic lesions of the heart, brain, and prostate gland in male rats, and of the brain in female rats occurred with exposures to CDMA-modulated RFR at 900 MHz. <https://doi.org/10.22427/NTP-TR-595>

National Toxicology Program, U.S. National Institute of Environmental Sciences 2018 Toxicology and carcinogenesis studies in B6C3F1/n mice exposed to whole-body radio frequency radiation at a frequency (1,900 MHz) and modulations (GSM and CDMA) used by cell phones. NTP Technical Report 596.

CONCLUSIONS: Under the conditions of these 2-year studies, there was equivocal evidence of carcinogenic activity (see a summary of the peer review panel comments and the public discussion on this Technical Report in Appendix L) of GSM-modulated cell phone RFR at 1,900 MHz in male B6C3F1/N mice based on the combined incidences of fibrosarcoma, sarcoma, or malignant fibrous histiocytoma in the skin and the incidences of alveolar/ bronchiolar adenoma or carcinoma (combined) in the lung. There was equivocal evidence of carcinogenic activity of GSM-modulated cell phone RFR at 1,900 MHz in female B6C3F1/N mice based on the incidences of malignant lymphoma (all organs). There was equivocal evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 1,900 MHz in male B6C3F1/N mice based on the incidences of hepatoblastoma of the liver. There was equivocal evidence of carcinogenic activity of CDMA-modulated cell phone RFR at 1,900 MHz in female B6C3F1/N mice based on the incidences of malignant lymphoma (all organs). Exposure to GSM- or CDMA-modulated cell phone RFR at 1,900 MHz did not increase the incidence of any nonneoplastic lesions in male or female B6C3F1/N mice.

<https://ntp.niehs.nih.gov/publications/reports/tr/500s/tr596/index.html>

Ouadah, N. S., Lecomte, A., Robidel, F., Olsson, A., Deltour, I., Schüz, J., ... Villégier, A.-S. 2018 Possible effects of radiofrequency electromagnetic fields on in vivo C6 brain tumors in Wistar rats. *Journal of Neuro-Oncology*, 140(3), 539–546.

PURPOSE: Glioblastoma is a malignant brain tumor which has one of the poorest prognosis. It is not clear if toxic environmental factors can influence its aggressiveness. Recently, it was suggested that brain cancer patients with heavy cell phone use showed reduced survival. Here we aimed to assess the effect of controlled brain averaged specific absorption rate (BASAR) from heavy use of cell phone radiofrequency electromagnetic fields (RF-EMF) on in vivo C6 brain tumors in Wistar rats. METHODS: C6 cells grafted male rats were exposed to GSM 900 MHz signal at environmental BASAR, 0 (sham), 0.25 or 0.5 W/kg (5 days a week, 45 min a day in restraint), or were cage controls (no restraint). At death, tumor volume and immunohistochemistry for CD31, cleaved caspase (CC) 3 and Ki67 were assessed to examine vascularization, apoptosis and cellular divisions, respectively. Moreover, immune cell invasion, necrosis and mitotic index were determined. RESULTS: Results showed no BASAR effect on survival (31 days post-graft median), tumor volume, mitotic index, vascularization, infiltration, necrosis or cell division. However, results suggested a BASAR-dependent reduction of immune cell invasion and apoptosis. CONCLUSIONS: Our data suggested an action of RF-EMF by reducing immune cell invasion and glioblastoma cell apoptosis, at probably too low amplitude to impact survival. Further replication studies are needed to confirm these observations. <https://doi.org/10.1007/s11060-018-03012-y>

Pandey, N., & Giri, S. 2018 Melatonin attenuates radiofrequency radiation (900 MHz)-induced oxidative stress, DNA damage and cell cycle arrest in germ cells of male Swiss albino mice. *Toxicology and Industrial Health*, 34(5), 315–327. Increasing male infertility of unknown aetiology can be associated with environmental factors. Extensive use of mobile phones has exposed the general population to unprecedented levels of radiofrequency radiations (RFRs) that may adversely affect male reproductive health. Therefore, the present study investigated the effect of RFR Global System for Mobile communication (GSM) type, 900 MHz and melatonin supplementation on germ cell development during spermatogenesis. Swiss albino mice were divided into four groups. One group received RFR exposure for 3 h twice/day for 35 days and the other group received the same exposure but with melatonin (N-acetyl-5-methoxytryptamine) (MEL; 5 mg/kg bw/day). Two other groups received only MEL or remain unexposed. Sperm head abnormality, total sperm count, biochemical assay for lipid peroxides, reduced glutathione, superoxide dismutase activity and testis histology were evaluated. Additionally, flow cytometric evaluation of germ cell subtypes and comet assay were performed in testis. Extensive DNA damage in germ cells of RFR-exposed animals along with arrest in pre-meiotic stages of spermatogenesis eventually leading to low sperm count and sperm head abnormalities were observed. Furthermore, biochemical assays revealed excess free radical generation resulting in histological and morphological changes in testis and germ cells morphology, respectively. However, these effects were either diminished or absent in RFR-exposed animals supplemented with melatonin. Hence, it can be concluded that melatonin inhibits pre-meiotic spermatogenesis arrest in male germ cells through its anti-oxidative potential and ability to improve DNA reparative pathways, leading to normal sperm count and sperm morphology in RFR-exposed animals. <https://doi.org/10.1177/0748233718758092>



Pastacı Özsoğacı N, Düzgün Ergün D, Durmuş S, Tunçdemir M, Uzun H, Gelişgen R, & Özçelik D. 2018 Selenium supplementation ameliorates electromagnetic field-induced oxidative stress in the HEK293 cells. *J Trace Elem Med Biol*, 50, 572–579. There is a widespread use of 2.4 GHz electromagnetic radiation emitting devices especially in communication and education. Recent studies show the adverse effects of electromagnetic fields (EMF) such as oxidative stress, cellular damage and apoptosis on tissues. Selenium (Se) has antioxidant properties by inhibiting oxidative damage being within the structure of antioxidant enzymes like glutathione peroxidase (GSH-Px) and it has also regulatory function for cell cycle and apoptosis. The aim of this study was to investigate the effect of Se on 2.4 GHz frequency EMF exposed human embryonic kidney cells (HEK293) by means of alterations in apoptotic and oxidative stress parameters. Our study was planned as control, EMF, 100 nM Se + EMF, 200 nM Se + EMF groups. EMF groups were exposed to 2.4 GHz EMF for 1 h, element groups were incubated with two different doses of Se added cell culture medium for 48 h before EMF exposure. MDA levels were significantly higher whereas SOD and GSH-Px activities were significantly lower in EMF compared to control. 100 and 200 nM Se + EMF application decreased MDA levels, increased SOD and GSH-Px activities than EMF. Apoptosis and caspase-3 were statistically significantly higher but bcl-2 was lower in EMF than control. Apoptosis and caspase-3 were lower in 100 and 200 nM Se + EMF, although bcl-2 were higher than EMF. In conclusion, Se has protective effects against 2.4 GHz EMF-induced oxidative stress by reducing lipid peroxidation, regulating SOD and GSH-Px activity. Also, Se has inhibitory effect on 2.4 GHz EMF induced apoptosis by increasing the expression of anti-apoptotic protein bcl-2 and suppressing apoptosis regulatory protein caspase-3. <https://doi.org/10.1016/j.jtemb.2018.04.008>

Peleg, M., Nativ, O., & Richter, E. D. 2018 Radio frequency radiation-related cancer: assessing causation in the occupational/military setting. *Environmental Research*, 163, 123–133. BACKGROUND AND AIM: We reexamine whether radio frequency radiation (RFR) in the occupational and military settings is a human carcinogen. METHODS: We extended an analysis of an already-reported case series of patients with cancer previously exposed to whole-body prolonged RFR, mainly from communication equipment and radar. We focused on hematolymphatic (HL) cancers. We used analysis by percentage frequency (PF) of a cancer type, which is the proportion of a specific cancer type relative to the total number of cancer cases. We also examined and analyzed the published data on three other cohort studies from similar military settings from different countries. RESULTS: The PF of HL cancers in the case series was very high, at 40% with only 23% expected for the series age and gender profile, confidence interval CI95%: 26-56%,  $p < 0.01$ , 19 out of 47 patients had HL cancers. We also found high PF for multiple primaries. As for the three other cohort studies: In the Polish military sector, the PF of HL cancers was 36% in the exposed population as compared to 12% in the unexposed population,  $p < 0.001$ . In a small group of employees exposed to RFR in Israeli defense industry, the PF of HL cancers was 60% versus 17% expected for the group age and gender profile,  $p < 0.05$ . In Belgian radar battalions the HL PF was 8.3% versus 1.4% in the control battalions as shown in a causes of deaths study and HL cancer mortality rate ratio was 7.2 and statistically significant. Similar findings were reported on radio amateurs and Korean war technicians. Elevated risk ratios were previously reported in most of the above studies. CONCLUSIONS: The consistent association of RFR and highly elevated HL cancer risk in the four groups spread over three countries, operating different RFR equipment types and analyzed by different research protocols, suggests a cause-effect relationship between RFR and HL cancers in military/occupational settings. While complete measurements of RFR exposures were not available and rough exposure assessments from patients interviews and from partial exposure data were used instead, we have demonstrated increased HL cancers in occupational groups with relatively high RFR exposures. Our findings, combined with other studies, indicate that exposures incurred in the military settings evaluated here significantly increased the risk of HL cancers. Accordingly, the RFR military exposures in these occupations should be substantially reduced and further efforts should be undertaken to monitor and measure those exposures and to follow cohorts exposed to RFR for cancers and other health effects. Overall, the epidemiological studies on excess risk for HL and other cancers together with brain tumors in cellphone users and experimental studies on RFR and carcinogenicity make a coherent case for a cause-effect relationship and classifying RFR exposure as a human carcinogen (IARC group 1). <https://doi.org/10.1016/j.envres.2018.01.003>

Philips, Alisdair, Henshaw, Denis L., Lamburn, Graham, & O'Carroll, Michael. 2018 Brain tumours: rise in Glioblastoma Multiforme incidence in England 1995-2015 suggests an adverse environmental or lifestyle factor. *Journal of Environmental and Public Health*, 20. Objective. To investigate detailed trends in malignant brain tumour incidence over a recent time period. Methods. UK Office of National Statistics (ONS) data covering 81,135 ICD10 C71 brain tumours diagnosed in England (1995–2015) were used to calculate incidence rates (ASR) per 100k person-years, age-standardised to the European Standard Population (ESP–2013). Results. We report a sustained and highly statistically significant ASR rise in glioblastoma multiforme (GBM) across all ages. The ASR for GBM more than doubled from 2.4 to 5.0, with annual case numbers rising from 983 to 2531. Overall, this rise is mostly hidden in the overall data by a reduced incidence of lower-grade tumours. Conclusions. The rise is of importance for clinical resources and brain tumour aetiology. The rise cannot be fully accounted for by promotion of lower-grade tumours, random chance or improvement in diagnostic techniques as it affects specific areas of the brain and only one type of brain tumour. Despite the large variation in case numbers by age, the percentage rise is similar across the age groups, which suggests

widespread environmental or lifestyle factors may be responsible. This article reports incidence data trends and does not provide additional evidence for the role of any particular risk factor.

<https://www.hindawi.com/journals/jep/aip/7910754/>

Piepoli, M. F., Hoes, A. W., Brotons, C., Hobbs, R. F. D., Corra, U., & Task Force for the 2016 guidelines on cardiovascular disease prevention in clinical practice. 2018 Main messages for primary care from the 2016 European Guidelines on cardiovascular disease prevention in clinical practice. *The European Journal of General Practice*, 24(1), 51–56. In 2016, a new version of the European Guidelines on Cardiovascular Prevention was released, representing a partnership between the European Association for Cardiovascular Prevention and Rehabilitation of the European Society of Cardiology (ESC) and nine European societies, including Wonca-Europe. The ESC guidelines underscore the importance of a lifetime approach to cardiovascular (CV) risk since both CV risk and prevention are dynamic and continuous as patients' age and/or accumulate co-morbidities. Healthy people of all ages should be encouraged to adopt a healthy lifestyle, as well as improved lifestyle and reduced risk factor levels are paramount in patients at increased risk of developing cardiovascular disease (CVD) and in those with established CVD. Healthcare professionals, and especially general practitioners, play an important role in helping patients achieve this and should set a personal example of healthy lifestyle behaviour. The ESC guidelines are based on "to do" and "not to do" messages. Of note, what remains uncertain is stated at the end of each dedicated chapter, confirming that guidelines are not absolute rules, and should be interpreted in the light of the healthcare worker's knowledge and experience, patient preferences and the local social, cultural and economic situation. <https://doi.org/10.1080/13814788.2017.1398320>

Ra, C. K., Cho, J., Stone, M. D., De La Cerda, J., Goldenson, N. I., Moroney, E., ... Leventhal, A. M. 2018 **Association of Digital Media Use With Subsequent Symptoms of Attention-Deficit/Hyperactivity Disorder Among Adolescents.** *JAMA*, 320(3), 255–263.

Importance: Modern digital platforms are easily accessible and intensely stimulating; it is unknown whether frequent use of digital media may be associated with symptoms of attention-deficit/hyperactivity disorder (ADHD). Objective: To determine whether the frequency of using digital media among 15- and 16-year-olds without significant ADHD symptoms is associated with subsequent occurrence of ADHD symptoms during a 24-month follow-up. Design, Setting, and Participants: Longitudinal cohort of students in 10 Los Angeles County, California, high schools recruited through convenience sampling. Baseline and 6-, 12-, 18-, and 24-month follow-up surveys were administered from September 2014 (10th grade) to December 2016 (12th grade). Of 4100 eligible students, 3051 10th-graders (74%) were surveyed at the baseline assessment. Exposures: Self-reported use of 14 different modern digital media activities at a high-frequency rate over the preceding week was defined as many times a day (yes/no) and was summed in a cumulative index (range, 0-14). Main Outcomes and Measures: Self-rated frequency of 18 ADHD symptoms (never/rare, sometimes, often, very often) in the 6 months preceding the survey. The total numbers of 9 inattentive symptoms (range, 0-9) and 9 hyperactive-impulsive symptoms (range, 0-9) that students rated as experiencing often or very often were calculated. Students who had reported experiencing often or very often 6 or more symptoms in either category were classified as being ADHD symptom-positive. Results: Among the 2587 adolescents (63% eligible students; 54.4% girls; mean [SD] age 15.5 years [0.5 years]) who did not have significant symptoms of ADHD at baseline, the median follow-up was 22.6 months (interquartile range [IQR], 21.8-23.0, months). The mean (SD) number of baseline digital media activities used at a high-frequency rate was 3.62 (3.30); 1398 students (54.1%) indicated high frequency of checking social media (95% CI, 52.1%-56.0%), which was the most common media activity. High-frequency engagement in each additional digital media activity at baseline was associated with a significantly higher odds of having symptoms of ADHD across follow-ups (OR, 1.11; 95% CI, 1.06-1.16). This association persisted after covariate adjustment (OR, 1.10; 95% CI, 1.05-1.15). The 495 students who reported no high-frequency media use at baseline had a 4.6% mean rate of having ADHD symptoms across follow-ups vs 9.5% among the 114 who reported 7 high-frequency activities (difference, 4.9%; 95% CI, 2.5%-7.3%) and vs 10.5% among the 51 students who reported 14 high-frequency activities (difference, 5.9%; 95% CI, 2.6%-9.2%). Conclusions and Relevance: Among adolescents followed up over 2 years, there was a statistically significant but modest association between higher frequency of digital media use and subsequent symptoms of ADHD. Further research is needed to determine whether this association is causal.

<https://doi.org/10.1001/jama.2018.8931>

Russell, C. L. 2018 5 G wireless telecommunications expansion: Public health and environmental implications. *Environmental Research*, 165, 484–495. The popularity, widespread use and increasing dependency on wireless technologies has spawned a telecommunications industrial revolution with increasing public exposure to broader and higher frequencies of the electromagnetic spectrum to transmit data through a variety of devices and infrastructure. On the horizon, a new generation of even shorter high frequency 5G wavelengths is being proposed to power the Internet of Things (IoT). The IoT promises us convenient and easy lifestyles with a massive 5G interconnected telecommunications network, however, the expansion of broadband with shorter wavelength radiofrequency radiation highlights the concern that health and safety issues remain unknown. Controversy continues with regards to harm from current 2G, 3G and 4G wireless technologies. 5G technologies are far less studied for human or environmental effects. It is argued that the addition of this added high frequency

5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome both from both physical and mental health perspectives. Radiofrequency radiation (RF) is increasingly being recognized as a new form of environmental pollution. Like other common toxic exposures, the effects of radiofrequency electromagnetic radiation (RF EMR) will be problematic if not impossible to sort out epidemiologically as there no longer remains an unexposed control group. This is especially important considering these effects are likely magnified by synergistic toxic exposures and other common health risk behaviors. Effects can also be non-linear. Because this is the first generation to have cradle-to-grave lifespan exposure to this level of man-made microwave (RF EMR) radiofrequencies, it will be years or decades before the true health consequences are known. Precaution in the roll out of this new technology is strongly indicated. This article will review relevant electromagnetic frequencies, exposure standards and current scientific literature on the health implications of 2G, 3G, 4G exposure, including some of the available literature on 5G frequencies. The question of what constitutes a public health issue will be raised, as well as the need for a precautionary approach in advancing new wireless technologies. <https://doi.org/10.1016/j.envres.2018.01.016>

Sage, C., & Burgio, E. 2018 Electromagnetic Fields, Pulsed Radiofrequency Radiation, and Epigenetics: How Wireless Technologies May Affect Childhood Development. *Child Development*, 89(1), 129–136. Mobile phones and other wireless devices that produce electromagnetic fields (EMF) and pulsed radiofrequency radiation (RFR) are widely documented to cause potentially harmful health impacts that can be detrimental to young people. New epigenetic studies are profiled in this review to account for some neurodevelopmental and neurobehavioral changes due to exposure to wireless technologies. Symptoms of retarded memory, learning, cognition, attention, and behavioral problems have been reported in numerous studies and are similarly manifested in autism and attention deficit hyperactivity disorders, as a result of EMF and RFR exposures where both epigenetic drivers and genetic (DNA) damage are likely contributors. Technology benefits can be realized by adopting wired devices for education to avoid health risk and promote academic achievement. <https://doi.org/10.1111/cdev.12824>

Salmen, S. H., Alharbi, S. A., Faden, A. A., & Wainwright, M. 2018 Evaluation of effect of high frequency electromagnetic field on growth and antibiotic sensitivity of bacteria. *Saudi Journal of Biological Sciences*, 25(1), 105–110. This study was aimed to evaluate the impact of high frequency electromagnetic fields (HF-EMF at 900 and 1800 MHz) on DNA, growth rate and antibiotic susceptibility of *S. aureus*, *S. epidermidis*, and *P. aeruginosa*. In this study, bacteria were exposed to 900 and 1800 MHz for 2 h and then inoculated to new medium when their growth rate and antibiotic susceptibility were evaluated. Results for the study of bacterial DNA unsuccessful to appearance any difference exposed and non-exposed *S. aureus* and *S. epidermidis*. Exposure of *S. epidermidis* and *S. aureus* to electromagnetic fields mostly produced no statistically significant decrease in bacterial growth, except for *S. aureus* when exposure to 900 MHz at 12 h. Exposure of *P. aeruginosa* to electromagnetic fields at 900 MHz however, lead to a significant reduction in growth rate, while 1800 MHz had insignificant effect. With the exception of *S. aureus*, treated with amoxicillin (30 mg) and exposed to electromagnetic fields, radiation treatment had no significant effect on bacterial sensitivity to antibiotics. <https://doi.org/10.1016/j.sjbs.2017.07.006>

Santini, S. J., Cordone, V., Falone, S., Mijit, M., Tatone, C., Amicarelli, F., & Di Emidio, G. 2018 Role of Mitochondria in the Oxidative Stress Induced by Electromagnetic Fields: Focus on Reproductive Systems. *Oxidative Medicine and Cellular Longevity*. Modern technologies relying on wireless communication systems have brought increasing levels of electromagnetic field (EMF) exposure. This increased research interest in the effects of these radiations on human health. There is compelling evidence that EMFs affect cell physiology by altering redox-related processes. Considering the importance of redox milieu in the biological competence of oocyte and sperm, we reviewed the existing literature regarding the effects of EMFs on reproductive systems. Given the role of mitochondria as the main source of reactive oxygen species (ROS), we focused on the hypothesis of a mitochondrial basis of EMF-induced reproductive toxicity. MEDLINE, Web of Science, and Scopus database were examined for peer-reviewed original articles by searching for the following keywords: “extremely low frequency electromagnetic fields (ELF-EMFs),” “radiofrequency (RF),” “microwaves,” “Wi-Fi,” “mobile phone,” “oxidative stress,” “mitochondria,” “fertility,” “sperm,” “testis,” “oocyte,” “ovarian follicle,” and “embryo.” These keywords were combined with other search phrases relevant to the topic. Although we reported contradictory data due to lack of uniformity in the experimental designs, a growing body of evidence suggests that EMF exposure during spermatogenesis induces increased ROS production associated with decreased ROS scavenging activity. Numerous studies revealed the detrimental effects of EMFs from mobile phones, laptops, and other electric devices on sperm quality and provide evidence for extensive electron leakage from the mitochondrial electron transport chain as the main cause of EMF damage. In female reproductive systems, the contribution of oxidative stress to EMF-induced damages and the evidence of mitochondrial origin of ROS overproduction are reported, as well. In conclusion, mitochondria seem to play an important role as source of ROS in both male and female reproductive systems under EMF exposure. Future and more standardized studies are required for a better understanding of molecular mechanisms underlying EMF potential challenge to our reproductive system in order to improve preventive strategies. <https://doi.org/10.1155/2018/5076271>

Selmaoui, B., Andrianome, S., Ghosn, R., & de Seze, R. 2018 Effect of acute exposure to radiofrequency electromagnetic fields emitted by a mobile phone (GSM 900 MHz) on electrodermal responsiveness in healthy human. *International Journal of Radiation Biology*, 94(10), 890–895.

**PURPOSE:** The present study aimed to determine the effect of acute exposure to electromagnetic fields (EMF) emitted by a mobile phone on electrodermal activity (EDA) in response to an auditory stimulus. **MATERIALS AND METHODS:** The EDA of 28 young volunteers was recorded following 26 min of exposure to a GSM mobile phone (900 MHz). Palmar sensors enabled repeat recording of 2 min 45 s in the pre-exposure, exposure and post-exposure phases in response to sound stimuli. **RESULTS:** The latency, amplitude of skin conductance responses (SCRs), integral of skin conductance response and number of SCRs in response to the auditory stimuli were not modified by exposure. Skin conductance and tonic activity decomposition of the recorded signal were significantly different between the two sessions ( $p < .0001$ ), but the changes could not be attributed to EMF exposure. There was also a tendency toward a fast reduction in the amplitude and number of electrodermal responses after placement of the mobile phone. In response to successive stimuli, there was a significant difference between the first response and subsequent responses for all variables except latency. **CONCLUSIONS:** Our results showed a decrease in the number of responses and their amplitude as a result of placement of the mobile device and whether it was turned “on” or “off”, but there were no changes associated with exposure to GSM radiofrequency waves in this group of volunteers.

<https://doi.org/10.1080/09553002.2018.1503431>

Shahin S, Banerjee S, Swarup V, Singh SP, & Chaturvedi CM. 2018 2.45-GHz Microwave Radiation Impairs Hippocampal Learning and Spatial Memory: Involvement of Local Stress Mechanism-Induced Suppression of iGluR/ERK/CREB Signaling. *Toxicol Sci*, 161(2), 349–374. Microwave (MW) radiation induced oxidative stress reduces dendritic arborization, spine density and number of hippocampal pyramidal neurons and hence, impair learning and spatial memory through p53-dependent/independent apoptosis of hippocampal neuronal and nonneuronal cells. However, the mechanisms responsible for MW radiation induced impairment in memory formation remains still unknown. This study elucidates the effect of short (15 days) and long-term (30 and 60 days) low level 2.45 GHz MW radiation-induced local stress on the hippocampal spatial memory formation pathway in adult male mice. Twelve-weeks old mice were exposed to 2.45 GHz MW radiation (continuous-wave with overall average Power density of 0.0248 mW/cm<sup>2</sup> and overall average whole body SAR value of 0.0146 W/Kg) @ 2 h/d for 15, 30, and 60 days. Learning and spatial memory was assessed by 8-arm radial maze. We have investigated the alterations in serum corticosterone level and the expression of glucocorticoid receptor, corticotropin-releasing hormone (CRH), inducible nitric oxide synthase (i-NOS), iGluRs, PSD-95-neuronal NOS (n-NOS) system, protein kinase A, protein kinase C $\epsilon$ -ERK1/2-pERK1/2 in all the hippocampal subregions, viz. CA1, CA2, CA3, and DG through immunohistochemistry/immunofluorescence and alterations in the expression of hippocampal glucocorticoid receptor, CRH-receptor 1 (CRH-R1), cAMP-response element-binding (CREB), and phosphorylated-CREB (p-CREB) through western blot analysis. We observed that 2.45 GHz MW irradiated mice showed slow learning and significantly increased number of working and reference memory errors in radial maze task. Further, 2.45 GHz MW radiation exposure increases serum corticosterone level and the expression of CRH, CRH-R1, and i-NOS, while the expression of iGluRs, n-NOS, PSD-95, protein kinase C $\epsilon$ , protein kinase A, ERK-p-ERK, CREB, and p-CREB decreases in above mentioned hippocampal subregions in a duration dependent manner. Our findings led us to conclude that 2.45 GHz MW radiation exposure induced local stress suppresses signaling mechanism(s) of hippocampal memory formation.

<https://doi.org/10.1093/toxsci/kfx221>

Sherrard, R. M., Morellini, N., Jourdan, N., El-Esawi, M., Arthaut, L.-D., Niessner, C., ... Ahmad, M. 2018 Low-intensity electromagnetic fields induce human cryptochrome to modulate intracellular reactive oxygen species. *PLoS Biology*, 16(10), e2006229.

Exposure to man-made electromagnetic fields (EMFs), which increasingly pollute our environment, have consequences for human health about which there is continuing ignorance and debate. Whereas there is considerable ongoing concern about their harmful effects, magnetic fields are at the same time being applied as therapeutic tools in regenerative medicine, oncology, orthopedics, and neurology. This paradox cannot be resolved until the cellular mechanisms underlying such effects are identified. Here, we show by biochemical and imaging experiments that exposure of mammalian cells to weak pulsed electromagnetic fields (PEMFs) stimulates rapid accumulation of reactive oxygen species (ROS), a potentially toxic metabolite with multiple roles in stress response and cellular ageing. Following exposure to PEMF, cell growth is slowed, and ROS-responsive genes are induced. These effects require the presence of cryptochrome, a putative magnetosensor that synthesizes ROS. We conclude that modulation of intracellular ROS via cryptochromes represents a general response to weak EMFs, which can account for either therapeutic or pathological effects depending on exposure. Clinically, our findings provide a rationale to optimize low field magnetic stimulation for novel therapeutic applications while warning against the possibility of harmful synergistic effects with environmental agents that further increase intracellular ROS. <https://doi.org/10.1371/journal.pbio.2006229>

Suzuki, Y., Sasaki, K., Taki, M., Wake, K., Watanabe, S., Mizuno, M., ... Sasaki, H. 2018 Ocular Effects of Exposure to 40, 75, and 95 GHz Millimeter Waves. *Journal of Infrared, Millimeter, and Terahertz Waves*, 39. The objective of this study was to develop a model of ocular damage induced by 40, 75, and 95 GHz continuous millimeter waves (MMW), thereby allowing

assessment of the clinical course of ocular damage resulting from exposure to thermal damage-inducing MMW. This study also examined the dependence of ocular damage on incident power density. Pigmented rabbit eyes were exposed to 40, 75, and 95 GHz MMW from a spot-focus-type lens antenna. Slight ocular damage was observed 10 min after MMW exposure, including reduced cornea thickness and reduced transparency. Diffuse fluorescein staining around the pupillary area indicated corneal epithelial injury. Slit-lamp examination 1 day after MMW exposure revealed a round area of opacity, accompanied by fluorescence staining, in the central pupillary zone. Corneal edema, indicative of corneal stromal damage, peaked 1 day after MMW exposure, with thickness gradually subsiding to normal. Three days after exposure, ocular conditions had almost normalized, though corneal thickness was slightly greater than that before exposure. The 50% probability of ocular damage (DD50) was in the order  $40 > 95 \approx 75$  GHz at the same incident power densities. <https://doi.org/10.1007/s10762-018-0497-z>

Szymanski, L., Cios, A., Lewicki, S., Szymanski, P., & Stankiewicz, W. 2018 Fas/FasL pathway and cytokines in keratinocytes in atopic dermatitis – Manipulation by the electromagnetic field. PLOS ONE, 13(10), e0205103. Background Atopic dermatitis (AD) is one of the most frequent skin diseases. Changes of the keratinocytes functionality play a major role in the development of AD. For example, activation of the Fas (CD95)/FasL (CD178) pathway in AD does not lead to extensive apoptosis in skin. Binding of the Fas receptor to its protein ligand—FasL, which are present on the (AD)-modified keratinocytes, should result in the sequential induction of cell death, but there is no evidence of extensive apoptosis of these cells. This suggests that non-apoptotic mechanism of Fas/ FasL pathway is commonly encountered, although not examined in the case of AD, phenomenon. An electromagnetic field, which was used to influence cultured cells in this study, can modulate proliferation, apoptosis, differentiation, and metabolism in various cells. <https://doi.org/10.1371/journal.pone.0205103>

Takembo, C. N., Mvogo, A., Ekobena Fouda, H. P., & Kofané, T. C. 2018 Modulated wave formation in myocardial cells under electromagnetic radiation. International Journal of Modern Physics B, 1850165. We exclusively analyze the onset and condition of formation of modulated waves in a diffusive FitzHugh–Nagumo model for myocardial cell excitations. The cells are connected through gap junction coupling. An additive magnetic flux variable is used to describe the effect of electromagnetic induction, while electromagnetic radiation is imposed on the magnetic flux variable as a periodic forcing. We used the discrete multiple scale expansion and obtained, from the model equations, a single differential-difference amplitude nonlinear equation. We performed the linear stability analysis of this equation and found that instability features are importantly influenced by the induced electromagnetic gain. We present the unstable and stable regions of modulational instability (MI). The resulting analytic predictions are confirmed by numerical experiments of the generic equations. The results reveal that due to MI, an initial steady state that consisted of a plane wave with low amplitude evolves into a modulated localized wave patterns, soliton-like in shape, with features of synchronization. Furthermore, the formation of periodic pulse train with breathing motion presents a disappearing pattern in the presence of electromagnetic radiation. This could provide guidance and better understanding of sudden heart failure exposed to heavily electromagnetic radiation. <https://doi.org/10.1142/S0217979218501655>

Thielens, A., Bell, D., Mortimore, D. B., Greco, M. K., Martens, L., & Joseph, W. 2018 Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz. Scientific Reports, 8(1), 3924. Insects are continually exposed to Radio-Frequency (RF) electromagnetic fields at different frequencies. The range of frequencies used for wireless telecommunication systems will increase in the near future from below 6 GHz (2 G, 3 G, 4 G, and WiFi) to frequencies up to 120 GHz (5 G). This paper is the first to report the absorbed RF electromagnetic power in four different types of insects as a function of frequency from 2 GHz to 120 GHz. A set of insect models was obtained using novel Micro-CT (computer tomography) imaging. These models were used for the first time in finite-difference time-domain electromagnetic simulations. All insects showed a dependence of the absorbed power on the frequency. All insects showed a general increase in absorbed RF power at and above 6 GHz, in comparison to the absorbed RF power below 6 GHz. Our simulations showed that a shift of 10% of the incident power density to frequencies above 6 GHz would lead to an increase in absorbed power between 3–370%. <https://doi.org/10.1038/s41598-018-22271-3>

Varghese, R., Majumdar, A., Kumar, G., & Shukla, A. 2018 Rats exposed to 2.45GHz of non-ionizing radiation exhibit behavioral changes with increased brain expression of apoptotic caspase 3. Pathophysiology: The Official Journal of the International Society for Pathophysiology, 25(1), 19–30. In recent years there has been a tremendous increase in use of Wi-Fi devices along with mobile phones, globally. Wi-Fi devices make use of 2.4GHz frequency. The present study evaluated the impact of 2.45GHz radiation exposure for 4h/day for 45days on behavioral and oxidative stress parameters in female Sprague Dawley rats. Behavioral tests of anxiety, learning and memory were started from day 38. Oxidative stress parameters were estimated in brain homogenates after sacrificing the rats on day 45. In Morris water maze, elevated plus maze and light dark box test, the 2.45GHz radiation exposed rats elicited memory decline and anxiety behavior. Exposure decreased activities of super oxide dismutase, catalase and reduced glutathione levels whereas increased levels of brain lipid peroxidation was encountered in the radiation exposed rats, showing compromised anti-oxidant defense. Expression of caspase 3 gene in brain samples were quantified which unraveled notable increase in the apoptotic marker caspase 3 in 2.45GHz radiation exposed group as compared to sham exposed group. No significant changes were observed in histopathological examinations and brain levels of TNF- $\alpha$ .

Analysis of dendritic arborization of neurons showcased reduction in number of dendritic branching and intersections which corresponds to alteration in dendritic structure of neurons, affecting neuronal signaling. The study clearly indicates that exposure of rats to microwave radiation of 2.45GHz leads to detrimental changes in brain leading to lowering of learning and memory and expression of anxiety behavior in rats along with fall in brain antioxidant enzyme systems.

<https://doi.org/10.1016/j.pathophys.2017.11.001>

Vargová, B., Majláth, I., Kurimský, J., Cimbala, R., Kosterec, M., Tryjanowski, P., ... Majláthová, V. 2018 Electromagnetic radiation and behavioural response of ticks: an experimental test. *Experimental & Applied Acarology*, 75(1), 85–95. Factors associated with the increased usage of electronic devices, wireless technologies and mobile phones nowadays are present in increasing amounts in our environment. All living organisms are constantly affected by electromagnetic radiation which causes serious environmental pollution. The distribution and density of ticks in natural habitats is influenced by a complex of abiotic and biotic factors. Exposure to radio-frequency electromagnetic field (RF-EMF) constitutes a potential cause altering the presence and distribution of ticks in the environment. Our main objective was to determine the affinity of *Dermacentor reticulatus* ticks towards RF-EMF exposure. Originally designed and constructed radiation-shielded tube (RST) test was used to test the affinity of ticks under controlled laboratory conditions. All test were performed in an electromagnetic compatibility laboratory in an anechoic chamber. Ticks were irradiated using a Double-Ridged Waveguide Horn Antenna to RF-EMF at 900 and 5000 MHz, 0 MHz was used as control. The RF-EMF exposure to 900 MHz induced a higher concentration of ticks on irradiated arm of RST as opposed to the RF-EMF at 5000 MHz, which caused an escape of ticks to the shielded arm. This study represents the first experimental evidence of RF-EMF preference in *D. reticulatus*. The projection of obtained results to the natural environment could help assess the risk of tick borne diseases and could be a tool of preventive medicine.

<https://doi.org/10.1007/s10493-018-0253-z>

Yakymenko, I., Burlaka, A., Tsybulin, I., Brieieva, I., Buchynska, L., Tsehmistrenko, I., & Chekhun, F. 2018 Oxidative and mutagenic effects of low intensity GSM 1800 MHz microwave radiation. *Experimental Oncology*, 40(4), 282–287. AIM: Despite a significant number of epidemiological studies on potential carcinogenicity of microwave radiation (MWR) from wireless devices and a bulk of experimental studies on oxidative and mutagenic effects of low intensity MWR, the discussion on potential carcinogenicity of low intensity MWR is going on. This study aims to assess oxidative and mutagenic effects of low intensity MWR from a typical commercial model of a modern smartphone. MATERIALS AND METHODS: The model of developing quail embryos has been used for the assessment of oxidative and mutagenic effects of Global System for Mobile communication (GSM) 1800 MHz MWR from a commercial model of smartphone. The embryos were exposed in ovo to 0.32  $\mu\text{W}/\text{cm}^2$ , discontinuously - 48 s - On, 12 s - Off, during 5 days before and 14 days through the incubation period. RESULTS: The exposure of quail embryos before and during the incubation period to low intensity GSM 1800 MHz has resulted in expressive statistically significant oxidative effects in embryonic cells, including a 2-fold increase in superoxide generation rate and 85% increase in nitrogen oxide generation rate, damages of DNA integrity and oxidative damages of DNA (up to twice increased levels of 8-oxo-dG in cells of 1-day old chicks from the exposed embryos). Finally, the exposure resulted in a significant, almost twice, increase of embryo mortality. CONCLUSION: The exposure of model biological system to low intensity GSM 1800 MHz MWR resulted in significant oxidative and mutagenic effects in exposed cells, and thus should be recognized as a significant risk factor for living cells.

<https://doi.org/10.3109/15368378.2015.1043557>

## 2017

Al-Serori, H., Kundi, M., Ferk, F., Mišík, M., Nersesyan, A., Murbach, M., ... Knasmüller, S. 2017 Evaluation of the potential of mobile phone specific electromagnetic fields (UMTS) to produce micronuclei in human glioblastoma cell lines. *Toxicology in Vitro: An International Journal Published in Association with BIBRA*, 40, 264–271.

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.

<https://doi.org/10.1016/j.tiv.2017.01.012>

Alam, M., D'Este, C., Banwell, C., & Lokuge, K. 2017 The impact of mobile phone based messages on maternal and child healthcare behaviour: a retrospective cross-sectional survey in Bangladesh. *BMC Health Services Research*, 17(1), 434.

**BACKGROUND:** Mobile phones are gradually becoming an integral part of healthcare services worldwide. We assessed the association between Aponjon mobile phone based messaging services and practices regarding childbirth and care of mother and neonates in selected areas in Bangladesh. **METHODS:** In early 2014, 476 subscriber mothers whose last born child's age was between 3 and 18 months, were recruited to the study by Dnet from selected areas of Bangladesh. One group of mothers received the early warning messages from Aponjon during pregnancy (exposed; n = 210) while the other group of new mothers did not receive the messages during pregnancy as they had enrolled in the service after childbirth (non-exposed; n = 266). We undertook regression analyses to investigate the relationship between timing of exposure to Aponjon messages and socio-economic factors and outcomes of safe delivery, immediate breastfeeding post birth, delayed bathing of the neonate, and number of postnatal care (PNC) visits. **RESULTS:** Women reported delivering babies at home without a skilled birth attendant (SBA) (n = 58, 12%), at home with SBA (n = 111, 23%) and at health facilities (n = 307, 65%). Most (n = 443, 93%) women breastfed babies immediately post birth. Babies were bathed after 72 h (n = 294, 62%), between 48 and 72 (n = 100, 21%) and between 0 and 47 (n = 80, 17%) hours after birth. PNC frequencies were reported as none (n = 273, 57%), 1 (n = 79, 17%), 2 (n = 54, 11%), 3 (n = 34, 7%) and 4 (n = 36, 8%). There was no significant association between exposure to Aponjon messages during pregnancy and presence of a SBA at birth, breastfeeding practices, and postnatal care visits, although delayed bathing up to 48 h was significant at the 10% but not 5% level (RRR 1.7; 95% CI 0.93-3.0; p = 0.083). Women with higher education, from higher income, older in age, with birth order 1 or 2 were more likely to birth at health facilities. Facility based delivery was an independent factor for delayed bathing and having postnatal care visits. **CONCLUSIONS:** Low cost mobile phone messages may have the potential to positively influence maternal and child healthcare behaviours, such as delayed timing of first bath, in resource-poor settings. Further studies are needed, with adequate sample size to detect significant change.

<https://doi.org/10.1186/s12913-017-2361-6>

Altun G, Kaplan S, Deniz OG, Kocacan SE, Canan S, Davis D, & Marangoz C. 2017 Protective effects of melatonin and omega-3 on the hippocampus and the cerebellum of adult Wistar albino rats exposed to electromagnetic fields. *JMAU*, 5(4), 230–241.

The purpose of the study was to investigate the effects of pulsed digital electromagnetic radiation emitted by mobile phones on the central nervous system of the adult Wistar albino rats. The study evaluated structural and functional impacts of four treatment arms: electromagnetic field (EMF) exposed; EMF exposed + melatonin treated group (EMF + Mel); EMF exposed + omega-3 ( $\omega$ 3) treated group (EMF +  $\omega$ 3); and control group (Cont). The 12-weeks-old rats were exposed to 900 MHz EMF for 60 min/day (4:00–5:00 p.m.) for 15 days. Stereological, biochemical and electrophysiological techniques were applied to evaluate protective effects of Mel and  $\omega$ 3. Significant cell loss in the CA1 and CA2 regions of hippocampus were observed in the EMF compared to other groups (p < 0.01). In the CA3 region of the EMF +  $\omega$ 3, a significant cell increase was found compared to other groups (p < 0.01). Granular cell loss was observed in the dentate gyrus of the EMF compared to the Cont (p < 0.01). EMF +  $\omega$ 3 has more granular cells in the cerebellum than the Cont, EMF + Mel (p < 0.01). Significant Purkinje cell loss was found in the cerebellum of EMF group compared to the other (p < 0.01). EMF + Mel and EMF +  $\omega$ 3 showed the same protection compared to the Cont (p > 0.05). The passive avoidance test showed that entrance latency into the dark compartment was significantly shorter in the EMF (p < 0.05). Additionally, EMF had a higher serum enzyme activity than the other groups (p < 0.01). In conclusion, our analyses confirm that EMF may lead to cellular damage in the hippocampus and the cerebellum, and that Mel and  $\omega$ 3 may have neuroprotective effects.

<https://doi.org/10.1016/j.jmau.2017.05.006>

Altuntas, G., Sadoglu, D., Ardic, S., Yilmaz, H., Imamoglu, M., & Turedi, S. 2017 Acute effects of the electromagnetic waves emitted by mobile phones on attention in emergency physicians. *The American Journal of Emergency Medicine*.

**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.

<https://doi.org/10.1016/j.ajem.2017.11.031>

Aslan, A., İkinci, A., Baş, O., Sönmez, O. F., Kaya, H., & Odacı, E. 2017 Long-term exposure to a continuous 900 MHz electromagnetic field disrupts cerebellar morphology in young adult male rats. *Biotechnic & Histochemistry: Official Publication of the Biological Stain Commission*, 92(5), 324–330. 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. <https://doi.org/10.1080/10520295.2017.1310295>

Bahreyni Toossi, M. H., Sadeghnia, H. R., Mohammad Mahdizadeh Feyzabadi, M., Hosseini, M., Hedayati, M., Mosallanejad, R., ... Alizadeh Rahvar, Z. 2017

Exposure to mobile phone (900-1800 MHz) during pregnancy: tissue oxidative stress after childbirth. *The Journal of Maternal-Fetal & Neonatal Medicine: The Official Journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians*, 1–6.

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. <https://doi.org/10.1080/14767058.2017.1315657>

Balekouzou, A., Yin, P., Afewerky, H. K., Bekolo, C., Pamatika, C. M., Nambei, S. W., ... Koffi, B. 2017 Behavioral risk factors of breast cancer in Bangui of Central African Republic: A retrospective case-control study. *PloS One*, 12(2), e0171154.

Breast cancer is recognized as a major public health problem in developing countries; however, there is very little evidence of behavioral factors associated with breast cancer risk. This study was conducted to identify lifestyles as risk factors for breast cancer among Central African women. A case-control study was conducted with 174 cases confirmed histologically by the pathology unit of the National Laboratory and 348 age-matched controls. Data collection tools included a questionnaire with interviews and medical records of patients. Data were analyzed using SPSS software version 20. Odd ratio (OR) and 95% confidence intervals (95% CI) were obtained by unconditional logistic regression. In total, 522 women were studied with a mean age of 45.8 (SD = 13.4) years. By unconditional logistic regression model, women with breast cancer were more likely to have attained illiterate and elementary education level [11.23 (95% CI, 4.65-27.14) and 2.40 (95% CI, 1.15-4.99)], married [2.09 (95% CI, 1.18-3.71)], positive family history [2.31 (95% CI, 1.36-3.91)], radiation exposure [8.21 (95% CI, 5.04-13.38)], consumption charcuterie [10.82 (95% CI, 2.39-48.90)], fresh fish consumption [4.26 (95% CI, 1.56-11.65)], groundnut consumption [6.46 (95% CI, 2.57-16.27)], soybean consumption [16.74 (95% CI, 8.03-39.84)], alcohol [2.53 (95% CI, 1.39-4.60)], habit of keeping money in bras [3.57 (95% CI, 2.24-5.69)], overweight [5.36 (95% CI, 4.46-24.57)] and obesity [3.11(95% CI, 2.39-20.42)]. However, decreased risk of breast cancer was associated with being employed [0.32 (95% CI, 0.19-0.56)], urban residence [0.16 (95% CI, 0.07-0.37)], groundnut oil consumption [0.05 (95% CI, 0.02-0.14)], wine consumption [0.16 (95% CI, 0.09-0.26)], non habit of keeping cell phone in bras [0.56 (95% CI, 0.35-0.89)] and physical activity [0.71(95% CI, 0.14-0.84)]. The study showed that little or no education, marriage, positive family history of cancer, radiation exposure, charcuterie, fresh fish, groundnut, soybean, alcohol, habit of keeping money in bras, overweight and obesity were associated with breast cancer risk among Central African women living in Bangui. Women living in Bangui should be more cautious on the behavioral risk associated with breast cancer. <https://doi.org/10.1371/journal.pone.0171154>

Bandara, P., & Weller, S. 2017 Cardiovascular disease: Time to identify emerging environmental risk factors. *European Journal of Preventive Cardiology*, 24(17), 1819–1823. Invited Editorial for special journal edition, concluding, “It is clearly time to investigate the potential role of RF-EMR exposure from common wireless device use on CVD. Noting that existing research findings are influenced by the funding source, 42 fresh directives are necessary for objective high quality research to expand current primary and secondary prevention strategies. <https://doi.org/10.1177/2047487317734898>



Bayat, M., Hemati, S., Soleimani-Estyar, R., & Shahin-Jafari, A. 2017 Effect of long-term exposure of mice to 900MHz GSM radiation on experimental cutaneous candidiasis. *Saudi Journal of Biological Sciences*, 24(4), 907–914. Mobile phones communicate with base stations using 900MHz microwaves. The current study was aimed to survey the effects of long-term 900MHz 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 (6h per day and 7d per week) to 900MHz 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 LD90 dose of *C. albicans*. Mortality of the mice was recorded and the candida load of the kidney homogenates from died animals was counted. 900MHz microwave exposed mice had 1.5day and 3.7day 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 900MHz 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. <https://doi.org/10.1016/j.sjbs.2015.12.005>

Bhargav, H., Srinivasan, T. M., Bista, S., Mooventhan, A., Suresh, V., Hankey, A., & Nagendra, H. R. 2017 Acute effects of mobile phone radiations on subtle energy levels of teenagers using electrophotonic imaging technique: A randomized controlled study. *International Journal of Yoga*, 10(1), 16–23. BACKGROUND: Mobile phones induce radio frequency electromagnetic field (RF-EMF) which has been found to affect subtle energy levels of adults through Electrophotonic Imaging (EPI) technique in a previous pilot study. MATERIALS AND METHODS: We enrolled 61 healthy right-handed healthy teenagers (22 males and 39 females) in the age range of  $17.40 \pm 0.24$  years from educational institutes in Bengaluru. Subjects were randomly divided into two groups: (1) (mobile phone in ON mode [MPON] at right ear) and (2) mobile phone in OFF mode (MPOF). Subtle energy levels of various organs of the subjects were measured using gas discharge visualization Camera Pro device, in double-blind conditions, at two points of time: (1) baseline and (2) after 15 min of MPON/MPOF exposure. As the data were found normally distributed, paired and independent samplest-test were applied to perform within and between group comparisons, respectively. RESULTS: The subtle energy levels were significantly reduced after RF-EMF exposure in MPON group as compared to MPOF group for following areas: (a) Pancreas ( $P= 0.001$ ), (b) thyroid gland ( $P= 0.002$ ), (c) cerebral cortex ( $P< 0.01$ ), (d) cerebral vessels ( $P< 0.05$ ), (e) hypophysis ( $P= 0.013$ ), (f) left ear and left eye ( $P< 0.01$ ), (g) liver ( $P< 0.05$ ), (h) right kidney ( $P< 0.05$ ), (i) spleen ( $P< 0.04$ ), and (j) immune system ( $P< 0.02$ ). CONCLUSION: Fifteen minutes of RF-EMF exposure exerted quantifiable effects on subtle energy levels of endocrine glands, nervous system, liver, kidney, spleen, and immune system of healthy teenagers. Future studies should try to correlate these findings with respective biochemical markers and standard radio-imaging techniques. <https://doi.org/10.4103/0973-6131.186163>

Bhatt, C. R., Benke, G., Smith, C. L., Redmayne, M., Dimitriadis, C., Dalecki, A., ... Abramson, M. J. 2017 Use of mobile and cordless phones and change in cognitive function: a prospective cohort analysis of Australian primary school children. *Environmental Health: A Global Access Science Source*, 16(1), 62. 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. <https://doi.org/10.1186/s12940-017-0250-4>

Bhatt, C. R., Redmayne, M., Billah, B., Abramson, M. J., & Benke, G. 2017 Radiofrequency-electromagnetic field exposures in kindergarten children. *Journal of Exposure Science & Environmental Epidemiology*, 27(5), 497–504. 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. <https://doi.org/10.1038/jes.2016.55>

Birks, L., Guxens, M., Papadopoulou, E., Alexander, J., Ballester, F., Estarlich, M., ... Vrijheid, M. 2017 Maternal cell phone use during pregnancy and child behavioral problems in five birth cohorts. *Environment International*, 104, 122–131.

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. <https://doi.org/10.1016/j.envint.2017.03.024>

Blank, M. 2017 Non-ionizing radiation (NIR): Evaluating safety. *Environmental Pollution*, 222, 153.

Magda Havas (Havas, 2016) summarized recent studies that show how non-ionizing radiation (NIR), often deemed to be safe, can cause cancer by stimulating molecular damage in cells. These studies stand in contrast to the currently accepted view that NIR only causes molecular damage when temperature is raised with sufficient energy to dislodge electrons. She stressed that the 'thermal mechanism' concept is only a hypothesis without evidence of mechanism, while biological evidence exists to show NIR can lead to free radical damage to DNA. Havas' position is strengthened by biological studies on the cellular stress response (CSR) which show that NIR stimulates the DNA in cells to synthesize stress proteins (Goodman and Blank, 1995, Goodman and Blank, 1998). These proteins, originally called 'heat shock proteins,' are clearly indicative of the body mobilizing a defense mechanism, and they serve as biological markers for cellular damage. This response occurs across different ranges in the electromagnetic (EM) spectrum and at relatively low levels — levels that are assumed to be safe according to the thermal criterion. In other words, the CSR is more sensitive than the response to temperature increase. Living cells react to EM forces across the ranges of the spectrum. For example, we have found the CSR is initiated both in Extremely Low Frequency (ELF) and Radio Frequency (RF) ranges (Goodman and Blank, 1995, Goodman and Blank, 1998). These responses indicate interaction with specific sites on DNA to initiate stress protein synthesis (Lin et al., 1999), and show that exposure to a wide range of EMR is potentially harmful to living cells. By contrast, when the thermal criterion is applied, a stress response is not found until the stimulus is at higher levels. These contrasting results are not surprising when one considers that the divisions of the EM spectrum were created by engineers and physicists who set frequency boundaries that did not take biological factors into account. It is clear that stress protein synthesis is stimulated across the ranges of the spectrum. If the public is to be protected, safety standards should be based on measurable properties that relate to protective biological mechanisms, rather than the less sensitive thermal criterion.

<https://doi.org/10.1016/j.envpol.2016.12.063>

Borovkova, M., Serebriakova, M., Fedorov, V., Sedykh, E., Vaks, V., Lichutin, A., ... Khodzitsky, M. 2017 Investigation of terahertz radiation influence on rat glial cells. *Biomedical Optics Express*, 8(1), 273. We studied an influence of

continuous terahertz (THz) radiation (0.12 – 0.18 THz, average power density of 3.2 mW/cm<sup>2</sup>) on a rat glial cell line. A dose-dependent cytotoxic effect of THz radiation is demonstrated. After 1 minute of THz radiation exposure a relative number of apoptotic cells increased in 1.5 times, after 3 minutes it doubled. This result confirms the concept of biological hazard of intense THz radiation. Diagnostic applications of THz radiation can be restricted by the radiation power density and exposure time. <https://doi.org/10.1364/BOE.8.000273>

Bortkiewicz, A., Gadzicka, E., & Szymczak, W. 2017 Mobile phone use and risk for intracranial tumors and salivary gland tumors – A meta-analysis. *International Journal of Occupational Medicine and Environmental Health*. Results of epidemiological studies on the association between use of mobile phone and brain cancer are ambiguous, as well as the results of 5 meta-analysis studies published to date. Since the last meta-analysis (2009), new case-control studies have been published, which theoretically could affect the conclusions on this relationship. Therefore, we decided to perform a new meta-analysis. We conducted a systematic review of multiple electronic data bases for relevant publications. The inclusion criteria were: original papers, case-control studies, published till the end of March 2014, measures of association (point estimates as odds ratio and confidence interval of the effect measured), data on individual exposure. Twenty four studies (26 846 cases, 50 013 controls) were included into the meta-analysis. A significantly higher risk of an intracranial tumor (all types) was noted for the period of mobile phone use over 10 years (odds ratio (OR) = 1.324, 95% confidence interval (CI): 1.028-1.704), and for the ipsilateral location (OR = 1.249, 95% CI: 1.022-1.526). The results support the hypothesis that long-term use of mobile phone increases risk of intracranial tumors, especially in the case of ipsilateral exposure. Further studies are needed to confirm this relationship. <https://doi.org/10.13075/ijomeh.1896.00802>

Bourdineaud, J.-P., Šrut, M., Štambuk, A., Tkalec, M., Brèthes, D., Malarić, K., & Klobučar, G. I. V. 2017 Electromagnetic fields at a mobile phone frequency (900 MHz) trigger the onset of general stress response along with DNA modifications in *Eisenia fetida* earthworms. *Arhiv Za Higijenu Rada I Toksikologiju*, 68(2), 142–152. *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<sup>-1</sup> for a period of two hours (corresponding to specific absorption rates ranging from 0.13 to 9.33 mW kg<sup>-1</sup>). 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<sup>-1</sup>. 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 MEK1 involved in signal transduction), oxidative stress (CAT, encoding catalase), and chemical and immune defence (LYS, encoding lysozyme, and MYD, encoding a myeloid differentiation factor) were up-regulated after exposure to 10 and modulated 23 V m<sup>-1</sup> 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. <https://doi.org/10.1515/aiht-2017-68-2928>

Brignardello-Petersen, R. 2017 Cell phone use may increase the risk of developing parotid gland tumors. *Journal of the American Dental Association* (1939), 148(5), e61. An association between mobile phone use and the risk for parotid gland tumor was observed (OR 1.28, CI 1.09–1.51). Results of the meta-analysis should be read with caution due to the limited number of studies available and their retrospective design. <https://doi.org/10.1016/j.adaj.2017.02.045>

Carlberg, M., & Hardell, L. 2017 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*, 2017, 9218486. 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. <https://doi.org/10.1155/2017/9218486>

Chandel, S., Kaur, S., Singh, H. P., Batish, D. R., & Kohli, R. K. 2017 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.

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<sub>2</sub>O<sub>2</sub>) and superoxide anion (O<sub>2</sub>•-) 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<sub>2</sub>O<sub>2</sub> and O<sub>2</sub>•-. 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. <https://doi.org/10.1016/j.jmau.2017.09.001>

Chauhan P, Verma HN, Sisodia R, & Kesari KK. 2017 Microwave radiation (2.45 GHz)-induced oxidative stress: Whole-body exposure effect on histopathology of Wistar rats. *Electromagn Biol Med*, 36(1), 20–30. Man-made microwave and radiofrequency (RF) radiation technologies have been steadily increasing with the growing demand of electronic appliances such as microwave oven and cell phones. These appliances affect biological systems by increasing free radicals, thus leading to oxidative damage. The aim of this study was to explore the effect of 2.45 GHz microwave radiation on histology and the level of lipid peroxide (LPO) in Wistar rats. Sixty-day-old male Wistar rats with 180 ± 10 g body weight were used for this study. Animals were divided into two groups: sham exposed (control) and microwave exposed. These animals were exposed for 2 h a day for 35 d to 2.45 GHz microwave radiation (power density, 0.2 mW/cm<sup>2</sup>). The whole-body specific absorption rate (SAR) was estimated to be 0.14 W/kg. After completion of the exposure period, rats were sacrificed, and brain, liver, kidney, testis and spleen were stored/preserved for determination of LPO and histological parameters. Significantly high level of LPO was observed in the liver (p < 0.001), brain (p < 0.004) and spleen (p < 0.006) in samples from rats exposed to microwave radiation. Also histological changes were observed in the brain, liver, testis, kidney and spleen after whole-body microwave exposure, compared to the control group. Based on the results obtained in this study, we conclude that exposure to microwave radiation 2 h a day for 35 d can potentially cause histopathology and oxidative changes in Wistar rats. These results indicate possible implications of such exposure on human health. <https://doi.org/10.3109/15368378.2016.1144063>

Cho YM, Lim HJ, Jang H, Kim K, Choi JW, Shin C, ... Kim N. 2017 A follow-up study of the association between mobile phone use and symptoms of ill health. *Environ Health Toxicol*, 32, e2017001. The duration and frequency of mobile phone calls, and their relationship with various health effects, have been investigated in our previous cross-sectional study. This 2-year period follow-up study aimed to assess the changes in these variables of same subjects. The study population comprised 532 non-patient adult subjects sampled from the Korean Genome Epidemiology Study. The subjects underwent a medical examination at a hospital in 2012/2013 and revisited the same hospital in 2014/2015 to have the same examination for the characteristics of mobile phone use performed. In addition, to evaluate the effects on health, the Headache Impact Test-6 (HIT-6), Psychosocial Well-being Index-Short Form, Beck Depression Inventory, Korean-Instrumental Activities of Daily Living, Perceived Stress Scale, Pittsburgh Sleep Quality Index, and 12-item Short Form Health Survey were analyzed. For all these tests, the higher the score, the greater the effect on health. Variances between scores in all the indices in the baseline and follow-up surveys were calculated, and correlations of each index were analyzed. The average duration per call and HIT-6 score of the subjects decreased significantly compared with those recorded two years ago. The results showed a slight but significant correlation between call duration changes and HIT-6 score changes for female subjects, but not for males. HIT-6 scores in the follow-up survey significantly decreased compared to those in the baseline survey, but long-time call users (subjects whose call duration was ≥5 minutes in both the baseline and follow-up surveys) had no statistically significant reduction in HIT-6 scores. This study suggests that increased call duration is a greater risk factor for increases in headache than any other type of adverse health effect, and that this effect can be chronic. <https://doi.org/10.5620/eh.t.e2017001>

Choi, K.-H., Ha, M., Ha, E.-H., Park, H., Kim, Y., Hong, Y.-C., ... Park, C. 2017 Neurodevelopment for the first three years following prenatal mobile phone use, radio frequency radiation and lead exposure. *Environmental Research*, 156, 810–817. Studies examining prenatal exposure to mobile phone use and its effect on child neurodevelopment show different results, according to child's developmental stages. 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. 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. 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. 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.  
<https://doi.org/10.1016/j.envres.2017.04.029>

Das, S., Chakraborty, S., & Mahanta, B. 2017 A study on the effect of prolonged mobile phone use on pure tone audiometry thresholds of medical students of Sikkim. *Journal of Postgraduate Medicine*. INTRODUCTION: Mobile phones have become indispensable for daily activities, and people are exposed to them from an early age. There is, however, concern about the harmful effect of the electromagnetic radiation emitted from the mobile phones. OBJECTIVE: The objective of the study was to study the effect of mobile phone on average pure tone audiometry (PTA) threshold of the person and to study the changes in the pure tone threshold at high frequencies such as 2 kHz, 4 kHz, and 8 kHz among the students with prolonged exposure to mobile phones. METHODOLOGY: A cross-sectional study was conducted among the medical students who have been using mobile phones for the past 5 years. The effect of mobile phones on the PTA threshold in the exposed ear and the nonexposed ear was assessed. RESULTS: The study shows that there is a significant difference in average air conduction (AC) and bone conduction (BC) hearing threshold among the exposed and the nonexposed ears ( $P < 0.05$ ). A significant rise of both AC and BC threshold at individual frequencies between the exposed and the nonexposed ear is also noted in this study. CONCLUSION: The study conducted shows changes in the hearing threshold of the exposed ear when compared with the nonexposed ear. There are however lot of unanswered questions which provide an interesting avenue for further research. Till concrete evidence is available the only feasible way to control its exposure is to limit the duration of usage of mobile phones.  
<https://doi.org/10.5620/ehs.e2017001>

Davis, D., Sears, M. E., Miller, A. B., & Bray, R. 2017 Microwave/Radiofrequency Radiation and Human Health: Clinical Management in the Digital Age. Ch 10. In *Integrative Environmental Medicine*, Ed. Cohen et al. Oxford University Press. Radiation from wireless transmitting devices can cause or worsen acute and chronic health conditions. Outdated exposure limits for cell phones and other wireless devices emitting microwave radiation, a form of radiofrequency radiation, are based solely on avoiding an increase in temperature and do not accommodate increasing evidence of nonthermal effects on reproductive, neurologic, developmental and cardiac health, and cancer. In 2016, the U.S. National Toxicology Program reported significantly greater risks of brain (i.e. gliomas) and heart tumors in the largest rodent study ever conducted. Case-control studies found that regular and heavy cell phone users incurred increased risks of these tumors. Increasing trends of aggressive gliomas among young people have been reported. Chapter 10 provides an overview of microwave chemistry and in vitro, in vivo, epidemiologic, and clinical study findings. Guidance from international authorities addresses history taking, clinical management of relevant exposures, and promotion of safer technologic approaches and policies.  
<https://oxfordmedicine.com/view/10.1093/med/9780190490911.001.0001/med-9780190490911-chapter-10>

de Oliveira, F. M., Carmona, A. M., & Ladeira, C. 2017a Genotoxicity assessment data for exfoliated buccal cells exposed to mobile phone radiation. *Data in Brief*, 15, 344–347. Healthy mobile phone users aged 18-30 y.o. provided exfoliated buccal cells samples from the right and left inner cheeks. A total of 2000 cells per subject were screened for the presence of micronuclei as a sign of genotoxic damage, according to the mobile phone use profile of each user.  
<https://doi.org/10.1016/j.dib.2017.09.048>

de Oliveira, F. M., Carmona, A. M., & Ladeira, C. 2017b Is mobile phone radiation genotoxic? An analysis of micronucleus frequency in exfoliated buccal cells. *Mutation Research. Genetic Toxicology and Environmental Mutagenesis*, 822, 41–46. Electromagnetic fields (EMF) are classified as “possibly carcinogenic” by the International Agency for Research on Cancer (IARC). Some publications have reported associations between EMF exposure and DNA damage, but many other studies contradict such findings. Cytomorphological changes, such as micronuclei (MN), indicative of genomic damage, are biomarkers of genotoxicity. To test whether mobile phone-associated EMF exposure affects the MN frequency in exfoliated buccal cells, we obtained cells smears from the left and right inner cheeks of healthy mobile phone users, aged 18-30 (n=86), who also completed a characterization survey. MN frequencies were tested for potential confounding factors and for duration of phone use and preferential side of mobile phone use. No relationship was observed between MN frequency and duration of mobile phone use in daily calls. Cells ipsilateral to mobile phone use did not present a statistically significantly higher MN frequency, compared to cells contralateral to exposure. A highly statistically significant ( $p < 0.0001$ ) increase in MN frequency was found in subjects reporting

regular exposure to genotoxic agents. Therefore, our results suggest that mobile phone-associated EMF do not to induce MN formation in buccal cells at the observed exposure levels. <https://doi.org/10.1016/j.mrgentox.2017.08.001>

de Siqueira, E. C., de Souza, F. T. A., Gomez, R. S., Gomes, C. C., & de Souza, R. P. 2017 Does cell phone use increase the chances of parotid gland tumor development? A systematic review and meta-analysis. *Journal of Oral Pathology & Medicine*, 46(7), 480–483. Background: Prior epidemiological studies had examined the association between cell phone use and the development of tumors in the parotid glands. However, there is no consensus about the question of whether cell phone use is associated with increased risk of tumors in the parotid glands. We performed a meta-analysis to evaluate the existing literature about the mean question and to determine their statistical significance. Methods: Primary association studies. Papers that associated cell phone use and parotid gland tumors development were included, with no restrictions regarding publication date, language, and place of publication. Systematic literature search using PubMed, SciELO and Embase followed by meta-analysis. Results and conclusion: Initial screening included 37 articles, and three were included in meta-analysis. Using three independent samples including 5087 subjects from retrospective case–control studies, cell phone use seems to be associated with greater odds (1.28, 95%- confidence interval: 1.09–1.51) to develop salivary gland tumor. Results should be read with caution due to the limited number of studies available and their retrospective design. <https://doi.org/10.1111/jop.12531>

Deniz, O. G., Kaplan, S., Selçuk, M. B., Terzi, M., Altun, G., Yurt, K. K., ... Davis, D. 2017 Effects of short and long term electromagnetic fields exposure on the human hippocampus. *Journal of Microscopy and Ultrastructure*. The increasing use of mobile phones may have a number of physiological and psychological effects on human health. Many animal and human studies have reported various effects on the central nervous system and cognitive performance from of exposure to electromagnetic fields (EMF) emitted by mobile phones. The aim of the present study was to evaluate the effects of mobile phones on the morphology of the human brain and on cognitive performance using stereological and spectroscopic methods and neurocognitive tests. Sixty healthy female medical school students aged 18–25 years were divided into a low exposure group (30 subjects, <30min daily use by the head) and high exposure group (30 subjects, >90min daily use by the head). Magnetic resonance images (MRI) of the brain analysed on OsiriX 3.2.1 workstation. Neuropsychological tests were performed for each subject. In addition, three dominant specific metabolites were analysed, choline at 3.21ppm, creatine at 3.04ppm and N-acetyl aspartate at 2.02ppm. Analysis of the spectroscopic results revealed no significant difference in specific metabolites between the groups ( $p>0.05$ ). There was also no significant difference in terms of hippocampal volume between the groups ( $p>0.05$ ). In contrast, the results of the stroop and digit span (backward) neurocognitive tests of high exposure group for evaluating attention were significantly poorer from low exposure group ( $p<0.05$ ). Based on these results, we conclude that a lack of attention and concentration may occur in subjects who talk on mobile phones for longer times, compared to those who use phones relatively less. <https://doi.org/10.1016/j.jmau.2017.07.001>

Deniz, Ö. G., Kivrak, E. G., Kaplan, A. A., & Altunkaynak, B. Z. 2017 Effects of folic acid on rat kidney exposed to 900MHz electromagnetic radiation. *Journal of Microscopy and Ultrastructure*. Because of increased use of cell phones, the purpose of this study was to investigation of the oxidative damage caused by electromagnetic radiation (EMR) emitted by cell phones and histological and morphometrical determination of the possible protective role of folic acid (FA) in preventing the detrimental effects of EMR on the kidney. Twenty-four adult male Wistar albino rats were divided into control (Cont), EMR, EMR+FA and FA groups, each containing six rats. The EMR and EMR+FA groups were exposed to EMR for 60min a day over a period of 21days, while no EMR exposure was applied to the Cont and FA groups. The source of the EMR was an EMR device which emits a digital signal producing 900-MHz frequency radiation. The generator connected to a one-monopole antenna was used in this study and the rats were placed in the plexiglass restrainer at an equal distance from the monopole antenna. Following the experimental period, and after tissue processing, a physical disector-Cavalieri method combination was applied to the sections. The mean volume of the cortex, medulla, proximal and distal tubules increased significantly in the EMR groups compared to the Cont group ( $p<0.01$ ). Contrarily, the total number of glomeruli in the EMR group decreased compared to the Cont group ( $p<0.01$ ). The protective effects of FA was observed in the kidney ( $p<0.05$ ). In conclusion, the 900-MHz EMR leads to kidney damage. FA may exhibit a protective effect against the adverse effects of EMR exposure in terms of the total number of glomeruli. <https://doi.org/10.1016/j.jmau.2017.06.001>

D'Silva, M. H. 2017 Effect of Radiofrequency Radiation Emitted from 2G and 3G Cell Phone on Developing Liver of Chick Embryo – A Comparative Study *Journal of Clinical and Diagnostic Research*. The increasing scientific evidence of various health hazards on exposure of Radiofrequency Radiation (RFR) emitted from both the cell phones and base stations have caused significant media attention and public discussion in recent years. The mechanism of interaction of RF fields with developing tissues of children and fetuses may be different from that of adults due to their smaller physical size and variation in tissue electromagnetic properties. The present study may provide an insight into the basic mechanisms by which RF fields interact with developing tissues in an embryo. Aim To evaluate the possible tissue and DNA damage in developing liver of chick embryo following chronic exposure to Ultra-High Frequency/Radiofrequency Radiation (UHF/RFR) emitted from 2G and 3G cell phone. Materials and Methods Fertilized chick embryos were incubated in four groups. Group A-experimental group exposed to 2G radiation (60 eggs), Group B- experimental group exposed to 3G radiation (60 eggs), Group C- sham exposed control group (60

eggs) and Group D— control group (48 eggs). On completion of scheduled duration, the embryos were collected and processed for routine histological studies to check structural changes in liver. The nuclear diameter and karyorrhexis changes of hepatocytes were analysed using oculometer and square reticule respectively. The liver procured from one batch of eggs from all the four groups was subjected to alkaline comet assay technique to assess DNA damage. The results were compared using one-way ANOVA test. Results In our study, the exposure of developing chick embryos to 2G and 3G cell phone radiations caused structural changes in liver in the form of dilated sinusoidal spaces with haemorrhage, increased vacuolations in cytoplasm, increased nuclear diameter and karyorrhexis and significantly increased DNA damage. Conclusion The chronic exposure of chick embryo liver to RFR emitted from 2G and 3G cell phone resulted in various structural changes and DNA damage. The changes were more pronounced in 3G experimental group. Based on these findings it is necessary to create awareness among public about the possible ill effects of RFR exposure from cell phone. <https://doi.org/10.7860/JCDR/2017/26360.10275>

Doyon, P. R., & Johansson, O. 2017 Electromagnetic fields may act via calcineurin inhibition to suppress immunity, thereby increasing risk for opportunistic infection: Conceivable mechanisms of action. *Medical Hypotheses*, 106, 71–87. While a good number of studies have demonstrated that modern, man-made ambient electromagnetic fields can have both stimulatory and inhibitory effect on immune system function, the precise mechanisms have yet to be completely elucidated. It is hypothesized here that, depending on the parameters, one of the means by which long-term electromagnetic field exposure has the potential to eventually lead to immunosuppression is via downstream inhibition of the enzyme calcineurin — a protein phosphatase, which activates the T-cells of the immune system and can be blocked by pharmaceutical agents. Calcineurin is the target of a class of pharmaceuticals called calcineurin inhibitors (e.g., cyclosporine, pimecrolimus and tacrolimus). When organ transplant recipients take such pharmaceuticals to prevent or suppress organ transplant rejection, one of the major side effects is immunosuppression leading to increased risk of opportunistic infection: e.g., fungal, viral (Epstein-Barr virus, cytomegalovirus), atypical bacterial (*Nocardia*, *Listeria*, mycobacterial, mycoplasma), and parasitic (e.g., toxoplasmosis) infections. Frequent anecdotal reports, as well as a number of scientific studies, have shown that electromagnetic field exposures may indeed produce the same effect: a weakened immune system leading to an increase in the same or similar opportunistic infections: i.e., fungal, viral, atypical bacterial, and parasitic infections. Furthermore, numerous research studies have shown that man-made electromagnetic fields have the potential to open voltage-gated calcium channels, which can in turn produce a pathological increase of intracellular calcium, leading downstream to the pathological production of a series of reactive oxygen species. Finally, there are a number of research studies demonstrating the inhibition of calcineurin by a pathological production of reactive oxygen species. Hence, it is hypothesized here that exposures to electromagnetic fields have the potential to inhibit immune system response by means of an eventual pathological increase in the influx of calcium into the cytoplasm of the cell, which induces a pathological production of reactive oxygen species, which in turn can have an inhibitory effect on calcineurin. Calcineurin inhibition leads to immunosuppression, which in turn leads to a weakened immune system and an increase in opportunistic infection. <https://doi.org/10.1016/j.mehy.2017.06.028>

Eghlidospour, M., Ghanbari, A., Mortazavi, S. M. J., & Azari, H. 2017 Effects of radiofrequency exposure emitted from a GSM mobile phone on proliferation, differentiation, and apoptosis of neural stem cells. *Anatomy & Cell Biology*, 50(2), 115–123. Due to the importance of neural stem cells (NSCs) in plasticity of the nervous system and treating neurodegenerative diseases, the main goal of this study was to evaluate the effects of radiofrequency radiation emitted from a GSM 900-MHz mobile phone with different exposure duration on proliferation, differentiation and apoptosis of adult murine NSCs in vitro. We used neurosphere assay to evaluate NSCs proliferation, and immunofluorescence assay of neural cell markers to examine NSCs differentiation. We also employed alamarBlue and caspase 3 apoptosis assays to assess harmful effects of mobile phone on NSCs. Our results showed that the number and size of resulting neurospheres and also the percentage of cells differentiated into neurons decreased significantly with increasing exposure duration to GSM 900-MHz radiofrequency (RF)-electromagnetic field (EMF). In contrast, exposure to GSM 900-MHz RF-EMF at different durations did not influence cell viability and apoptosis of NSCs and also their astrocytic differentiation. It is concluded that accumulating dose of GSM 900-MHz RF-EMF might have devastating effects on NSCs proliferation and neurogenesis requiring more causations in terms of using mobile devices. <https://doi.org/10.5115/acb.2017.50.2.115>

Esmekaya, M. A., Canseven, A. G., Kayhan, H., Tuysuz, M. Z., Sirav, B., & Seyhan, N. 2017 Mitochondrial hyperpolarization and cytochrome-c release in microwave-exposed MCF-7 cells. *General Physiology and Biophysics*, 36(2), 211–218. This study examines the effects of a 2.1-GHz WCDMA-modulated microwave (MW) radiation on apoptotic activity and mitochondrial membrane potential ( $\Delta\Psi_m$ ) in MCF-7 cells. The cells were exposed to the MW at a specific absorption rate (SAR) of 0.528 W/kg for 4 or 24 h. The antiproliferative effect of MW exposure was determined by the MTT test. Cytochrome-c and p53 levels were determined by an ELISA method. The relative  $\Delta\Psi_m$  was analysed by JC-1 staining using flow cytometer. Apoptotic rate of the cells was measured by Annexin-V-FITC staining. All assays were performed after certain time of incubations (15 min–4 h) following MW exposure. MW-exposed cells showed a significant decrease in viability when compared to unexposed cells. A significantly larger decrease was observed after longer exposure. The percentage of apoptotic cells, amount of

cytochrome-c, and relative  $\Delta\Psi_m$  were significantly higher in MW-exposed cells. The percent of apoptotic cells and relative  $\Delta\Psi_m$  in 24 h MW-exposed group was significantly higher than those in 4 h MW-exposed group. However, no significant change was observed in p53 levels. These results demonstrated that exposure to 2.1-GHz WCDMA-modulated MW radiation caused hyperpolarization of mitochondria that in turn induced apoptosis in MCF-7 cells. [https://doi.org/10.4149/gpb\\_2016021](https://doi.org/10.4149/gpb_2016021)

Ghatei, N., Sadr Nabavi, A., Bahreyni Toosi, M. H., Azimian, H., Homayoun, M., Ghasemnezhad Targhi, R., & Haghiri, H. 2017 Evaluation of bax, bcl-2, p21 and p53 genes expression variations on cerebellum of BALB/c mice before and after birth under mobile phone radiation exposure. *Iranian Journal of Basic Medical Sciences*, 20(9). Objective(s): The increasing rate of over using cell phones has been considerable in youths and pregnant women. We examined the effect of mobile phones radiation on genes expression variation on cerebellum of BALB/c mice before and after of the birth. Materials and Methods: In this study, a mobile phone jammer, which is an instrument to prevent receiving signals between cellular phones and base transceiver stations (two frequencies 900 and 1800 MHz) for exposure was used and twelve pregnant mice (BALB/c) divided into two groups (n=6), first group irradiated in pregnancy period (19th day), the second group did not irradiate in pregnancy period. After childbirth, offspring were classified into four groups (n=4): Group1: control, Group 2: B1 (Irradiated after birth), Group 3: B2 (Irradiated in pregnancy period and after birth), Group 4: B3 (Irradiated in pregnancy period). When maturity was completed (8-10 weeks old), mice were dissected and cerebellum was isolated. The expression level of bax, bcl-2, p21 and p53 genes examined by realtime reverse transcription polymerase chain reaction (Real-Time RT-PCR). Results: The data showed that mobile phone radio waves were ineffective on the expression level of bcl2 and p53 genes)  $P>0.05$ . Also gene expression level of bax decreased and gene expression level of p21 increased comparing to the control group ( $P<0.05$ ). Conclusion: From the obtained data it could be concluded that the mobile phone radiations did not induce apoptosis in cells of the cerebellum and the injured cells can be repaired by cell cycle arrest. <https://doi.org/10.22038/ijbms.2017.9273>

Gökçek-Saraç, Ç., Er, H., Kencebay Manas, C., Kantar Gok, D., Özen, Ş., & Derin, N. 2017 Effects of acute and chronic exposure to both 900 MHz and 2100 MHz electromagnetic radiation on glutamate receptor signaling pathway. *International Journal of Radiation Biology*, 1–10. PURPOSE: To demonstrate the molecular effects of acute and chronic exposure to both 900 and 2100 MHz radiofrequency electromagnetic radiation (RF-EMR) on the hippocampal level/activity of some of the enzymes - including PKA, CaMKII $\alpha$ , CREB, and p44/42 MAPK - from N-methyl-D-aspartate receptor (NMDAR)-related signaling pathways. MATERIALS AND METHODS: Rats were divided into the following groups: sham rats, and rats exposed to 900 and 2100 MHz RF-EMR for 2 h/day for acute (1 week) or chronic (10 weeks), respectively. Western blotting and activity measurement assays were used to assess the level/activity of the selected enzymes. RESULTS: The obtained results revealed that the hippocampal level/activity of selected enzymes was significantly higher in the chronic groups as compared to the acute groups at both 900 and 2100 MHz RF-EMR exposure. In addition, hippocampal level/activity of selected enzymes was significantly higher at 2100 MHz RF-EMR than 900 MHz RF-EMR in both acute and chronic groups. CONCLUSIONS: The present study provides experimental evidence that both exposure duration (1 week versus 10 weeks) and different carrier frequencies (900 vs. 2100 MHz) had different effects on the protein expression of hippocampus in Wistar rats, which might encourage further research on protection against RF-EMR exposure. <https://doi.org/10.1080/09553002.2017.1337279>

Gökçek-Saraç Ç, Özen Ş, & Derin N. 2017 Effects of 2G mobile phone exposure on both behavioural performance and levels of enzyme from NMDA-dependent pathway. *Progress In Electromagnetics Research Symposium - Spring (PIERS)*, St. Petersburg. Mobile communications are expanded day by day and bring along their potential adverse effects on human brain. One of the affected brain regions is known as hippocampus which is the most studied structure because of its well documented role in learning and memory. The major intracellular signaling pathway implemented in memory formation in the hippocampus is N-methyl-D-aspartate (NMDA)-dependent pathway including activation of kinases. Experimental animal studies have demonstrated several effects of short and/or long term RF-EMR exposure on cognitive functions and behaviors of animals. In the literature, little is known about the effects of RF-EMR exposure on NMDA receptor signalling pathway. Therefore, in the present study an attempt was taken to demonstrate possible effects of acute and chronic 900 MHz RF-EMR exposure on both passive avoidance behavior and hippocampal level of the enzymes from NMDA receptor related signalling pathway including p44/42 MAPK and its phosphorylated form (phospho p44/42 MAPK) using Western Blotting technique. Rats were divided into following groups: Sham rats, rats exposed to 900 MHz RF-EMR for 2h/day for 1 (acute) or 10 (chronic) weeks, respectively. Overall results indicated that both acute and chronic exposure to 900 MHz RF-EMR can impair passive avoidance behavior with minor effect on behavior of chronic group of rats. In addition, hippocampal levels of both p44/42 MAPK and phospho p44/42 MAPK were significantly higher in chronic group of rats. These findings demonstrated that different duration time (1 week versus 10 weeks) of 900 MHz RF-EMR exposure has different effects on both passive avoidance behavior of rats and hippocampal levels of p44/42 MAPK and phospho p44/42 MAPK from NMDA dependent pathway. <https://doi.org/10.1109/PIERS.2017.8262030>

Haas, A. J., Le Page, Y., Zhadobov, M., Sauleau, R., Dréan, Y. L., & Saligaut, C. 2017 Effect of acute millimeter wave exposure on dopamine metabolism of NGF-treated PC12 cells. *Journal of Radiation Research*, 1–7.



Several forthcoming wireless telecommunication systems will use electromagnetic frequencies at millimeter waves (MMWs), and technologies developed around the 60-GHz band will soon know a widespread distribution. Free nerve endings within the skin have been suggested to be the targets of MMW therapy which has been used in the former Soviet Union. So far, no studies have assessed the impact of MMW exposure on neuronal metabolism. Here, we investigated the effects of a 24-h MMW exposure at 60.4 GHz, with an incident power density (IPD) of 5 mW/cm<sup>2</sup>, on the dopaminergic turnover of NGF-treated PC12 cells. After MMW exposure, both intracellular and extracellular contents of dopamine (DA) and 3,4-dihydroxyphenylacetic acid (DOPAC) were studied using high performance liquid chromatography. Impact of exposure on the dopamine transporter (DAT) expression was also assessed by immunocytochemistry. We analyzed the dopamine turnover by assessing the ratio of DOPAC to DA, and measuring DOPAC accumulation in the medium. Neither dopamine turnover nor DAT protein expression level were impacted by MMW exposure. However, extracellular accumulation of DOPAC was found to be slightly increased, but not significantly. This result was related to the thermal effect, and overall, no evidence of non-thermal effects of MMW exposure were observed on dopamine metabolism. <https://doi.org/10.1093/jrr/rxx004>

Halmagyi, A., Surducun, E., & Surducun, V. 2017 The effect of low- and high-power microwave irradiation on in vitro grown Sequoia plants and their recovery after cryostorage. *Journal of Biological Physics*, 43(3), 367–379. Two distinct microwave power levels and techniques have been studied in two cases: low-power microwave (LPM) irradiation on in vitro Sequoia plants and high-power microwave (HPM) exposure on recovery rates of cryostored (-196°C) Sequoia shoot apices. Experimental variants for LPM exposure included: (a) in vitro plants grown in regular conditions (at 24 ± 1°C during a 16-h light photoperiod with a light intensity of 39.06 µEm<sup>-2</sup> s<sup>-1</sup> photosynthetically active radiation), (b) in vitro plants grown in the anechoic chamber with controlled environment without microwave irradiation, and (c) in vitro plants grown in the anechoic chamber with LPM irradiation for various times (5, 15, 30, 40 days). In comparison to control plants, significant differences in shoot multiplication and growth parameters (length of shoots and roots) were observed after 40 days of LPM exposure. An opposite effect was achieved regarding the content of total soluble proteins, which decreased with increasing exposure time to LPM. HPM irradiation was tested as a novel rewarming method following storage in liquid nitrogen. To our knowledge, this is the first report using this type of rewarming method. Although, shoot tips subjected to HPM exposure showed 28% recovery following cryostorage compared to 44% for shoot tips rewarmed in liquid medium at 22 ± 1 °C, we consider that the method represent a basis and can be further improved. The results lead to the overall conclusion that LPM had a stimulating effect on growth and multiplication of in vitro Sequoia plants, while the HPM used for rewarming of cryopreserved apices was not effective to achieve high rates of regrowth after liquid nitrogen exposure. <https://doi.org/10.1007/s10867-017-9457-4>

Hassanshahi, A., Shafeie, S. A., Fatemi, I., Hassanshahi, E., Allahtavakoli, M., Shabani, M., ... Shamsizadeh, A. 2017 The effect of Wi-Fi electromagnetic waves in unimodal and multimodal object recognition tasks in male rats. *Neurological Sciences: Official Journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology*, 38(6), 1069–1076. Wireless internet (Wi-Fi) electromagnetic waves (2.45 GHz) have widespread usage almost everywhere, especially in our homes. Considering the recent reports about some hazardous effects of Wi-Fi signals on the nervous system, this study aimed to investigate the effect of 2.4 GHz Wi-Fi radiation on multisensory integration in rats. This experimental study was done on 80 male Wistar rats that were allocated into exposure and sham groups. Wi-Fi exposure to 2.4 GHz microwaves [in Service Set Identifier mode (23.6 dBm and 3% for power and duty cycle, respectively)] was done for 30 days (12 h/day). Cross-modal visual-tactile object recognition (CMOR) task was performed by four variations of spontaneous object recognition (SOR) test including standard SOR, tactile SOR, visual SOR, and CMOR tests. A discrimination ratio was calculated to assess the preference of animal to the novel object. The expression levels of M1 and GAT1 mRNA in the hippocampus were assessed by quantitative real-time RT-PCR. Results demonstrated that rats in Wi-Fi exposure groups could not discriminate significantly between the novel and familiar objects in any of the standard SOR, tactile SOR, visual SOR, and CMOR tests. The expression of M1 receptors increased following Wi-Fi exposure. In conclusion, results of this study showed that chronic exposure to Wi-Fi electromagnetic waves might impair both unimodal and cross-modal encoding of information. <https://doi.org/10.1007/s10072-017-2920-y>

Havas, M. 2017 When theory and observation collide: Can non-ionizing radiation cause cancer? *Environmental Pollution*, 221:501–505.

This paper attempts to resolve the debate about whether non-ionizing radiation (NIR) can cause cancer—a debate that has been ongoing for decades. The rationale, put forward mostly by physicists and accepted by many health agencies, is that, “since NIR does not have enough energy to dislodge electrons, it is unable to cause cancer.” This argument is based on a flawed assumption and uses the model of ionizing radiation (IR) to explain NIR, which is inappropriate. Evidence of free-radical damage has been repeatedly documented among humans, animals, plants and microorganisms for both extremely low frequency (ELF) electromagnetic fields (EMF) and for radio frequency (RF) radiation, neither of which is ionizing. While IR directly damages DNA, NIR interferes with the oxidative repair mechanisms resulting in oxidative stress, damage to cellular components including DNA, and damage to cellular processes leading to cancer. Furthermore, free-radical damage explains the increased cancer risks

associated with mobile phone use, occupational exposure to NIR (ELF EMF and RFR), and residential exposure to power lines and RF transmitters including mobile phones, cell phone base stations, broadcast antennas, and radar installations.  
<https://doi.org/10.1016/j.envpol.2016.10.018>

He, Q., Zong, L., Sun, Y., Vijayalaxmi, null, Prihoda, T. J., Tong, J., & Cao, Y. 2017 Adaptive response in mouse bone marrow stromal cells exposed to 900MHz radiofrequency fields: Impact of poly (ADP-ribose) polymerase (PARP). *Mutation Research. Genetic Toxicology and Environmental Mutagenesis*, 820, 19–25. This study examined whether non-ionizing radiofrequency fields (RF) exposure is capable of inducing poly (ADP-ribose) polymerase-1 (PARP-1) in bone marrow stromal cells (BMSCs) and whether it plays a role in RF-induced adaptive response (AR). Bone marrow stromal cells (BMSCs) were exposed to 900MHz RF at 120μW/cm<sup>2</sup> power flux density for 3h/day for 5days and then challenged with a genotoxic dose of 1.5Gy gamma-radiation (GR). Some cells were also treated with 3-aminobenzamide (3-AB, 2mM final concentration), a potent inhibitor of PARP-1. Un-exposed and sham (SH)-exposed control cells as well as positive control cells exposed to gamma radiation (GR) were included in the experiments. The expression of PARP-1 mRNA and its protein levels as well as single strand breaks in the DNA and the kinetics of their repair were evaluated at several times after exposures. The results indicated the following. (a) Cells exposed to RF alone showed significantly increased PARP-1 mRNA expression and its protein levels compared with those exposed to SH- and GR alone. (b) Treatment of RF-exposed cells with 3-AB had diminished such increase in PARP-1. (c) Cells exposed to RF+GR showed significantly decreased genetic damage as well as faster kinetics of repair compared with those exposed to GR alone. (d) Cells exposed to RF+3-AB+GR showed no such decrease in genetic damage. Thus, the overall data suggested that non-ionizing RF exposure was capable of inducing PARP-1 which has a role in RF-induced AR.  
<https://doi.org/10.1016/j.mrgentox.2017.05.007>

Hiscock, H. G., Mouritsen, H., Manolopoulos, D. E., & Hore, P. J. 2017 Disruption of Magnetic Compass Orientation in Migratory Birds by Radiofrequency Electromagnetic Fields. *Biophysical Journal*, 113(7), 1475–1484. The radical-pair mechanism has been put forward as the basis of the magnetic compass sense of migratory birds. Some of the strongest supporting evidence has come from behavioral experiments in which birds exposed to weak time-dependent magnetic fields lose their ability to orient in the geomagnetic field. However, conflicting results and skepticism about the requirement for abnormally long quantum coherence lifetimes have cast a shroud of uncertainty over these potentially pivotal studies. Using a recently developed computational approach, we explore the effects of various radiofrequency magnetic fields on biologically plausible radicals within the theoretical framework of radical-pair magnetoreception. We conclude that the current model of radical-pair magnetoreception is unable to explain the findings of the reported behavioral experiments. Assuming that an unknown mechanism amplifies the predicted effects, we suggest experimental conditions that have the potential to distinguish convincingly between the two distinct families of radical pairs currently postulated as magnetic compass sensors. We end by making recommendations for experimental protocols that we hope will increase the chance that future experiments can be independently replicated. <https://doi.org/10.1016/j.bpj.2017.07.031>

Ibitayo AO, Afolabi OB, Akinyemi AJ, Ojiezeh TI, Adekoya KO, & Ojewunmi OO. 2017 RAPD Profiling, DNA Fragmentation, and Histomorphometric Examination in Brains of Wistar Rats Exposed to Indoor 2.5 Ghz Wi-Fi Devices Radiation. *Biomed Res Int*, 2017, 8653286. The advent of Wi-Fi connected high technology devices in executing day-to-day activities is fast evolving especially in developing countries of the world and hence the need to assess its safety among others. The present study was conducted to investigate the injurious effect of radiofrequency emissions from installed Wi-Fi devices in brains of young male rats. Animals were divided into four equal groups; group 1 served as control while groups 2, 3, and 4 were exposed to 2.5 Ghz at intervals of 30, 45, and 60 consecutive days with free access to food and water ad libitum. Alterations in harvested brain tissues were confirmed by histopathological analyses which showed vascular congestion and DNA damage in the brain was assayed using agarose gel electrophoresis. Histomorphometry analyses of their brain tissues showed perivascular congestion and tissue damage as well.  
<https://doi.org/10.1155/2017/8653286>

Kamali K, Atarod M, Sarhadi S, Nikbakht J, Emami M, Maghsoudi R, ... Ameli M. 2017 Effects of electromagnetic waves emitted from 3G+wi-fi modems on human semen analysis. *Urologia*, 84(4), 209–214. Objective The purpose of this study was to evaluate the effects of 3G+wifi modems on human sperm quality. A total of 40 semen specimens were gathered between March and September 2015, from healthy adult men. Methods The sperm samples were divided into two groups – 3G+wi-fi exposed and unexposed groups. In the unexposed group, the specimens were shielded by aluminum foil in three layers and put into an incubator at a temperature of 37°C for 50 minutes. The exposed group was positioned in another room in an incubator at a temperature of 37°C for 50 minutes. A 3G+wi-fi modem was put into the same incubator and a laptop computer was connected to the modem and was downloading for the entire 50 minutes. Semen analysis was done for each specimen and comparisons between parameters of the two groups were done by using Kolmogorov-Smirnov study and a paired t-test. Results Mean percentage of sperm with class A and B motility were not significantly different in two

groups ( $p = 0.22$  and  $0.54$ , respectively). In class C, it was significantly lower in the exposed group ( $p = 0.046$ ), while in class D it was significantly higher ( $p = 0.022$ ). Velocity curvilinear, velocity straight line, velocity average path, mean angular displacement, lateral displacement and beat cross frequency were significantly higher in the unexposed group. The limitation was the in vitro design. Conclusions Electromagnetic waves (EMWs) emitted from 3G+wi-fi modems cause a significant decrease in sperm motility and velocity, especially in non-progressive motile sperms. Other parameters of semen analysis did not change significantly. EMWs, which are used in communications worldwide, are a suspected cause of male infertility. Many studies evaluated the effects of cell phones and wi-fi on fertility. To our knowledge, no study has yet been done to show the effects of EMWs emitted from 3G+wi-fi modems on fertility. Our study revealed a significant decrease in the quality of human semen after exposure to EMWs emitted from 3G+wi-fi modems. <https://doi.org/10.5301/uj.5000269>

Karanam, N. K., Srinivasan, K., Ding, L., Sishc, B., Saha, D., & Story, M. D. 2017 Tumor-treating fields elicit a conditional vulnerability to ionizing radiation via the downregulation of BRCA1 signaling and reduced DNA double-strand break repair capacity in non-small cell lung cancer cell lines. *Cell Death & Disease*, 8(3), e2711.

The use of tumor-treating fields (TTFields) has revolutionized the treatment of recurrent and newly diagnosed glioblastoma (GBM). TTFields are low-intensity, intermediate frequency, alternating electric fields that are applied to tumor regions and cells using non-invasive arrays. The predominant mechanism by which TTFields are thought to kill tumor cells is the disruption of mitosis. Using five non-small cell lung cancer (NSCLC) cell lines we found that there is a variable response in cell proliferation and cell killing between these NSCLC cell lines that was independent of p53 status. TTFields treatment increased the G2/M population, with a concomitant reduction in S-phase cells followed by the appearance of a sub-G1 population indicative of apoptosis. Temporal changes in gene expression during TTFields exposure was evaluated to identify molecular signaling changes underlying the differential TTFields response. The most differentially expressed genes were associated with the cell cycle and cell proliferation pathways. However, the expression of genes found within the BRCA1 DNA-damage response were significantly downregulated ( $P < 0.05$ ) during TTFields treatment. DNA double-strand break (DSB) repair foci increased when cells were exposed to TTFields as did the appearance of chromatid-type aberrations, suggesting an interphase mechanism responsible for cell death involving DNA repair. Exposing cells to TTFields immediately following ionizing radiation resulted in increased chromatid aberrations and a reduced capacity to repair DNA DSBs, which were likely responsible for at least a portion of the enhanced cell killing seen with the combination. These findings suggest that TTFields induce a state of "BRCAness" leading to a conditional susceptibility resulting in enhanced sensitivity to ionizing radiation and provides a strong rationale for the use of TTFields as a combined modality therapy with radiation or other DNA-damaging agents. <https://doi.org/10.1038/cddis.2017.136>

Kim, J. H., Yu, D.-H., Huh, Y. H., Lee, E. H., Kim, H.-G., & Kim, H. R. 2017 Long-term exposure to 835 MHz RF-EMF induces hyperactivity, autophagy and demyelination in the cortical neurons of mice. *Scientific Reports*, 7, 41129. Radiofrequency electromagnetic field (RF-EMF) is used globally in conjunction with mobile communications. There are public concerns of the perceived deleterious biological consequences of RF-EMF exposure. This study assessed neuronal effects of RF-EMF on the cerebral cortex of the mouse brain as a proxy for cranial exposure during mobile phone use. C57BL/6 mice were exposed to 835 MHz RF-EMF at a specific absorption rate (SAR) of 4.0 W/kg for 5 hours/day during 12 weeks. The aim was to examine activation of autophagy pathway in the cerebral cortex, a brain region that is located relatively externally. Induction of autophagy genes and production of proteins including LC3B-II and Beclin1 were increased and accumulation of autolysosome was observed in neuronal cell bodies. However, proapoptotic factor Bax was down-regulated in the cerebral cortex. Importantly, we found that RF-EMF exposure led to myelin sheath damage and mice displayed hyperactivity-like behaviour. The data suggest that autophagy may act as a protective pathway for the neuronal cell bodies in the cerebral cortex during radiofrequency exposure. The observations that neuronal cell bodies remained structurally stable but demyelination was induced in cortical neurons following prolonged RF-EMF suggests a potential cause of neurological or neurobehavioural disorders. <https://doi.org/10.1038/srep41129>

Kim, J. H., Yu, D.-H., & Kim, H. R. 2017 Activation of autophagy at cerebral cortex and apoptosis at brainstem are differential responses to 835 MHz RF-EMF exposure. *The Korean Journal of Physiology & Pharmacology: Official Journal of the Korean Physiological Society and the Korean Society of Pharmacology*, 21(2), 179–188. With the explosive increase in exposure to radiofrequency electromagnetic fields (RF-EMF) emitted by mobile phones, public concerns have grown over the last few decades with regard to the potential effects of EMF exposure on the nervous system in the brain. Many researchers have suggested that RF-EMFs can effect diverse neuronal alterations in the brain, thereby affecting neuronal functions as well as behavior. Previously, we showed that long-term exposure to 835 MHz RF-EMF induces autophagy in the mice brain. In this study, we explore whether short-term exposure to RF-EMF leads to the autophagy pathway in the cerebral cortex and brainstem at 835 MHz with a specific absorption rate (SAR) of 4.0 W/kg for 4 weeks. Increased levels of autophagy genes and proteins such as LC3B-II and Beclin1 were demonstrated and the accumulation of autophagosomes and autolysosomes was observed in cortical neurons whereas apoptosis pathways were up-regulated in the brainstem but not in the cortex following 4 weeks of RF exposure. Taken together, the present study indicates that monthly exposure to RF-EMF induces autophagy in the cerebral cortex and

suggests that autophagic degradation in cortical neurons against a stress of 835 MHz RF during 4 weeks could correspond to adaptation to the RF stress environment. However, activation of apoptosis rather than autophagy in the brainstem is suggesting the differential responses to the RF-EMF stresses in the brain system. <https://doi.org/10.4196/kjpp.2017.21.2.179>

Kivrak, E. G., Altunkaynak, B. Z., Alkan, I., Yurt, K. K., Kocaman, A., & Onger, M. E. 2017 Effects of 900-MHz radiation on the hippocampus and cerebellum of adult rats and attenuation of such effects by folic acid and *Boswellia sacra*. *Journal of Microscopy and Ultrastructure*, 5(4), 216–224.

The radiation emitted from mobile phones has various deleterious effects on human health. This study was conducted to evaluate the effects of exposure to the 900-MHz radiation electromagnetic fields (EMF) emitted by mobile phones on Ammon's horn and the dentate gyrus (DG) in the hippocampus and cerebellum of male Wistar albino rats. We also investigated the neuroprotective effects of the antioxidants *Boswellia sacra* (BS) and folic acid (FA) against exposure to EMF. Twenty-four adult male rats were randomly divided into four groups of six animals each, an EMF group, an EMF + FA exposure group (EFA), an EMF + BS exposure group (EBS) and a control group (Cont). The EMF, EFA and EBS groups were exposed to 900-MHz EMF radiation inside a tube once daily over 21 days (60 min/day). The Cont group was not exposed to 900-MHz EMF. The results showed that EMF caused a significant decrease in total pyramidal and granular cell numbers in the hippocampus, and DG and in Purkinje cell numbers in the cerebellum in the EMF group compared to the other groups ( $p < 0.05$ ). BS and FA attenuated the neurodegenerative effects of EMF in the hippocampus and cerebellum. Significant differences were also determined between the numbers of neurons in the EFA and EMF groups, and between the EBS and EMF groups ( $p < 0.05$ ). However, there were no significant differences among Cont, EFA and EBS ( $p > 0.05$ ). Our results may contribute to ongoing research into the effects of 900-MHz EMF exposure. <https://doi.org/10.1016/j.jmau.2017.09.003>

Kleiber, C. E. 2017 Radiation from wireless technology elevates blood glucose and body temperature in 40-year-old type 1 diabetic male. *Electromagnetic Biology and Medicine*, 36(3), 259–264. A type 1 diabetic male reports multiple instances when his blood glucose was dramatically elevated by the presence of microwave radiation from wireless technology and plummeted when the radiation exposure ended. In one instance, his body temperature elevated in addition to his blood glucose. Both remained elevated for nearly 48 h after exposure with the effect gradually decreasing. Possible mechanisms for microwave radiation elevating blood glucose include effects on glucose transport proteins and ion channels, insulin conformational changes and oxidative stress. Temperature elevation may be caused by microwave radiation-triggered  $\text{Ca}^{2+}$  efflux, a mechanism similar to malignant hyperthermia. The potential for radiation from wireless technology to cause serious biological effects has important implications and necessitates a reevaluation of its near-ubiquitous presence, especially in hospitals and medical facilities. <https://doi.org/10.1080/15368378.2017.1323762>

Kocaman, A., Gül, M., Yurt, K. K., Altun, G., Zayman, E., & Kivrak, E. G. 2017 Does omega-3 have a protective effect on the rat adrenal gland exposed to 900 MHz electromagnetic fields? *Journal of Microscopy and Ultrastructure*, 5(4), 185–190. The aim of this study was to investigate the harmful effects of exposure to 900-megahertz (MHz) electromagnetic fields (EMF) and the protective effects of omega-3 (Omg-3) against EMF in the rat adrenal gland. Eighteen Wistar albino rats were randomly assigned into three groups, control (Cont), EMF, and EMF + Omg-3. The EMF and EMF + Omg-3 groups both consisted of six rats exposed to an EMF of 900 MHz for 60 min/day for 15 days. No procedure was applied to the six rats in the Cont group. At the end of the experiment, all rats were sacrificed, and the mean volumes of the cortex and medulla of the adrenal gland were estimated using a stereological counting technique. The stereological results showed that the mean volume of the adrenal gland increased significantly in the EMF-exposed groups compared to the Cont group. Additionally, the mean volume of the adrenal gland was significantly lower in the EMF + Omg-3 group compared to the EMF group. We suggest that Omg-3 therapy aimed at suppressing the effects of EMF may prove a safe alternative for animals, whether or not they are exposed to EMF. <https://doi.org/10.1016/j.jmau.2017.08.003>

Kostoff, R. N., & Lau, C. G. Y. 2017 Modified Health Effects of Non-ionizing Electromagnetic Radiation Combined with Other Agents Reported in the Biomedical Literature. In C. D. Geddes (Ed.), *Microwave Effects on DNA and Proteins* (pp. 97–157). Cham: Springer International Publishing. Ionizing and non-ionizing electromagnetic field (EMF) radiation, either stand-alone or in combination with other agents, exert health effects on biological systems. The present chapter examines the scope of non-ionizing EMF radiation combined effects; i.e., identifies effects on biological systems from combined exposure to non-ionizing electromagnetic fields/radiation and at least one other agent. Only articles in which the presence of non-ionizing EMF radiation had some effect (beneficial or adverse) on the biological system were selected. A comprehensive and novel query was developed using an iterative hybrid approach, whereby articles related by common text and by citation linkages were retrieved. This retrieved literature was: (1) clustered algorithmically into 32 biomedical sub-themes (assigned by the authors); (2) grouped through factor analysis into 32 factors; and (3) subsequently grouped manually (by the authors) into an effects-based taxonomy. The common principles within each thematic cluster/group that accounted for the combined effects were identified. Non-ionizing EMF radiation plays a supportive role in a wide range of beneficial and adverse effects. Major beneficial effects include

(1) accelerated healing of wounds and injuries in concert with other agents and (2) treatment of cancer by combining chemotherapy with radiation. Major adverse effects, on the other hand, include (1) enhanced carcinogenesis, (2) enhanced cellular or genetic mutations, and (3) teratogenicity. It should be noted that community consensus (unanimity among papers published in peer-reviewed journals) does not exist on these potential effects, either beneficial or adverse, although there is substantial credible scientific evidence supporting the above effects (as described in this chapter). In daily living, the body is exposed to multiple external agents simultaneously, e.g., myriad non-ionizing EMF radiations, pesticides, food additives, heavy metal, legal and illegal drugs, ionizing radiation, and air pollution. The number of combinations of potential external agents is large. Each combination could potentially have synergistic or antagonistic, and beneficial or adverse, effects. However, non-ionizing EMF radiation exposure safety standards are based primarily on stand-alone radiation exposures. When combined with other agents, the adverse effects of non-ionizing EMF radiation on biological systems may be more severe. Much work remains to be done before definitive statements about non-ionizing EMF radiation exposure safety can be made.

[https://doi.org/10.1007/978-3-319-50289-2\\_4](https://doi.org/10.1007/978-3-319-50289-2_4)

Kulaber, A., Kerimoğlu, G., Ersöz, Ş., Çolakoğlu, S., & Odacı, E. 2017 Alterations of thymic morphology and antioxidant biomarkers in 60-day-old male rats following exposure to a continuous 900 MHz electromagnetic field during adolescence. *Biotechnic & Histochemistry: Official Publication of the Biological Stain Commission*, 92(5), 331–337. We investigated changes in thymic tissue of male rats exposed to a 900 megahertz (MHz) electromagnetic field (EMF) on postnatal days 22–59. Three groups of six 21-day-old male Sprague-Dawley rats were allocated as: control (CG), sham (SG) and EMF (EMFG) groups. No procedure was performed on the CG rats. SG rats were placed in a Plexiglas cage for 1 h every day between postnatal days 22 and 59 without exposure to EMF. EMFG rats were placed in the same cage for the same periods as the SG rats and were exposed to 900 MHz EMF. Rats were sacrificed on postnatal day 60. Sections of thymus were stained for histological assessment. Oxidant/antioxidant parameters were investigated biochemically. Malondialdehyde (MDA) levels in EMFG increased compared to the other groups. Extravascular erythrocytes were observed in the medullary/corticomedullary regions in EMFG sections. We found that 900 MHz EMF applied for 1 h/day on postnatal days 22–59 can increase tissue MDA and histopathological changes in male rat thymic tissue. <https://doi.org/10.1080/10520295.2017.1312525>

Kuzay, D., Ozer, C., Sirav, B., Canseven, A. G., & Seyhan, N. 2017 Oxidative effects of extremely low frequency magnetic field and radio frequency radiation on testes tissues of diabetic and healthy rats. *Bratislavske Lekarske Listy*, 118(5), 278–282. With the development of technology, people are increasingly under the exposure of electromagnetic fields. Individuals with chronic diseases such as diabetes are now long-term exposed to Radio Frequency-RF radiation and extremely low frequency (ELF) magnetic fields (MFs). The purpose of this present study is to investigate oxidative effects and antioxidant parameters of ELF MFs and RF radiation on testis tissue in diabetic and healthy rats. Wistar male rats were divided into 10 groups. Intraperitoneal single dose STZ (65 mg/kg) dissolved in citrate buffer (0.1M (pH 4.5)) was injected to diabetes groups. ELF MFs and RF radiation were used as an electromagnetic exposure for 20 min/day, 5 days/week for one month. Testis tissue oxidant malondialdehyde (MDA), and antioxidants glutathione (GSH), and total nitric oxide (NOx) levels were determined. The results of ANOVA and Mann-Whitney tests were compared;  $p < 0.05$  was considered significant. ELF and RF radiation resulted in an increase in testicular tissue MDA and NOx levels ( $p < 0.05$ ), and caused a decrease in GSH levels ( $p < 0.05$ ) in both healthy and diabetic rats, yet more distinctively in diabetic rats. The most pronounced effect was recorded in D-RF + ELF group ( $p < 0.005$ ). Both radiation practices increased the oxidative stress in testis tissue while causing a decrease in antioxidant level which was more distinctive in diabetic rats (Tab. 1, Fig. 3, Ref. 30). [https://doi.org/10.4149/BLL\\_2017\\_055](https://doi.org/10.4149/BLL_2017_055)

Kuzniar A, Laffeber C, Eppink B, Bezstarosti K, Dekkers D, Woelders H, ... Kanaar R. 2017 Semi-quantitative proteomics of mammalian cells upon short-term exposure to non-ionizing electromagnetic fields. *PLoS One*, 12(2), e0170762. The potential effects of non-ionizing electromagnetic fields (EMFs), such as those emitted by power-lines (in extremely low frequency range), mobile cellular systems and wireless networking devices (in radio frequency range) on human health have been intensively researched and debated. However, how exposure to these EMFs may lead to biological changes underlying possible health effects is still unclear. To reveal EMF-induced molecular changes, unbiased experiments (without a priori focusing on specific biological processes) with sensitive readouts are required. We present the first proteome-wide semi-quantitative mass spectrometry analysis of human fibroblasts, osteosarcomas and mouse embryonic stem cells exposed to three types of non-ionizing EMFs (ELF 50 Hz, UMTS 2.1 GHz and WiFi 5.8 GHz). We performed controlled in vitro EMF exposures of metabolically labeled mammalian cells followed by reliable statistical analyses of differential protein- and pathway-level regulations using an array of established bioinformatics methods. Our results indicate that less than 1% of the quantitated human or mouse proteome responds to the EMFs by small changes in protein abundance. Further network-based analysis of the differentially regulated proteins did not detect significantly perturbed cellular processes or pathways in human and mouse cells in response to ELF, UMTS or WiFi exposure. In conclusion, our extensive bioinformatics analyses of semi-quantitative mass spectrometry data do not support the notion that the short-time exposures to non-ionizing EMFs have a consistent biologically significant bearing on mammalian cells in culture. <https://doi.org/10.1371/journal.pone.0170762>

Langer, C. E., de Llobet, P., Dalmau, A., Wiart, J., Goedhart, G., Hours, M., ... Vrijheid, M. 2017 Patterns of cellular phone use among young people in 12 countries: Implications for RF exposure. *Environment International*, 107, 65–74. Characterizing exposure to radiofrequency (RF) fields from wireless telecommunications technologies during childhood and adolescence is a research priority in investigating the health effects of RF. The Mobi-Expo study aimed to describe characteristics and determinants of cellular phone use in 534 young people (10-24years) in 12 countries. The study used a specifically designed software application installed on smartphones to collect data on the use of wireless telecommunications devices within this age group. The role of gender, age, maternal education, calendar period, and country was evaluated through multivariate models mutually adjusting for all variables. Call number and duration were higher among females compared to males (geometric mean (GM) ratio 1.17 and 1.42, respectively), among 20-24year olds compared to 10-14year olds (GM ratio 2.09 and 4.40, respectively), and among lowest compared to highest social classes (GM ratio 1.52 and 1.58, respectively). The number of SMS was higher in females (GM ratio 1.46) and the middle age group (15-19year olds: GM ratio 2.21 compared to 10-14year olds) and decreased over time. Data use was highest in the oldest age group, whereas Wi-Fi use was highest in the middle age group. Both data and Wi-Fi use increased over time. Large differences in the number and duration of calls, SMS, and data/Wi-Fi use were seen by country, with country and age accounting for up to 50% of the variance. Hands-free and laterality of use did not show significant differences by sex, age, education, study period, or country. Although limited by a convenience sample, these results provide valuable insights to the design, analysis, and interpretation of future epidemiological studies concerning the health effects of exposure resulting from cellular phone use in young people. In addition, the information provided by this research may be used to design strategies to minimize RF exposure. <https://doi.org/10.1016/j.envint.2017.06.002>

Levine, H., Jørgensen, N., Martino-Andrade, A., Mendiola, J., Weksler-Derri, D., Mindlis, I., ... Swan, S. H. 2017 Temporal trends in sperm count: a systematic review and meta-regression analysis. *Human Reproduction Update*, 23(6), 646–659. BACKGROUND: Reported declines in sperm counts remain controversial today and recent trends are unknown. A definitive meta-analysis is critical given the predictive value of sperm count for fertility, morbidity and mortality. OBJECTIVE AND RATIONALE: To provide a systematic review and meta-regression analysis of recent trends in sperm counts as measured by sperm concentration (SC) and total sperm count (TSC), and their modification by fertility and geographic group. SEARCH METHODS: PubMed/MEDLINE and EMBASE were searched for English language studies of human SC published in 1981-2013. Following a predefined protocol 7518 abstracts were screened and 2510 full articles reporting primary data on SC were reviewed. A total of 244 estimates of SC and TSC from 185 studies of 42 935 men who provided semen samples in 1973-2011 were extracted for meta-regression analysis, as well as information on years of sample collection and covariates [fertility group ("Unselected by fertility" versus 'Fertile'), geographic group ("Western", including North America, Europe Australia and New Zealand versus "Other", including South America, Asia and Africa), age, ejaculation abstinence time, semen collection method, method of measuring SC and semen volume, exclusion criteria and indicators of completeness of covariate data]. The slopes of SC and TSC were estimated as functions of sample collection year using both simple linear regression and weighted meta-regression models and the latter were adjusted for pre-determined covariates and modification by fertility and geographic group. Assumptions were examined using multiple sensitivity analyses and nonlinear models. OUTCOMES: SC declined significantly between 1973 and 2011 (slope in unadjusted simple regression models -0.70 million/ml/year; 95% CI: -0.72 to -0.69;  $P < 0.001$ ; slope in adjusted meta-regression models = -0.64; -1.06 to -0.22;  $P = 0.003$ ). The slopes in the meta-regression model were modified by fertility ( $P$  for interaction = 0.064) and geographic group ( $P$  for interaction = 0.027). There was a significant decline in SC between 1973 and 2011 among Unselected Western (-1.38; -2.02 to -0.74;  $P < 0.001$ ) and among Fertile Western (-0.68; -1.31 to -0.05;  $P = 0.033$ ), while no significant trends were seen among Unselected Other and Fertile Other. Among Unselected Western studies, the mean SC declined, on average, 1.4% per year with an overall decline of 52.4% between 1973 and 2011. Trends for TSC and SC were similar, with a steep decline among Unselected Western (-5.33 million/year, -7.56 to -3.11;  $P < 0.001$ ), corresponding to an average decline in mean TSC of 1.6% per year and overall decline of 59.3%. Results changed minimally in multiple sensitivity analyses, and there was no statistical support for the use of a nonlinear model. In a model restricted to data post-1995, the slope both for SC and TSC among Unselected Western was similar to that for the entire period (-2.06 million/ml, -3.38 to -0.74;  $P = 0.004$  and -8.12 million, -13.73 to -2.51,  $P = 0.006$ , respectively). WIDER IMPLICATIONS: This comprehensive meta-regression analysis reports a significant decline in sperm counts (as measured by SC and TSC) between 1973 and 2011, driven by a 50-60% decline among men unselected by fertility from North America, Europe, Australia and New Zealand. Because of the significant public health implications of these results, research on the causes of this continuing decline is urgently needed. <https://doi.org/10.1093/humupd/dmx022>

Li, J.-H., Jiang, D.-P., Wang, Y.-F., Yan, J.-J., Guo, Q.-Y., Miao, X., ... Guo, G.-Z. 2017 Influence of electromagnetic pulse on the offspring sex ratio of male BALB/c mice. *Environmental Toxicology and Pharmacology*, 54, 155–161. Public concern is growing about the exposure to electromagnetic fields (EMF) and its effect on male reproductive health. Detrimental effect of EMF exposure on sex hormones, reproductive performance and sex-ratio was reported. The present study was designed to clarify whether paternal exposure to electromagnetic pulse (EMP) affects offspring sex ratio in mice. 50 male BALB/c mice aged 5-6 weeks were exposed to EMP daily for 2 weeks before mated with non-exposed females at 0d, 7d, 14d, 21d and 28d after

exposure. Sex hormones including total testosterone, LH, FSH, and GnRH were detected using radioimmunoassay. The sex ratio was examined by PCR and agarose gel electrophoresis. The results of D0, D21 and D28 showed significant increases compared with sham-exposed groups. The serum testosterone increased significantly in D0, D14, D21, and D28 compared with sham-exposed groups ( $p < 0.05$ ). Overall, this study suggested that EMP exposure may lead to the disturbance of reproductive hormone levels and affect the offspring sex ratio. <https://doi.org/10.1016/j.etap.2017.06.015>

Lin, J. C. 2017 Cancer Occurrences in Laboratory Rats from Exposure to RF and Microwave Radiation. *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, PP(99), 1–1. Health effects of radio frequency (RF) and microwave radiation have been a subject of scientific inquiry and public interest of late because of widespread global usage of mobile communication devices by billions of people everywhere. A minute increase in health risks such as cancer from RF radiation might lead to significant consequences for health of the general public. A recent U.S. government announcement of discovery of rare cancers in rats exposed to RF radiation is an important occurrence. Note that any new or single report should not be viewed in isolation. The U.S. government project was organized to confront the weaknesses of prior laboratory rodent studies on the potential of RF exposure to impact human health such as cancer in controlled environments. Indeed, several published reports on animal cancer investigations involving prolonged exposures to RF radiation are contentious and perplexing. The discrepancies have presented ambiguity in assessing public health threats from RF exposure. It is the objective of this review to provide a critical and analytical synopsis and assessment on current progress in cancers in rats exposed, lifelong, to RF and microwave radiation. Its focus is on laboratory studies involving cancer production and promotion, and survival of experimental rats. Of special interest is carcinogenesis in the head—cancer development in the head. The question of whether RF exposure from wireless and mobile devices and systems poses a health risk would likely remain equivocal and controversial for some time to come. <https://doi.org/10.1109/JERM.2017.2721427>

Lippi G, Danese E, Brocco G, Gelati M, Salvagno GL, & Montagnana M. 2017 Acute effects of 30 minutes of exposure to a smartphone call on in vitro platelet function. *Blood Transfus*, 15, 249–253. Background. Significant concerns are now regularly raised about the safety of excessive mobile phone use. This study was aimed to assess the acute effects of radiofrequency waves emitted by a commercial smartphone on platelet function. Materials and methods. Two sequential citrated blood samples were collected from 16 healthy volunteers recruited from laboratory staff. The first sample was placed in a plastic rack, 1 cm distant from a commercial smartphone receiving a 30-min call and emitting 900 MHz radiofrequency waves. The second sample was placed in another plastic rack, isolated from radiofrequency wave sources, for the same period. The platelet count and the mean platelet volume were then assessed in all blood samples, whereas platelet function was evaluated using the platelet function analyser-100 (PFA-100). Results. A 30-min exposure of citrated blood to smartphone radiofrequency waves induced significant prolongation of collagen-epinephrine aggregation (median increase, 10%) and a considerable increase of mean platelet volume (median increase, 5%), whereas collagen-adenosine diphosphate aggregation and platelet count remained unchanged. Discussion. This study demonstrates that smartphone radiofrequency waves induce significant perturbation of platelet structure and function, thus providing further support to concerns regarding excessive use of mobile phones. Caution should also be taken with regards to blood products containing platelets, which should be kept far away from mobile phones and smartphones throughout the production pipeline and storage period. <https://doi.org/10.2450/2016.0327-15>

Lu, X., Oda, M., Ohba, T., Mitsubuchi, H., Masuda, S., & Katoh, T. 2017 Association of excessive mobile phone use during pregnancy with birth weight: an adjunct study in Kumamoto of Japan Environment and Children's Study. *Environmental Health and Preventive Medicine*, 22(1), 52. BACKGROUND: Low birth weight has been shown to be closely associated with neonatal mortality and morbidity, inhibited growth, poor cognitive development, and chronic diseases later in life. Some studies have also shown that excessive mobile phone use in the postnatal period may lead to behavioral complications in the children during their growing years; however, the relationship between mobile phone use during pregnancy and neonatal birth weight is not clear. The aim of the present study was to determine the associations of excessive mobile phone use with neonatal birth weight and infant health status. METHODS: A sample of 461 mother and child pairs participated in a survey on maternal characteristics, infant characteristics, and maternal mobile phone usage information during pregnancy. RESULTS: Our results showed that pregnant women tend to excessively use mobile phones in Japan. The mean infant birth weight was lower in the excessive use group than in the ordinary use group, and the frequency of infant emergency transport was significantly higher in the excessive use group than in the ordinary use group. CONCLUSIONS: Excessive mobile phone use during pregnancy may be a risk factor for lower birth weight and a high rate of infant emergency transport. <https://doi.org/10.1186/s12199-017-0656-1>

Marino, A. A., Kim, P. Y., & Il, C. F. 2017 Trigeminal neurons detect cellphone radiation: Thermal or nonthermal is not the question. *Electromagnetic Biology and Medicine*, 36(2), 123–131. Cellphone electromagnetic radiation produces temperature alterations in facial skin. We hypothesized that the radiation-induced heat was transduced by warmth-sensing trigeminal neurons, as evidenced by changes in cognitive processing of the afferent signals. Ten human volunteers were exposed

on the right side of the face to 1 GHz radiation in the absence of acoustic, tactile, and low-frequency electromagnetic stimuli produced by cellphones. Cognitive processing manifested in the electroencephalogram (EEG) was quantitated by analysis of brain recurrence (a nonlinear technique). The theoretical temperature sensitivity of warmth-sensing neurons was estimated by comparing changes in membrane voltage expected as a result of heat transduction with membrane-voltage variance caused by thermal noise. Each participant underwent sixty 12-s trials. The recurrence variable  $r$  ("percent recurrence") was computed second by second for the  $\Delta$  band of EEGs from two bilaterally symmetric derivations (decussated and nondecussated). Percent recurrence during radiation exposure (first 4 s of each trial) was reduced in the decussated afferent signal compared with the control (last four seconds of each trial); mean difference,  $r = 1.1 \pm 0.5\%$ ,  $p < 0.005$ . Mean relative  $\Delta$  power did not differ between the exposed and control intervals, as expected. Trigeminal neurons were capable of detecting temperature changes far below skin temperature increases caused by cellphone radiation. Simulated cellphone radiation affected brain electrical activity associated with nonlinear cognitive processing of radiation-induced thermal afferent signals. Radiation standards for cellphones based on a thermal/nonthermal binary distinction do not prevent neurophysiological consequences of cellphone radiation. <https://doi.org/10.1080/15368378.2016.1194294>

Mokarram, P., Sheikhi, M., Mortazavi, S. M. J., Saeb, S., & Shokrpour, N. 2017 Effect of Exposure to 900 MHz GSM Mobile Phone Radiofrequency Radiation on Estrogen Receptor Methylation Status in Colon Cells of Male Sprague Dawley Rats. *Journal of Biomedical Physics & Engineering*, 7(1), 79–86. BACKGROUND: Over the past several years, the rapidly increasing use of mobile phones has raised global concerns about the biological effects of exposure to radiofrequency (RF) radiation. Numerous studies have shown that exposure to electromagnetic fields (EMFs) can be associated with effects on the nervous, endocrine, immune, cardiovascular, hematopoietic and ocular systems. In spite of genetic diversity, the onset and progression of cancer can be controlled by epigenetic mechanisms such as gene promoter methylation. There are extensive studies on the epigenetic changes of the tumor suppressor genes as well as the identification of methylation biomarkers in colorectal cancer. Some studies have revealed that genetic changes can be induced by exposure to RF radiation. However, whether or not RF radiation is capable of inducing epigenetic alteration has not been clarified yet. To date, no study has been conducted on the effect of radiation on epigenetic alterations in colorectal cancer (CRC). Several studies have also shown that methylation of estrogen receptor  $\alpha$  (ER $\alpha$ ), MYOD, MGMT, SFRP2 and P16 play an important role in CRC. It can be hypothesized that RF exposure can be a reason for the high incidence of CRC in Iran. This study aimed to investigate whether epigenetic pattern of ER $\alpha$  is susceptible to RF radiation and if RF radiation can induce radioadaptive response as epigenetic changes after receiving the challenge dose ( $\gamma$ -ray). MATERIAL AND METHOD: 40 male Sprague-Dawley rats were divided into 4 equal groups (Group I: exposure to RF radiation of a GSM cell phone for 4 hours and sacrificed after 24 hours; Group II: RF exposure for 4 hours, exposure to Co-60 gamma radiation (3 Gy) after 24 hours and sacrificed after 72 hrs; Group III: only 3Gy gamma radiation; Group 4: control group). DNA from colon tissues was extracted to evaluate the methylation status by methylation specific PCR. RESULTS: Our finding showed that exposure to GSM cell phone RF radiation was capable of altering the pattern of ER $\alpha$  gene methylation compared to that of non-exposed controls. Furthermore, no adaptive response phenomenon was induced in the pattern of ER $\alpha$  gene methylation after exposure to the challenging dose of Co-60  $\gamma$ -rays. CONCLUSION: It can be concluded that exposure to RF radiation emitted by GSM mobile phones can lead to epigenetic detrimental changes in ER $\alpha$  promoter methylation pattern.

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5401136/>

Momoli, F., Siemiatycki, J., McBride, M. L., Parent, M.-É., Richardson, L., Bedard, D., ... Krewski, D. 2017 Probabilistic Multiple-Bias Modeling 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*, 186(7), 885–893. We undertook a re-analysis of the Canadian data from the 13-country case-control Interphone Study (2001-2004), in which researchers evaluated the associations of mobile phone use with the risks of brain, acoustic neuroma, and parotid gland tumors. In the main publication of the multinational Interphone Study, investigators concluded that biases and errors prevented a causal interpretation. We applied a probabilistic multiple-bias model to address possible biases simultaneously, using validation data from billing records and nonparticipant questionnaires as information on recall error and selective participation. In our modeling, we sought to adjust for these sources of uncertainty and to facilitate interpretation. For glioma, when comparing those in the highest quartile of use (>558 lifetime hours) to those who were not regular users, the odds ratio was 2.0 (95% confidence interval: 1.2, 3.4). After adjustment for selection and recall biases, the odds ratio was 2.2 (95% limits: 1.3, 4.1). There was little evidence of an increase in the risk of meningioma, acoustic neuroma, or parotid gland tumors in relation to mobile phone use. Adjustments for selection and recall biases did not materially affect interpretation in our results from Canadian data. <https://doi.org/10.1093/aje/kwx157>

Mortazavi, S. M. J., Mostafavi-Pour, Z., Daneshmand, M., Zal, F., Zare, R., & Mosleh-Shirazi, M. A. 2017 Adaptive Response Induced by Pre-Exposure to 915 MHz Radiofrequency: A Possible Role for Antioxidant Enzyme Activity. *Journal of Biomedical Physics & Engineering*, 7(2), 137–142. BACKGROUND: Over the past few years, the rapid use of high frequency electromagnetic fields like mobile phones has raised global concerns about the negative health effects of its use. Adaptive response is the ability



of a cell or tissue to better resist stress damage by prior exposure to a lesser amount of stress. This study aimed to assess whether radiofrequency radiation can induce adaptive response by changing the antioxidant balance. **MATERIALS AND METHODS:** In order to assess RF-induced adaptive response in tissues, we evaluated the level of GSH and the activity of GR in liver. 50 rats were divided into 5 groups. Three groups were pre-exposed to 915 MHz RF radiation, 4 hours per day for one week at different powers, as low, medium and high. 24 hours after the last exposure to radiation, they were exposed to 4 Gy sublethal dose of gamma radiation and then sacrificed after 5 hours. Their livers were removed, washed and were kept at -80o C until used. **RESULTS:** Our finding showed that pre-exposure to 915 MHz radiofrequency radiation with specific power could induce adaptive response in liver by inducing changes in the activity and level of antioxidant enzymes. **CONCLUSION:** It can be concluded that pre-exposure to microwave radiation could increase the level of GSH and the activity of GR enzyme, although these increases were seen just in low power group, and the GR activity was indicated in medium power group. This increase protects tissue from oxidative damage induced by sublethal dose of gamma radiation.  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5447250/>

Nakouti I, Hobbs G, Teethaisong Y, & Phipps D. 2017 A demonstration of athermal effects of continuous microwave irradiation on the growth and antibiotic sensitivity of *Pseudomonas aeruginosa* PAO1. *Biotechnol Prog*, 33(1), 37–44. Stress, caused by exposure to microwaves (2.45 GHz) at constant temperature ( $37 \pm 0.5^{\circ}\text{C}$ ), alters the growth profile of *Pseudomonas aeruginosa* PAO1. In the absence of microwave treatment a simple, highly reproducible growth curve was observed over 24 h or more. Microwave treatment caused no reduction in growth during the first 6 h, but at a later stage (>12 h) the growth was markedly different to the controls. Secondary growth, typical of the presence of persisters clearly became apparent, as judged by both the dissolved oxygen and the cell density profiles. These treated cells showed distinct morphological changes, but on regrowth these cells reverted to normal. The microwave induced persisters were subject to antibiotic challenge (tobramycin) and showed increased sensitivity when compared to the unstressed planktonic cells. This is in marked contrast to antibiotic induced persisters which show increased resistance. This provides evidence for both a nonthermal effect of microwaves and a previously undescribed route to a novel form of antibiotic susceptible persister cells. <https://doi.org/10.1002/btpr.2392>

Novoselova, E. G., Glushkova, O. V., Khrenov, M. O., Novoselova, T. V., Lunin, S. M., & Fesenko, E. E. 2017 Extremely low-level microwaves attenuate immune imbalance induced by inhalation exposure to low-level toluene in mice. *International Journal of Radiation Biology*, 1–9. **PURPOSE:** To clarify whether extremely low-level microwaves (MW) alone or in combination with p38 inhibitor affect immune cell responses to inhalation exposure of mice to low-level toluene. **MATERIALS AND METHODS:** The cytokine profile, heat shock proteins expression, and the activity of several signal cascades, namely, NF- $\kappa$ B, SAPK/JNK, IRF-3, p38 MAPK, and TLR4 were measured in spleen lymphocytes of mice treated to air-delivered toluene (0.6 mg/m(3)) or extremely low-level microwaves (8.15-18 GHz,  $1\mu\text{W}/\text{cm}^2$ , 1 Hz swinging frequency) or combined action of these two factors. **RESULTS:** A single exposure to air-delivered low-level toluene induced activation of NF- $\kappa$ B, SAPK/JNK, IFR-3, p38 MAPK and TLR4 pathways. Furthermore, air toluene induced the expression of Hsp72 and enhanced IL-1, IL-6, and TNF- $\alpha$  in blood plasma, which is indicative of a pro-inflammatory response. Exposure to MW alone also resulted in the enhancement of the plasma cytokine values (e.g. IL-6, TNF- $\alpha$ , and IFN- $\gamma$ ) and activation of the NF- $\kappa$ B, MAPK p38, and especially the TLR4 pathways in splenic lymphocytes. Paradoxically, pre-exposure to MW partially recovered or normalized the lymphocyte parameters in the toluene-exposed mice, while the p38 inhibitor XI additionally increased protective activity of microwaves by down regulating MAPKs (JNK and p38), IKK, as well as expression of TLR4 and Hsp90- $\alpha$ . **CONCLUSIONS:** The results suggest that exposure to low-intensity MW at specific conditions may recover immune parameters in mice undergoing inhalation exposure to low-level toluene via mechanisms involving cellular signaling. <https://doi.org/10.1080/09553002.2017.1270473>

Obajuluwa, A. O., Akinyemi, A. J., Afolabi, O. B., Adekoya, K., Sanya, J. O., & Ishola, A. O. 2017 Exposure to radio-frequency electromagnetic waves alters acetylcholinesterase gene expression, exploratory and motor coordination-linked behaviour in male rats. *Toxicology Reports*, 4, 530–534. - WiFi exposure caused a significant increase in anxiety level and affect locomotor function. - WiFi exposure caused a significant decrease in AChE activity in rats. - WiFi exposure alters AChE mRNA expression level in rats. Humans in modern society are exposed to an ever-increasing number of electromagnetic fields (EMFs) and some studies have demonstrated that these waves can alter brain function but the mechanism still remains unclear. Hence, this study sought to investigate the effect of 2.5 Ghz band radio-frequency electromagnetic waves (RF-EMF) exposure on cerebral cortex acetylcholinesterase (AChE) activity and their mRNA expression level as well as locomotor function and anxiety-linked behaviour in male rats. Animals were divided into four groups namely; group 1 was control (without exposure), group 2–4 were exposed to 2.5 Ghz radiofrequency waves from an installed WI-FI device for a period of 4, 6 and 8 weeks respectively. The results revealed that WiFi exposure caused a significant increase in anxiety level and affect locomotor function. Furthermore, there was a significant decrease in AChE activity with a concomitant increase in AChE mRNA expression level in WiFi exposed rats when compared with control. In conclusions, these data showed that long term exposure to WiFi may lead to adverse effects such as neurodegenerative diseases as observed by a significant alteration on AChE gene expression and some neurobehavioral parameters associated with brain damage. <https://doi.org/10.1016/j.toxrep.2017.09.007>

Othman H, Ammari M, Rtibi K, Bensaid N, Sakly M, & Abdelmelek H. 2017 Postnatal development and behavior effects of in-utero exposure of rats to radiofrequency waves emitted from conventional WiFi devices *Environ Toxicol Pharmacol*, 52, 239–247. Effects of gestational exposure to 2.45 GHz WiFi signal for 2 h/day along gestation period on the offspring were studied. Offspring showed neurodevelopment impairments but no behavior alteration at adult age. Cerebral oxidative stress equilibrium as well as cholinesterase activity in brain and serum were altered. The present work investigated the effects of prenatal exposure to radiofrequency waves of conventional WiFi devices on postnatal development and behavior of rat offspring. Ten Wistar albino pregnant rats were randomly assigned to two groups (n = 5). The experimental group was exposed to a 2.45 GHz WiFi signal for 2 h a day throughout gestation period. Control females were subjected to the same conditions as treated group without applying WiFi radiations. After delivery, the offspring was tested for physical and neurodevelopment during its 17 postnatal days (PND), then for anxiety (PND 28) and motricity (PND 40-43), as well as for cerebral oxidative stress response and cholinesterase activity in brain and serum (PND 28 and 43). Our main results showed that the in-utero WiFi exposure impaired offspring neurodevelopment during the first seventeen postnatal days without altering emotional and motor behavior at adult age. Besides, prenatal WiFi exposure induced cerebral oxidative stress imbalance (increase in malondialdehyde level (MDA) and hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) levels and decrease in catalase (CAT) and superoxide dismutase (SOD) activities) at 28 but not 43 days old, also the exposure affected acetylcholinesterase activity at both cerebral and seric levels. Thus, the current study revealed that maternal exposure to WiFi radiofrequencies led to various adverse neurological effects in the offspring by affecting neurodevelopment, cerebral stress equilibrium and cholinesterase activity.  
<https://doi.org/10.1016/j.etap.2017.04.016>

Othman H, Ammari M, Sakly M, & Abdelmelek H. 2017 Effects of prenatal exposure to WIFI signal (2.45GHz) on postnatal development and behavior in rat: Influence of maternal restraint. *Behav Brain Res*, 326, 291–302. Effects of gestational exposure to WiFi signal and restraint along gestation period on the offspring were studied. -The pups were evaluated for physical development and neuromotor maturation. -Gestational WiFi exposure and restraint, adversely affected offspring neurodevelopment and behavior at adulthood. -Progeny brain oxidative balance and serum biochemistry were disrupted. The present study was carried out to investigate the potential combined influence of maternal restraint stress and 2.45 GHz WiFi signal exposure on postnatal development and behavior in the offspring of exposed rats. 24 pregnant albino Wistar rats were randomly assigned to four groups: Control, WiFi-exposed, restrained and both WiFi-exposed and restrained groups. Each of WiFi exposure and restraint occurred 2 h/day along gestation till parturition. The pups were evaluated for physical development and neuromotor maturation. Moreover, elevated plus maze test, open field activity and stationary beam test were also determined on postnatal days 28, 30 and 31, respectively. After behavioral tests, the rats were anesthetized and their brains were removed for biochemical analysis. Our main findings showed no detrimental effects on gestation progress and outcomes at delivery in all groups. Subsequently, WiFi and restraint, per se and mainly in concert altered physical development of pups with slight differences between genders. Behaviorally, the gestational WiFi irradiation, restraint and especially the associated treatment affected the neuromotor maturation mainly in male progeny. At adult age, we noticed anxiety, motor deficit and exploratory behavior impairment in male offspring co-exposed to WiFi radiation and restraint, and in female progeny subjected to three treatments. The biochemical investigation showed that, all three treatments produced global oxidative stress in brain of both sexes. As for serum biochemistry, phosphorus, magnesium, glucose, triglycerides and calcium levels were disrupted. Taken together, prenatal WiFi radiation and restraint, alone and combined, provoked several behavioral and biochemical impairments at both juvenile and adult age of the offspring.  
<https://doi.org/10.1016/j.bbr.2017.03.011>

Oyewopo, A. O., Olaniyi, S. K., Oyewopo, C. I., & Jimoh, A. T. 2017 Radiofrequency electromagnetic radiation from cell phone causes defective testicular function in male Wistar rats. *Andrologia* 49(10):e12772 Cell phones have become an integral part of everyday life. As cell phone usage has become more widespread, concerns have increased regarding the harmful effects of radiofrequency electromagnetic radiation from these devices. The current study was undertaken to investigate the effects of the emitted radiation by cell phones on testicular histomorphometry and biochemical analyses. Adult male Wistar rats weighing 180-200 g were randomly allotted to control, group A (switched off mode exposure), group B (1-hr exposure), group C (2-hr exposure) and group D (3-hr exposure). The animals were exposed to radiofrequency electromagnetic radiation of cell phone for a period of 28 days. Histomorphometry, biochemical and histological investigations were carried out. The histomorphometric parameters showed no significant change (p < .05) in the levels of germinal epithelial diameter in all the experimental groups compared with the control group. There was no significant change (p < .05) in cross-sectional diameter of all the experimental groups compared with the control group. Group D rats showed a significant decrease (p < .05) in lumen diameter compared with group B rats. There was an uneven distribution of germinal epithelial cells in groups B, C and D. However, there was degeneration of the epithelia cells in group D when compared to the control and group B rats. Sera levels of malondialdehyde (MDA) and superoxide dismutase (SOD), which are markers of reactive oxygen species, significantly increased (MDA) and decreased (SOD), respectively, in all the experimental groups compared with the control group. Also sera levels of gonadotropic hormones (FSH, LH

and testosterone) significantly decreased ( $p < .05$ ) in groups C and D compared with the control group. The study demonstrates that chronic exposure to radiofrequency electromagnetic radiation of cell phone leads to defective testicular function that is associated with increased oxidative stress and decreased gonadotropic hormonal profile. <https://doi.org/10.1111/and.12772>

Pakhomov, A., Bojarinova, J., Cherbunin, R., Chetverikova, R., Grigoryev, P. S., Kavokin, K., ... Chernetsov, N. 2017 Very weak oscillating magnetic field disrupts the magnetic compass of songbird migrants. *Journal of the Royal Society, Interface*, 14(133). Previously, it has been shown that long-distance migrants, garden warblers (*Sylvia borin*), were disoriented in the presence of narrow-band oscillating magnetic field (1.403 MHz OMF, 190 nT) during autumn migration. This agrees with the data of previous experiments with European robins (*Erithacus rubecula*). In this study, we report the results of experiments with garden warblers tested under a 1.403 MHz OMF with various amplitudes ( $\sim 0.4$ , 1,  $\sim 2.4$ , 7 and 20 nT). We found that the ability of garden warblers to orient in round arenas using the magnetic compass could be disrupted by a very weak oscillating field, such as an approximate 2.4, 7 and 20 nT OMF, but not by an OMF with an approximate 0.4 nT amplitude. The results of the present study indicate that the sensitivity threshold of the magnetic compass to the OMF lies around 2-3 nT, while in experiments with European robins the birds were disoriented in a 15 nT OMF but could choose the appropriate migratory direction when a 5 nT OMF was added to the stationary magnetic field. The radical-pair model, one of the mainstream theories of avian magnetoreception, cannot explain the sensitivity to such a low-intensity OMF, and therefore, it needs further refinement. <https://doi.org/10.1098/rsif.2017.0364>

Pandey, N., Giri, S., Das, S., & Upadhyaya, P. 2017 Radiofrequency radiation (900 MHz)-induced DNA damage and cell cycle arrest in testicular germ cells in swiss albino mice *Toxicology and Industrial Health*, 33(4), 373–384. Even though there are contradictory reports regarding the cellular and molecular changes induced by mobile phone emitted radiofrequency radiation (RFR), the possibility of any biological effect cannot be ruled out. In view of a widespread and extensive use of mobile phones, this study evaluates alterations in male germ cell transformation kinetics following RFR exposure and after recovery. Swiss albino mice were exposed to RFR (900 MHz) for 4 h and 8 h duration per day for 35 days. One group of animals was terminated after the exposure period, while others were kept for an additional 35 days post-exposure. RFR exposure caused depolarization of mitochondrial membranes resulting in destabilized cellular redox homeostasis. Statistically significant increases in the damage index in germ cells and sperm head defects were noted in RFR-exposed animals. Flow cytometric estimation of germ cell subtypes in mice testis revealed 2.5-fold increases in spermatogonial populations with significant decreases in spermatids. Almost fourfold reduction in spermatogonia to spermatid turnover (1C:2C) and three times reduction in primary spermatocyte to spermatid turnover (1C:4C) was found indicating arrest in the premeiotic stage of spermatogenesis, which resulted in loss of post-meiotic germ cells apparent from testis histology and low sperm count in RFR-exposed animals. Histological alterations such as sloughing of immature germ cells into the seminiferous tubule lumen, epithelium depletion and maturation arrest were also observed. However, all these changes showed recovery to varied degrees following the post-exposure period indicating that the adverse effects of RFR on mice germ cells are detrimental but reversible. To conclude, RFR exposure-induced oxidative stress causes DNA damage in germ cells, which alters cell cycle progression leading to low sperm count in mice. <https://doi.org/10.1177/0748233716671206>

Poh, A. H., Moghavvemi, M., Shafiei, M. M., Leong, C. S., Lau, Y. L., Adikan, F. R. M., ... Hassan, M. A. A. 2017 Effects of low-powered RF sweep between 0.01-20 GHz on female *Aedes Aegypti* mosquitoes: A collective behaviour analysis. *PLOS ONE*, 12(6), e0178766. There are many products claiming to be an electronic solution towards repelling mosquitoes. Several reviews were published in debunking these claims. However, there is a lack of a systematic study on effects of electromagnetic (EM) or more specifically, radio frequency (RF) waves against mosquitoes due to the conclusions made in those years. Therefore, we attempt to establish a fundamental study on female *Aedes Aegypti* (Linnaeus) mosquitoes by quantifying the collective behavior of the mosquitoes against a continuous stream of low-powered RF signals via a broadband horn antenna using image processing methods. By examining the average lateral and vertical positions of the mosquitoes versus frequency and time, the data shows negligible consistency in the reactions of the mosquitoes toward the different frequencies ranging from 10 to 20,000.00 MHz, with a step of 10 MHz. This was done by examining 33 hours of spatiotemporal data, which was divided into three sessions. All three sessions showed totally different convolutions in the positions in arbitrary units based on the raster scan of the image processing output. Several frequencies apparently showed up to 0.2–70% shift in both lateral and vertical components along the spectrum, without repeatability for all three sessions. This study contributes to the following: A pilot study for establishing the collective effects of RF against mosquitoes, open-source use, and finally a low-cost and easily adaptable platform for the study of EM effects against any insects. <https://doi.org/10.1371/journal.pone.0178766>

Prasad, M., Kathuria, P., Nair, P., Kumar, A., & Prasad, K. 2017 Mobile phone use and risk of brain tumours: a systematic review of association between study quality, source of funding, and research outcomes. *Neurological Sciences: Official Journal of the Italian Neurological Society and of the Italian Society of Clinical Neurophysiology*. Mobile phones emit electromagnetic radiations that are classified as possibly carcinogenic to humans. Evidence for increased risk for brain tumours accumulated in RF-EMR References 2017 to mid-2022

parallel by epidemiologic investigations remains controversial. This paper aims to investigate whether methodological quality of studies and source of funding can explain the variation in results. PubMed and Cochrane CENTRAL searches were conducted from 1966 to December 2016, which was supplemented with relevant articles identified in the references. Twenty-two case control studies were included for systematic review. Meta-analysis of 14 case-control studies showed practically no increase in risk of brain tumour [OR 1.03 (95% CI 0.92-1.14)]. However, for mobile phone use of 10 years or longer (or >1640 h), the overall result of the meta-analysis showed a significant 1.33 times increase in risk. The summary estimate of government funded as well as phone industry funded studies showed 1.07 times increase in odds which was not significant, while mixed funded studies did not show any increase in risk of brain tumour. Metaregression analysis indicated that the association was significantly associated with methodological study quality ( $p < 0.019$ , 95% CI 0.009-0.09). Relationship between source of funding and log OR for each study was not statistically significant ( $p < 0.32$ , 95% CI 0.036-0.010). We found evidence linking mobile phone use and risk of brain tumours especially in long-term users ( $\geq 10$  years). Studies with higher quality showed a trend towards high risk of brain tumour, while lower quality showed a trend towards lower risk/protection. <https://doi.org/10.1007/s10072-017-2850-8>

Qureshi, S. T., Memon, S. A., Abassi, A. R., Sial, M. A., & Bughio, F. A. 2017 Radiofrequency radiations induced genotoxic and carcinogenic effects on chickpea (*Cicer arietinum* L.) root tip cells. *Saudi Journal of Biological Sciences*, 24(4), 883–891. Present study was under taken to predict the possible DNA damages (genotoxicity) and carcinogenicity caused by radiofrequency radiations (RF) to living tissue. Dry seeds of chickpea were treated with GSM cell phone (900MHz) and laptop (3.31GHz) as RF source for 24 and 48h. Untreated seeds were used as (0h) negative control and Gamma rays (250 Gray) as positive control. Plant chromosomal aberration assay was used as genotoxicity marker. All the treatment of RF inhibits seed germination percentage. 48h laptop treatment has the most negative effect as compared to untreated control. A decrease was observed in mitotic index (M.I) and increase in abnormality index (A.I) with the increase in exposure duration and frequency in (Hz). Cell membrane damages were also observed only in 48h exposure of cell phone and laptop (RF). Maximum nuclear membrane damages and ghost cells were again recorded in 48h exposure of cell phone and laptop. The radiofrequency radiations (900MHz and 3.31GHz) are only genotoxic as they induce micronuclei, bi-nuclei, multi-nuclei and scattered nuclei but could be carcinogenic as 48h incubation of RF induced fragmentation and ghost cells. Therefore cell phones and laptop should not be used unnecessarily to avoid possible genotoxic and carcinogenic effects. <https://doi.org/10.1016/j.sjbs.2016.02.011>

Redmayne, M. 2017 Where's Your Phone? A Survey of Where Women Aged 15-40 Carry Their Smartphone and Related Risk Perception: A Survey and Pilot Study *PLOS ONE*, 12(1), e0167996. Smartphones are now owned by most young adults in many countries. Installed applications regularly update while the phone is in standby. If it is kept near the body, this can lead to considerably higher exposure to radiofrequency electromagnetic radiation than occurred without internet access. Very little is known about current smartphone carrying habits of young women. This survey used an online questionnaire to ask about smartphone location under several circumstances to inform the power calculation for a women's health study. They were also asked about risk perceptions. Data was analysed using Pearson chi square. Three age categories were made: 15–20, 21–30, 31–40. Smartphones were generally kept on standby (96% by day, 83% at night). Of all participants, in the last week the most common locations of the phone when not in use or during passive use was off-body (86%), in the hand (58%), a skirt/trouser pocket (57%), or against the breast (15%). Pocket and near-the-breast storage were significant by age ( $\chi^2_{215.04}$ ,  $p = 0.001$  and  $\chi^2_{210.96}$ ,  $p = 0.04$ , respectively), both positively influenced by the youngest group. The same influence lay in the association between holding the phone ( $\chi^2_{211.082}$ ,  $p = 0.004$ ) and pocket-storage ( $\chi^2_{219.971}$ ,  $p < 0.001$ ) during passive use. For calls, 36.5% solely used the phone against the head. More than half kept the phone 20–50 cms from their head at night (53%), while 13% kept it closer than 20 cms. Many (36%) thought RF-EMR exposure was related to health problems while 16% did not. There was no relationship between thinking RF-EMR exposure causes health problems in general and carrying the phone against the upper or lower body ( $p = 0.69$  and  $p = 0.212$ , respectively). However, calls with the phone against the head were positively related to perception of health risk ( $\chi^2_{6.695}$ ,  $p = 0.035$ ). Our findings can be used in the power calculation for a case-control study. <https://doi.org/10.1371/journal.pone.0167996>

Sannino, A., Zeni, O., Romeo, S., Massa, R., & Scarfi, M. R. 2017 Adverse and beneficial effects in Chinese hamster lung fibroblast cells following radiofrequency exposure *Bioelectromagnetics* 38(4):245-254 In this study, the effect of radiofrequency (RF) exposure to 1950 MHz, Universal Mobile Telecommunication System signal, was investigated in Chinese hamster lung fibroblast cell line (V79). Genotoxic and cytotoxic effects of 20-h exposure at specific absorption rate (SAR) values from 0.15 W/kg to 1.25 W/kg were measured by means of cytokinesis-block micronucleus (MN) assay. Exposure was carried out blinded under strictly controlled conditions of dosimetry and temperature. The effect of RF exposure alone at four SAR values was tested, that is, 0.15, 0.3, 0.6, and 1.25 W/kg. A statistically significant increase in MN frequency was found in cultures exposed to 0.15 and 0.3 W/kg ( $P < 0.05$ ) compared to sham-exposed ones, in the absence of cytotoxicity. SAR values of 0.6 and 1.25 W/kg did not exert any effect. Moreover, to evaluate the ability of RF to exert protective effects with respect to a chemical mutagen, cell cultures were also pre-exposed for 20 h at 0.3 or 1.25 W/kg, and then treated with 500 ng/ml of mitomycin-C (MMC). A significant reduction in the frequency of MN was detected in cultures pre-exposed to 1.25 W/kg compared to cultures treated with MMC alone ( $P < 0.05$ ), indicating induction of adaptive response. Such a decrease was not induced by pre-exposure

at 0.3 W/kg SAR. Taken together, our results indicated that V79 is a sensitive cell model to evidence either adverse or beneficial effects of RF exposure, depending on experimental conditions applied.  
<https://doi.org/10.1002/bem.22034>

Sato, Y., Kojimahara, N., & Yamaguchi, N. 2017 Analysis of mobile phone use among young patients with brain tumors in Japan. *Bioelectromagnetics* 38(5):249-355 The purpose of this study was to clarify ownership and usage of mobile phones among young patients with brain tumors in Japan. The subjects of this study were patients with brain tumors diagnosed between 2006 and 2010 who were between the ages of 6 and 18 years. The target population for the analysis was 82 patients. Patients were divided into two groups: 16 patients who were mobile phone owners 1 year before diagnosis, and 66 patients who did not own mobile phones (non-owners). Using data on the mobile phone ownership rate obtained from three general-population surveys, we calculated the expected number of mobile phone owners. The three age-adjusted standardized ownership ratios were 0.83 (95% confidence interval [CI]: 0.56-1.22), 0.51 (95% CI: 0.24-1.04), and 0.75 (95% CI: 0.42-1.32). The mobile phone ownership prevalence among the young Japanese patients with brain tumors in the current study does not differ from available estimates for the general population of corresponding age. However, since the use of mobile phones among children is increasing annually, investigations into the health effects of mobile phone use among children should continue.  
<https://doi.org/10.1002/bem.22047>

Senavirathna, M. D. H. J., & Asaeda, T. 2017 Microwaves affect *Myriophyllum aquaticum* plants differently depending on the wave polarization. *Biologia Plantarum*, 61(2), 378–384. Previous studies on microwave exposure on plants have revealed variations in sensitivity of plants to different microwave frequencies, exposure durations, and power intensities. However, the effects of different polarizations of microwaves on plants have not been studied. Therefore, we investigated the effect of horizontally and vertically polarized 2 GHz continuous microwaves on *Myriophyllum aquaticum* plants at 1.8 W m<sup>-2</sup> power density. The electric potential variation along the vascular tissues were investigated for 1.5 h and growth parameters, pigmentation, and H<sub>2</sub>O<sub>2</sub> formation were studied during 48 h microwave exposure. Exposure to horizontally polarized microwaves, decreased standard deviation of electric potential variation and increased H<sub>2</sub>O<sub>2</sub> content significantly. Vertically polarized microwaves increased the standard deviation of electric potential variation and photosynthetic pigments significantly. However, none of the polarizations altered growth parameters (shoot length, stem diameter, and internodal length). Thermographic images taken for 1 h continuous microwave exposure did not indicate alteration in the temperature of the plants for both vertical and horizontal polarities. <https://doi.org/10.1007/s10535-016-0660-0>

Sepehrimanesh, M., Kazemipour, N., Saeb, M., Nazifi, S., & Davis, D. L. 2017 Proteomic analysis of continuous 900-MHz radiofrequency electromagnetic field exposure in testicular tissue: a rat model of human cell phone exposure. *Environmental Science and Pollution Research International*, 24(15), 13666–13673. Although cell phones have been used worldwide, some adverse and toxic effects were reported for this communication technology apparatus. To analyze in vivo effects of exposure to radiofrequency-electromagnetic field (RF-EMF) on protein expression in rat testicular proteome, 20 Sprague-Dawley rats were exposed to 900 MHz RF-EMF for 0, 1, 2, or 4 h/day for 30 consecutive days. Protein content of rat testes was separated by high-resolution two-dimensional electrophoresis using immobilized pH gradient (pI 4-7, 7 cm) and 12% acrylamide and identified by MALDI-TOF/TOF-MS. Two protein spots were found differentially overexpressed ( $P < 0.05$ ) in intensity and volume with induction factors 1.7 times greater after RF-EMF exposure. After 4 h of daily exposure for 30 consecutive days, ATP synthase beta subunit (ASBS) and hypoxia up-regulated protein 1 precursor (HYOU1) were found to be significantly up-regulated. These proteins affect signaling pathways in rat testes and spermatogenesis and play a critical role in protein folding and secretion in the endoplasmic reticulum. Our results indicate that exposure to RF-EMF produces increases in testicular proteins in adults that are related to carcinogenic risk and reproductive damage. In light of the widespread practice of men carrying phones in their pockets near their gonads, where exposures can exceed as-tested guidelines, further study of these effects should be a high priority.  
<https://doi.org/10.1007/s11356-017-8882-z>

Shahin, S., Singh, S. P., & Chaturvedi, C. M. 2017 Mobile phone (1800MHz) radiation impairs female reproduction in mice, *Mus musculus*, through stress induced inhibition of ovarian and uterine activity. *Reproductive Toxicology* (Elmsford, N.Y.), 73, 41–60.

Present study investigated the long-term effects of mobile phone (1800MHz) radiation in stand-by, dialing and receiving modes on the female reproductive function (ovarian and uterine histo-architecture, and steroidogenesis) and stress responses (oxidative and nitrosative stress). We observed that mobile phone radiation induces significant elevation in ROS, NO, lipid peroxidation, total carbonyl content and serum corticosterone coupled with significant decrease in antioxidant enzymes in hypothalamus, ovary and uterus of mice. Compared to control group, exposed mice exhibited reduced number of developing and mature follicles as well as corpus lutea. Significantly decreased serum levels of pituitary gonadotrophins (LH, FSH), sex steroids (E<sub>2</sub> and P<sub>4</sub>) and expression of SF-1, StAR, P-450<sub>scc</sub>, 3 $\beta$ -HSD, 17 $\beta$ -HSD, cytochrome P-450 aromatase, ER- $\alpha$  and ER- $\beta$  were observed in all the exposed groups of mice, compared to control. These findings suggest that mobile phone radiation induces oxidative and nitrosative stress, which affects the reproductive performance of female mice. <https://doi.org/10.1016/j.reprotox.2017.08.001>

Sharma, A., Kesari, K. K., Saxena, V. K., & Sisodia, R. 2017 Ten gigahertz microwave radiation impairs spatial memory, enzymes activity, and histopathology of developing mice brain. *Molecular and Cellular Biochemistry*. For decades, there has been an increasing concern about the potential hazards of non-ionizing electromagnetic fields that are present in the environment and alarming as a major pollutant or electro-pollutant for health risk and neuronal diseases. Therefore, the objective of the present study was to explore the effects of 10 GHz microwave radiation on developing mice brain. Two weeks old mice were selected and divided into two groups (i) sham-exposed and (ii) microwave-exposed groups. Animals were exposed for 2 h/day for 15 consecutive days. After the completion of exposure, within an hour, half of the animals were autopsied immediately and others were allowed to attain 6 weeks of age for the follow-up study. Thereafter results were recorded in terms of various biochemical, behavioral, and histopathological parameters. Body weight result showed significant changes immediately after treatment, whereas non-significant changes were observed in mice attaining 6 weeks of age. Several other endpoints like brain weight, lipid peroxidation, glutathione, protein, catalase, and superoxide dismutase were also found significantly ( $p < 0.05$ ) altered in mice whole brain. These significant differences were found immediately after exposure and also in follow-up on attaining 6 weeks of age in microwave exposure group. Moreover, statistically significant ( $p < 0.001$ ) effect was investigated in spatial memory of the animals, in learning to locate the position of platform in Morris water maze test. Although in probe trial test, sham-exposed animals spent more time in searching for platform into the target quadrant than in opposite or other quadrants. Significant alteration in histopathological parameters (qualitative and quantitative) was also observed in CA1 region of the hippocampus, cerebral cortex, and ansiform lobule of cerebellum. Results from the present study concludes that the brain of 2 weeks aged mice was very sensitive to microwave exposure as observed immediately after exposure and during follow-up study at 6 weeks of age.  
<https://doi.org/10.1007/s11010-017-3051-8>

Smith, C. J., & Perfetti, T. A. 2017 Tumor site concordance and genetic toxicology test correlations in NTP 2-year feed studies. *Toxicology Research and Application*, 1, 2397847317739942. This study presents an analysis of species, sex concordance in tumorigenicity among National Toxicology Program (NTP) chemicals tested for carcinogenicity by feed. It includes mutagenicity and other genetic toxicology test results, as well as Log P values. A total of 213 chemicals were tested in 212 2-year studies by exposing F334/N rats and B6C3F1 mice in their feed. Twenty-two of the 213 chemicals tested were clearly neoplastic in male and female rats and mice. Thirteen of these 22 chemicals were positive in at least one Ames test representing a prediction accuracy of 59.1%. Seventy-six of 213 chemicals tested were not neoplastic in either rodent species. Of the 22 ubiquitously neoplastic chemicals, 14 were concordant for developing tumors at the same anatomical site both across species and across sex within species. Of the 22 ubiquitously neoplastic chemicals, none were concordant for developing tumors at the same anatomical site across species, but not across sex within species. The neoplastic response to chemicals administered in feed displays more concordance within either male or female rats, or male and female mice, than between male rats and male mice, or female rats and female mice. In the NTP feed studies, negative Ames test results are more predictive of neoplastic responses than positive Ames test results. Log P values for the chemicals that produced tumors in male and female rats and mice were compared to chemicals that did not produce tumors. A statistical comparison between these Log P values showed no relationship between Log P values and neoplasticity.  
<https://doi.org/10.1177/2397847317739942>

Solek, P., Majchrowicz, L., Bloniarz, D., Krotoszynska, E., & Koziorowski, M. 2017 Pulsed or continuous electromagnetic field induce p53/p21-mediated apoptotic signaling pathway in mouse spermatogenic cells in vitro and thus may affect male fertility. *Toxicology*, 382, 84–92. The impact of electromagnetic field (EMF) on the human health and surrounding environment is a common topic investigated over the years. A significant increase in the electromagnetic field concentration arouses public concern about the long-term effects of EMF on living organisms associated with many aspects. In the present study, we investigated the effects of pulsed and continuous electromagnetic field (PEMF/CEMF) on mouse spermatogenic cell lines (GC-1 spg and GC-2 spd) in terms of cellular and biochemical features in vitro. We evaluated the effect of EMF on mitochondrial metabolism, morphology, proliferation rate, viability, cell cycle progression, oxidative stress balance and regulatory proteins. Our results strongly suggest that EMF induces oxidative and nitrosative stress-mediated DNA damage, resulting in p53/p21-dependent cell cycle arrest and apoptosis. Therefore, spermatogenic cells due to the lack of antioxidant enzymes undergo oxidative and nitrosative stress-mediated cytotoxic and genotoxic events, which contribute to infertility by reduction in healthy sperm cells pool. In conclusion, electromagnetic field present in surrounding environment impairs male fertility by inducing p53/p21-mediated cell cycle arrest and apoptosis. <https://doi.org/10.1016/j.tox.2017.03.015>

Sun, Y., Zong, L., Gao, Z., Zhu, S., Tong, J., & Cao, Y. 2017 Mitochondrial DNA damage and oxidative damage in HL-60 cells exposed to 900MHz radiofrequency fields. *Mutation Research*, 797–799, 7–14. HL-60 cells, derived from human promyelocytic leukemia, were exposed to continuous wave 900MHz radiofrequency fields (RF) at 120μW/cm(2) power intensity for 4h/day for 5 consecutive days to examine whether such exposure is capable damaging the mitochondrial DNA (mtDNA) mediated through the production of reactive oxygen species (ROS). In addition, the effect of RF exposure was examined on 8-

hydroxy-2'-dexoyguanosine (8-OHdG) which is a biomarker for oxidative damage and on the mitochondrial synthesis of adenosine triphosphate (ATP) which is the energy required for cellular functions. The results indicated a significant increase in ROS and significant decreases in mitochondrial transcription factor A, mtDNA polymerase gamma, mtDNA transcripts and mtDNA copy number in RF-exposed cells compared with those in sham-exposed control cells. In addition, there was a significant increase in 8-OHdG and a significant decrease in ATP in RF-exposed cells. The response in positive control cells exposed to gamma radiation (GR, which is also known to induce ROS) was similar to those in RF-exposed cells. Thus, the overall data indicated that RF exposure was capable of inducing mtDNA damage mediated through ROS pathway which also induced oxidative damage. Prior-treatment of RF- and GR-exposed the cells with melatonin, a well-known free radical scavenger, reversed the effects observed in RF-exposed cells. <https://doi.org/10.1016/j.mrfmmm.2017.03.001>

Suzuki, S., Okutsu, M., Suganuma, R., Komiya, H., Nakatani-Enomoto, S., Kobayashi, S., ... Fujimori, K. 2017 Influence of radiofrequency-electromagnetic waves from 3rd-generation cellular phones on fertilization and embryo development in mice *Bioelectromagnetics*, 38(6), 466–473. The purpose of this study was to evaluate the effects of 3rd-generation (3G) cellular phone radiofrequency-electromagnetic wave (RF-EMW) exposure on fertilization and embryogenesis in mice. Oocytes and spermatozoa were exposed to 3G cellular phone RF-EMWs, 1.95 GHz wideband code division multiple access, at a specific absorption rate of 2 mW/g for 60 min, or to sham exposure. After RF-EMW exposure, in vitro fertilization and intracytoplasmic sperm injection were performed. Rates of fertilization, embryogenesis (8-cell embryo, blastocyst), and chromosome aberration were compared between the combined spermatozoa and oocyte groups: both exposed, both non-exposed, one exposed, and the other non-exposed. Rates of fertilization, embryogenesis, and blastocyst formation did not change significantly across the four groups. Considering that the degree of exposure in the present study was  $\geq 100$  times greater than daily exposure of human spermatozoa and even greater than daily exposure of oocytes, the present results indicate safety of RF-EMW exposure in humans. <https://doi.org/10.1002/bem.22063>

Taheri, M., Mortazavi, S. M. J., Moradi, M., Mansouri, S., Hatam, G. R., & Nouri, F. 2017 Evaluation of the Effect of Radiofrequency Radiation Emitted From Wi-Fi Router and Mobile Phone Simulator on the Antibacterial Susceptibility of Pathogenic Bacteria *Listeria monocytogenes* and *Escherichia coli*. *Dose-Response: A Publication of International Hormesis Society*, 15(1), 1559325816688527. Mobile phones and Wi-Fi radiofrequency radiation are among the main sources of the exposure of the general population to radiofrequency electromagnetic fields (RF-EMF). Previous studies have shown that exposure of microorganisms to RF-EMFs can be associated with a wide spectrum of changes ranged from the modified bacterial growth to the alterations of the pattern of antibiotic resistance. Our laboratory at the nonionizing department of the Ionizing and Non-ionizing Radiation Protection Research Center has performed experiments on the health effects of exposure to animal models and humans to different sources of electromagnetic fields such as cellular phones, mobile base stations, mobile phone jammers, laptop computers, radars, dentistry cavitrons, magnetic resonance imaging, and Helmholtz coils. On the other hand, we have previously studied different aspects of the challenging issue of the ionizing or nonionizing radiation-induced alterations in the susceptibility of microorganisms to antibiotics. In this study, we assessed if the exposure to 900 MHz GSM mobile phone radiation and 2.4 GHz radiofrequency radiation emitted from common Wi-Fi routers alters the susceptibility of microorganisms to different antibiotics. The pure cultures of *Listeria monocytogenes* and *Escherichia coli* were exposed to RF-EMFs generated either by a GSM 900 MHz mobile phone simulator and a common 2.4 GHz Wi-Fi router. It is also shown that exposure to RF-EMFs within a narrow level of irradiation (an exposure window) makes microorganisms resistant to antibiotics. This adaptive phenomenon and its potential threats to human health should be further investigated in future experiments. Altogether, the findings of this study showed that exposure to Wi-Fi and RF simulator radiation can significantly alter the inhibition zone diameters and growth rate for *L. monocytogenes* and *E. coli*. These findings may have implications for the management of serious infectious diseases. <https://doi.org/10.1177/1559325816688527>

Taheri, Mohammad, Roshanaei, G., Ghaffari, J., Rahimnejad, S., Khosroshahi, B. N., Aliabadi, M., & Eftekharian, M. M. 2017 The effect of Base Transceiver Station waves on some immunological and hematological factors in exposed persons *Human Antibodies*, 25(1–2), 31–37. BACKGROUND: Since the number of mobile subscribers has significantly increased in recent years, the installation and deployment of Base Transceiver Station (BTS) antennas sending and receiving signals has become common and inevitable in different regions. OBJECTIVE: In this study, we have tried to evaluate the effect of the waves on some immunological and hematological parameters in exposed individuals. In this study, the exposed and non-exposed individuals were used as the test and control groups, respectively. METHODS: The test group was healthy people who resided in the vicinity of the Base Transceiver Station (BTS) antenna and received the maximum of radiation. The control group was selected from the healthy individuals that were matched with the exposed group by age. They resided in a distance of Base Transceiver Station (BTS) antenna and received the minimum of radiation. After stating complete explanations and obtaining the consent, the venous blood samples were taken from them. Then, CBC and the level of cytokines including IL-4, IL-10 and interferon  $\gamma$  were performed on the samples and the results were analyzed by SPSS software. RESULTS: In the test group, the whole number of white blood cells, the level of hematocrit, percent of monocytes, eosinophils and basophils were significantly lower than the control group.

The number of red blood cells, their average volume and the mean concentration of hemoglobin were notably higher than the controls. There was not observed a significant difference between the two groups in hemoglobin, its mean concentration, platelet count, percent of lymphocytes and neutrophils as well as serum levels of cytokines IL-4, IL-10 and interferon  $\gamma$ .  
**CONCLUSIONS:** It seems that radiation of mobile phone antennas influenced the blood and immune systems, but further study should be done to exactly determine the targets. <https://doi.org/10.3233/HAB-160303>

Taye, R. R., Deka, M. K., & Rahman, A. 2017 Effect of electromagnetic radiation of cell phone tower on foraging behaviour of Asiatic honey bee, *Apis cerana* F. (Hymenoptera: Apidae). *Journal of Entomology and Zoology Studies*, 3. The effect of electromagnetic radiation (EMR) of cell phone tower on foraging behaviour of honey bee, *Apis cerana* F. was studied at Assam Agricultural University, Jorhat from December to May during 2012-13 and 2013-14 at an interval of 15 days. To quantify the effect of EMR, five treatments were placed at varying distance from the tower having different radiation level. The present study results revealed that the peak foraging behaviour of worker bees continues from March to May. The foraging behaviour of worker bees were observed maximum in colonies placed at 500m followed by 1000m, 300m and 200m and least at 100m distance from the tower. The results from the present investigation revealed that the *Apis cerana* colonies in close proximity to cell phones towers were most affected by the electromagnetic radiation emitted by the cell phone tower.<https://www.entomoljournal.com/archives/?year=2017&vol=5&issue=3&ArticleId=1986>

Topsakal, S., Ozmen, O., Cicek, E., & Comlekci, S. 2017 The ameliorative effect of gallic acid on pancreas lesions induced by 2.45 GHz electromagnetic radiation (Wi-Fi) in young rats. *Journal of Radiation Research and Applied Sciences*, 10(3), 233–240. The aim of this study was to investigate the effects of electromagnetic radiation (EMR) on the pancreas tissue of young rats and the ameliorative effect of Gallic acid (GA). Six-week-old, 48 male rats were equally divided into four groups: Sham group, EMR group (2.45 GHz), EMR (2.45 GHz)+GA group (30 mg/kg/daily) orally and GA group (30 mg/kg/daily). After 30 days, serum and pancreatic tissue samples were harvested for biochemical, histopathological and immunohistochemical analysis. Serum amylase, lipase, glucose, and tissue malondialdehyde, total oxidant status and oxidative stress index were increased, whereas total antioxidant status decreased in the EMR group. The histopathological examination of the pancreases indicated slight degenerative changes in some pancreatic endocrine and exocrine cells and slight inflammatory cell infiltrations in the EMR group. At the immunohistochemical examination, marked increase was observed in calcitonin gene related protein and Prostaglandin E2 expressions in pancreatic cells in this group. There were no changes in interleukin-6 expressions. GA ameliorated biochemical and pathological findings in the EMR+GA group. These findings clearly demonstrate that EMR can cause degenerative changes in both endocrine and exocrine pancreas cells in rats during the developmental period and GA has an ameliorative effect.<https://doi.org/10.1016/j.jrras.2017.04.009>

Türedi, S., Kerimoğlu, G., Mercantepe, T., & Odacı, E. 2017 Biochemical and pathological changes in the male rat kidney and bladder following exposure to continuous 900-MHz electromagnetic field on postnatal days 22-59 *International Journal of Radiation Biology*, 1–10. **PURPOSE:** To investigate the effect on male rat kidney and bladder tissues of exposure to 900-megahertz (MHz) electromagnetic field (EMF) applied on postnatal days 22-59, inclusive. **MATERIALS AND METHODS:** Twenty-four male Sprague Dawley rats, aged 21 days, were used. These were divided equally into one of three groups, control (CG), sham (SG) or EMF (EMFG). CG was not exposed to any procedure. SG rats were kept inside a cage, without being exposed to the effect of EMF, for 1 h a day on postnatal days 22-59, inclusive. EMFG rats were exposed to continuous 900-MHz EMF for 1 h a day under the same conditions as those for the SG rats. Rats were sacrificed on postnatal day 60, and the kidney and bladder tissues were removed. Tissues were stained with hematoxylin and eosin (H&E) and Masson trichrome for histomorphological evaluation. The TUNEL method was used to assess apoptosis. Transmission electron microscopy (TEM) was also used for the kidney tissue. Oxidant/antioxidant parameters were studied in terms of biochemical values. **RESULTS:** The findings showed that tissue malondialdehyde increased in EMFG compared to CG and SG in both kidney ( $p = 0.004$  and  $p = 0.004$ , respectively) and bladder tissue ( $p = 0.004$ ,  $p = 0.006$ , respectively), while catalase and glutathione levels decreased compared to CG ( $p = 0.004$ ;  $p = 0.004$ , respectively) and SG ( $p = 0.004$ ;  $p = 0.004$ , respectively). In the EMF group, pathologies such as dilatation and vacuolization in the distal and proximal tubules, degeneration in glomeruli and an increase in cells tending to apoptosis were observed in kidney tissue. In bladder tissue, degeneration in the transitional epithelium and stromal irregularity and an increase in cells tending to apoptosis were observed in EMFG. Additionally, EMFG samples exhibited glomerular capillary degeneration with capillary basement membranes under TEM. **CONCLUSIONS:** We conclude that continuous exposure to the effect of 900-MHz EMF for 1 h a day on postnatal days 22-59, inclusive, causes an increase in oxidative stress and various pathological changes in male rat kidney and bladder tissues. <https://doi.org/10.1080/09553002.2017.1350768>

Vargova B, Kurimsky J, Cimbala R, Kosterec M, Majlath I, Pipova N, ... Majlathova V. 2017 Ticks and radio-frequency signals: behavioural response of ticks (*Dermacentor reticulatus*) in a 900 MHz electromagnetic field. *Syst Appl Acarol*, 22(5), 683–693.

The electromagnetic field (EMF) is present in the environment throughout the world and encompasses both natural and human-made sources of electromagnetic fields. It has been shown that EMF influences a variety of biological systems, including the

RF-EMR References 2017 to mid-2022



behavioural responses of both vertebrates and invertebrates. As such, determining the effects of the EMF on the ecosystem in detail may be important for understanding the ecology and biology of organisms, particularly those, such as ticks, that are important in disease transmission. Our main goal was to determine if the tick, *Dermacentor reticulatus*, interacts with the EMF. An experimental behavioural test of tick sensitivity to radio frequency power radiation was performed under laboratory conditions. Tests were performed in an electromagnetic compatibility laboratory in a radio frequency electromagnetic field (RF-EMF) anechoic chamber. Ticks were irradiated using a Double-Ridged Waveguide Horn Antenna with 900 MHz RF-EMF. The applied radio-frequency power was tuned below the proposed limit for public exposure to mobile phone base stations. We found that exposure induces an immediate tick locomotor response manifested either in a previously unreported jerking movement of the whole body or in jerking of the first pair of legs. Overall, ticks exhibited significantly greater movement in the presence of the RF-EMF. Significant sex differences relative to RF-EMF exposure were observed in both response variables. In the presence of RF-EMF, body jerking by females was greater than in males and vice versa for leg jerks. This study represents the first experimental evidence of a behavioural response of *D. reticulatus* ticks to exposure to RF-EMF.  
<https://doi.org/10.11158/saa.22.5.7>

Vilić, M., Gajger, I. T., Tucak, P., Štambuk, A., Šrut, M., Klobučar, G., ... Tkalec, M. 2017 Effects of short-term exposure to mobile phone radiofrequency (900 MHz) on the oxidative response and genotoxicity in honey bee larvae. *Journal of Apicultural Research*, 56(4), 430–438. Exposure of different animal species to radiofrequency electromagnetic fields (RF-EMF) could cause various biological effects such as oxidative stress, genotoxic effects and dysfunction of the immune system. However, there are a lack of results on oxidative stress response and genotoxicity in the honey bee (*Apis mellifera*) after exposure to RF-EMF. This study was performed to investigate the effects of exposure to RF-EMF on the activity of catalase, superoxide dismutase, glutathione S-transferase, lipid peroxidation level and DNA damage in honey bee larvae. Honey bee larvae were exposed to RF-EMF at 900 MHz and field levels of 10, 23, 41 and 120 V m<sup>-1</sup> for 2 h. At a field level of 23 V m<sup>-1</sup> the effect of 80% AM 1 kHz sinusoidal and 217 Hz modulation was investigated as well. Catalase activity and the lipid peroxidation level decreased significantly in the honey bee larvae exposed to the unmodulated field at 10 V m<sup>-1</sup> compared to the control. Superoxide dismutase and glutathione S-transferase activity in the honey bee larvae exposed to unmodulated fields were not statistically different compared to the control. DNA damage increased significantly in honey bee larvae exposed to modulated (80% AM 1 kHz sinus) field at 23 V m<sup>-1</sup> compared to the control and all other exposure groups. These results suggest that RF-EMF effects in honey bee larvae appeared only after exposure to a certain EMF conditions. The increase of the field level did not cause a linear dose-response in any of the measured parameters. Modulated RF-EMF produced more negative effects than the corresponding unmodulated field. Although honey bees in nature would not be exposed to such high field levels as used in our experiments, our results show the need for further intensive research in all stages of honey bee development.  
<https://doi.org/10.1080/00218839.2017.1329798>

Wang, J., Su, H., Xie, W., & Yu, S. 2017 Mobile Phone Use and The Risk of Headache: A Systematic Review and Meta-analysis of Cross-sectional Studies. *Scientific Reports*, 7(1), 12595. Headache is increasingly being reported as a detrimental effect of mobile phone (MP) use. However, studies aimed to investigate the association between MP use and headache yielded conflicting results. To assess the consistency of the data on the topic, we performed a systematic review and meta-analysis of the available cross-sectional studies. Published literature from PubMed and other databases were retrieved and screened, and 7 cross-sectional studies were finally included in this meta-analysis. The pooled odds ratio (OR) and 95% confidence interval (CI) were calculated. We found that the risk of headache was increased by 38% in MP user compared with non-MP user (OR, 1.38; 95% CI, 1.18-1.61,  $p < 0.001$ ). Among MP users, the risk of headache was also increased in those who had longer daily call duration (2-15 min vs. <2 min: OR, 1.62; 95% CI, 1.34-1.98,  $p < 0.001$ ; >15 min vs. <2 min: OR, 2.50; 95% CI, 1.76-3.54,  $p < 0.001$ ) and higher daily call frequency (2-4 calls vs. <2 calls: OR, 1.37; 95% CI, 1.07-1.76,  $p < 0.001$ ; >4 calls vs. <2 calls: OR, 2.52; 95% CI, 1.78-3.58,  $p < 0.001$ ). Our data indicate that MP use is significantly associated with headache, further epidemiologic and experimental studies are required to affirm and understand this association. <https://doi.org/10.1038/s41598-017-12802-9>

Wang, K., Lu, J.-M., Xing, Z.-H., Zhao, Q.-R., Hu, L.-Q., Xue, L., ... Mei, Y.-A. 2017 Effect of 1.8 GHz radiofrequency electromagnetic radiation on novel object associative recognition memory in mice. *Scientific Reports*, 7, 44521. Mounting evidence suggests that exposure to radiofrequency electromagnetic radiation (RF-EMR) can influence learning and memory in rodents. In this study, we examined the effects of single exposure to 1.8 GHz RF-EMR for 30 min on subsequent recognition memory in mice, using the novel object recognition task (NORT). RF-EMR exposure at an intensity of >2.2 W/kg specific absorption rate (SAR) power density induced a significant density-dependent increase in NORT index with no corresponding changes in spontaneous locomotor activity. RF-EMR exposure increased dendritic-spine density and length in hippocampal and prefrontal cortical neurons, as shown by Golgi staining. Whole-cell recordings in acute hippocampal and medial prefrontal cortical slices showed that RF-EMR exposure significantly altered the resting membrane potential and action potential frequency, and reduced the action potential half-width, threshold, and onset delay in pyramidal neurons. These results demonstrate that exposure to 1.8 GHz RF-EMR for 30 min can significantly increase recognition memory in mice, and can change dendritic-spine

morphology and neuronal excitability in the hippocampus and prefrontal cortex. The SAR in this study (3.3 W/kg) was outside the range encountered in normal daily life, and its relevance as a potential therapeutic approach for disorders associated with recognition memory deficits remains to be clarified. <https://doi.org/10.1038/srep44521>

Ward, A. F., Duke, K., Gneezy, A., & Bos, M. W. 2017 Brain Drain: The Mere Presence of One's Own Smartphone Reduces Available Cognitive Capacity. *Journal of the Association for Consumer Research*, 2(2), 140–154. Our smartphones enable—and encourage—constant connection to information, entertainment, and each other. They put the world at our fingertips, and rarely leave our sides. Although these devices have immense potential to improve welfare, their persistent presence may come at a cognitive cost. In this research, we test the “brain drain” hypothesis that the mere presence of one's own smartphone may occupy limited-capacity cognitive resources, thereby leaving fewer resources available for other tasks and undercutting cognitive performance. Results from two experiments indicate that even when people are successful at maintaining sustained attention—as when avoiding the temptation to check their phones—the mere presence of these devices reduces available cognitive capacity. Moreover, these cognitive costs are highest for those highest in smartphone dependence. We conclude by discussing the practical implications of this smartphone-induced brain drain for consumer decision-making and consumer welfare. <https://doi.org/10.1086/691462>

Wdowiak, A., Mazurek, P. A., Wdowiak, A., & Bojar, I. 2017 Effect of electromagnetic waves on human reproduction. *Annals of Agricultural and Environmental Medicine: AAEM*, 24(1), 13–18. Electromagnetic radiation (EMR) emitting from the natural environment, as well as from the use of industrial and everyday appliances, constantly influence the human body. The effect of this type of energy on living tissues may exert various effects on their functioning, although the mechanisms conditioning this phenomenon have not been fully explained. It may be expected that the interactions between electromagnetic radiation and the living organism would depend on the amount and parameters of the transmitted energy and type of tissue exposed. Electromagnetic waves exert an influence on human reproduction by affecting the male and female reproductive systems, the developing embryo, and subsequently, the foetus. Knowledge concerning this problem is still being expanded; however, all the conditionings of human reproduction still remain unknown. The study presents the current state of knowledge concerning the problem, based on the latest scientific reports. <https://doi.org/10.5604/12321966.1228394>

Woelders, H., de Wit, A., Lourens, A., Stockhofe, N., Engel, B., Hulsege, I., ... Zwamborn, P. 2017 Study of potential health effects of electromagnetic fields of telephony and Wi-Fi, using chicken embryo development as animal model. *Bioelectromagnetics*. The objective of this study is to investigate possible biological effects of radiofrequency electromagnetic fields (RF-EMF) as used in modern wireless telecommunication in a well-controlled experimental environment using chicken embryo development as animal model. Chicken eggs were incubated under continuous experimental exposure to GSM (1.8 GHz), DECT (1.88 GHz), UMTS (2.1 GHz), and WLAN (5.6 GHz) radiation, with the appropriate modulation protocol, using a homogeneous field distribution at a field strength of approximately 3 V/m, representing the maximum field level in a normal living environment. Radiation-shielded exposure units/egg incubators were operating in parallel for exposed and control eggs in a climatized homogeneous environment, using 450 eggs per treatment in three successive rounds per treatment. Dosimetry of the exposure (field characteristics and specific absorption rate) were studied. Biological parameters studied included embryo death during incubation, hatching percentage, and various morphological and histological parameters of embryos and chicks and their organs, and gene expression profiles of embryos on day 7 and day 18 of incubation by microarray and qPCR. No conclusive evidence was found for induced embryonic mortality or malformations by exposure to the used EMFs, or for effects on the other measured parameters. Estimated differences between treatment groups were always small and the effect of treatment was not significant. In a statistical model that ignored possible interaction between rounds and exposure units, some of the many pairwise comparisons of exposed versus control had P-values lower than 0.05, but were not significant after correction for multiple testing. <https://doi.org/10.1002/bem.22026>

Yilmaz, A., Tumkaya, L., Akyildiz, K., Kalkan, Y., Bodur, A. F., Sargin, F., ... Yazici, Z. A. 2017 Lasting hepatotoxic effects of prenatal mobile phone exposure. *The Journal of Maternal-Fetal & Neonatal Medicine: The Official Journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstetricians*, 30(11), 1355–1359. OBJECTIVE: In this study, the livers of rats born to mothers exposed to electromagnetic field (EMF) were examined 60 days postpartum for biochemical and histopathological changes. METHODS: Pregnant rats were exposed to radiation (900 MHz EMF, 24 h/day for 20 days) using a digital signal generator by placing the device centrally under the cage, which formed the study (EMF) group, while untreated matching rats served as controls. Livers and blood were obtained from litters (seven males and seven females) of both groups 60 days after birth, which were used for biochemical and histopathological analyses. RESULTS: There was a significant increase in the levels of malondialdehyde (MDA) ( $p < 0.05$ ) that was accompanied by a significant fall in glutathione (GSH) ( $p < 0.01$ ) in the liver. The serum levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were significantly increased ( $p < 0.05$ ). Histopathologically, the liver sections of the EMF group showed intense degeneration in hepatocytes with cytoplasmic eosinophilic structures, pyknotic nuclei and fibrosis.

**CONCLUSION:** We demonstrate that the intrauterine harmful effects of EMF on the livers of rats persist into adulthood.  
<https://doi.org/10.1080/14767058.2016.1214124>

Yorgancilar, E., Dasdag, S., Akdag, M. Z., Akkus, Z., Akdag, M., & Topcu, I. 2017 Does all-day and long-term exposure to radiofrequency radiation emitted from Wi-Fi affect hearing? *Biotechnology & Biotechnological Equipment*, 31(6), 1204–1209. We investigated the long-term effects of radiofrequency radiation (RFR) emitted from Wi-Fi systems on hearing. Sixteen Wistar albino rats were divided equally into two groups: sham control and exposure groups. The rats in the experimental group were exposed to 2.4 GHz RFR emitted from a Wi-Fi generator for 24 h/day for one year. The same procedure was applied to the rats in the sham group, except that the Wi-Fi generator was turned off. All groups were kept in Faraday cages during the 12 months to eliminate external electromagnetic fields. The distance between the Wi-Fi generator antenna and the exposure cages was 50 cm. Pre-exposure distortion product otoacoustic emissions (DPOAE) of all rats were measured at the beginning, 6th and 12th months of the study. The DPOAE values of the sham, baseline and exposure groups were compared statistically. For the 6000 Hz hearing frequency, the DPOAE values in the exposure group were lower than those in the sham group ( $p < 0.05$ ). Similarly, the 6000 Hz hearing frequency values obtained at the end of the 12th month were also lower than the baseline and 6-month values in the exposure group ( $p < 0.05$ ). In contrast, the DPOAE values at the 6th and 12th months of exposure for the 2000 Hz hearing frequency were higher than the baseline value ( $p < 0.05$ ). These results indicated that 12 months of RFR (24 h/day) at 50 cm from a 2.4 GHz Wi-Fi source can affect hearing. However, further studies are necessary.  
<https://doi.org/10.1080/13102818.2017.1373033>

Zhang, J., Sumich, A., & Wang, G. Y. 2017 Acute effects of radiofrequency electromagnetic field emitted by mobile phone on brain function. *Bioelectromagnetics*, 38(5), 329–338. Due to its attributes, characteristics, and technological resources, the mobile phone (MP) has become one of the most commonly used communication devices. Historically, ample evidence has ruled out the substantial short-term impact of radiofrequency electromagnetic field (RF-EMF) emitted by MP on human cognitive performance. However, more recent evidence suggests potential harmful effects associated with MP EMF exposure. The aim of this review is to readdress the question of whether the effect of MP EMF exposure on brain function should be reopened. We strengthen our argument focusing on recent neuroimaging and electroencephalography studies, in order to present a more specific analysis of effects of MP EMF exposure on neurocognitive function. Several studies indicate an increase in cortical excitability and/or efficiency with EMF exposure, which appears to be more prominent in fronto-temporal regions and has been associated with faster reaction time. Cortical excitability might also underpin disruption to sleep. However, several inconsistent findings exist, and conclusions regarding adverse effects of EMF exposure are currently limited. It also should be noted that the crucial scientific question of the effect of longer-term MP EMF exposure on brain function remains unanswered and essentially unaddressed.  
<https://doi.org/10.1002/bem.22052>

Zhao, L., Li, J., Hao, Y. H., Gao, Y. B., Wang, S. M., Zhang, J., ... Peng, R. Y. 2017 Microwave-induced Apoptosis and Cytotoxicity of NK Cells through ERK1/2 Signaling. *Biomedical and Environmental Sciences: BES*, 30(5), 323–332. **OBJECTIVE:** To investigate microwave-induced morphological and functional injury of natural killer (NK) cells and uncover their mechanisms. **METHODS:** NK-92 cells were exposed to 10, 30, and 50 mW/cm<sup>2</sup> microwaves for 5 min. Ultrastructural changes, cellular apoptosis and cell cycle regulation were detected at 1 h and 24 h after exposure. Cytotoxic activity was assayed at 1 h after exposure, while perforin and NKG2D expression were detected at 1 h, 6 h, and 12 h after exposure. To clarify the mechanisms, phosphorylated ERK (p-ERK) was detected at 1 h after exposure. Moreover, microwave-induced cellular apoptosis and cell cycle regulation were analyzed after blockade of ERK signaling by using U0126. **RESULTS:** Microwave-induced morphological and ultrastructural injury, dose-dependent apoptosis ( $P < 0.001$ ) and cell cycle arrest ( $P < 0.001$ ) were detected at 1 h after microwave exposure. Moreover, significant apoptosis was still detected at 24 h after 50 mW/cm<sup>2</sup> microwave exposure ( $P < 0.01$ ). In the 30 mW/cm<sup>2</sup> microwave exposure model, microwaves impaired the cytotoxic activity of NK-92 cells at 1 h and down regulated perforin protein both at 1 h and 6 h after exposure ( $P < 0.05$ ). Furthermore, p-ERK was down regulated at 1 h after exposure ( $P < 0.05$ ), while ERK blockade significantly promoted microwave-induced apoptosis ( $P < 0.05$ ) and downregulation of perforin ( $P < 0.01$ ). **CONCLUSION:** Microwave dose-dependently induced morphological and functional injury in NK-92 cells, possibly through ERK-mediated regulation of apoptosis and perforin expression.  
<https://doi.org/10.3967/bes2017.043>

Zothansiam, Zosangzuali, M., Lalramdinpuui, M., & Jagetia, G. C. 2017 Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations. *Electromagnetic Biology and Medicine*, 1–11. Radiofrequency radiations (RFRs) emitted by mobile phone base stations have raised concerns on its adverse impact on humans residing in the vicinity of mobile phone base stations. Therefore, the present study was envisaged to evaluate the effect of RFR on the DNA damage and antioxidant status in cultured human peripheral blood lymphocytes (HPBLs) of individuals residing in the vicinity of mobile phone base stations and comparing it with RF-EMR References 2017 to mid-2022

healthy controls. The study groups matched for various demographic data including age, gender, dietary pattern, smoking habit, alcohol consumption, duration of mobile phone use and average daily mobile phone use. The RF power density of the exposed individuals was significantly higher ( $p < 0.0001$ ) when compared to the control group. The HPBLs were cultured and the DNA damage was assessed by cytokinesis blocked micronucleus (MN) assay in the binucleate lymphocytes. The analyses of data from the exposed group ( $n = 40$ ), residing within a perimeter of 80 m of mobile base stations, showed significantly ( $p < 0.0001$ ) higher frequency of micronuclei when compared to the control group, residing 300 m away from the mobile base station/s. The analysis of various antioxidants in the plasma of exposed individuals revealed a significant attrition in glutathione (GSH) concentration ( $p < 0.01$ ), activities of catalase (CAT) ( $p < 0.001$ ) and superoxide dismutase (SOD) ( $p < 0.001$ ) and rise in lipid peroxidation (LOO) when compared to controls. Multiple linear regression analyses revealed a significant association among reduced GSH concentration ( $p < 0.05$ ), CAT ( $p < 0.001$ ) and SOD ( $p < 0.001$ ) activities and elevated MN frequency ( $p < 0.001$ ) and LOO ( $p < 0.001$ ) with increasing RF power density.

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