

As part of my research looking at microwave radio frequencies and whether that have the propensity to cause biological harm I have been collecting and evaluating studies over the last 3 years. I have purposely listed only positive studies (those that show biological effects) to demonstrate that not all “swans are white”. The evidence provided below demonstrates the current view held by many people that RF emission below basic restrictions set by RF Standards and International Guidelines are safe in fact refutable. The studies listed below have set exposures that are within ICNIRP RF basic restrictions. A summary of the effects and health implications is provided at the end of the document.

Studies (~2012 – to present day)

900MHz – 1800Mhz Microwave Radiation Studies (typically mobile phone frequencies)

- 1. Effect of electromagnetic irradiation produced by 3G mobile phone on male rat reproductive system in a simulated scenario.** Significant decrease in sperm count, increase in the lipid peroxidation damage in sperm cells, reduction in seminiferous tubules and testicular weight and DNA damage were observed following exposure to EMF in male albino rats. The results suggest that mobile phone exposure adversely affects male fertility. <http://www.ncbi.nlm.nih.gov/pubmed/25241589> [OS, DD, SE]
- 2. Evaluation of oxidant stress and antioxidant defense in discrete brain regions of rats exposed to 900 MHz radiation.** Altered behavioural performances were found in RF-EMR-exposed rats. Additionally, elevated TBARS level was found with all brain regions studied. RF-EMR exposure significantly decreased TA in the amygdala and cerebellum but its level was not significantly changed in other brain regions. GST activity was significantly decreased in the hippocampus but, its activity was unaltered in other brain regions studied. RF-EMR exposure for a month induced oxidative stress in rat brain, but its magnitude was different in different regions studied. <http://www.ncbi.nlm.nih.gov/pubmed/25174055?dopt=Abstract> [OS, BM, EA]
- 3. The effects of prenatal exposure to a 900-MHz electromagnetic field on the 21-day-old male rat heart.** Malondialdehyde, superoxide dismutase and catalase values were significantly higher in the experimental group rats, while glutathione values were lower. Light microscopy revealed irregularities in heart muscle fibers and apoptotic changes in the experimental group. Electron microscopy revealed crista loss and swelling in the mitochondria, degeneration in myofibrils and structural impairments in Z bands. Our study results suggest that exposure to EMF in the prenatal period causes oxidative stress and histopathological changes in male rat pup heart tissue. <http://www.ncbi.nlm.nih.gov/pubmed/25166431?dopt=Abstract> [OS, EA, AP, CI, EM]
- 4. Pathological effects of prenatal exposure to a 900 MHz electromagnetic field on the 21-day-old male rat kidney.** Light microscopy revealed some degenerative changes in the tubule epithelium, small cystic formations in the primitive tubules and large cysts in the cortico-medullary or medullary regions in the experimental group. Electron microscopy revealed a loss of peritubular capillaries and atypical parietal layer epithelial cells in the experimental group. Biochemical analysis showed significantly increased MDA levels in the experimental group and decreased SOD and CAT levels. EMF applied during the prenatal period can caused pathological changes in kidney tissue in 21-day-old male rats owing to oxidative stress and decreased antioxidant enzyme levels. <http://www.ncbi.nlm.nih.gov/pubmed/25158858?dopt=Abstract> [OS, EA, CI]
- 5. The effect of prenatal exposure to 900-megahertz electromagnetic field on the, 21-old-day rat testicle.** NEMFG rats exhibited irregularities in seminiferous tubule basal membrane and epithelium, immature germ cells in the lumen, and a decreased diameter in seminiferous tubules and thickness of epithelium. Apoptotic index, lipid peroxidation and DNA oxidation were higher in NEMFG rats than in NCG. 21-day-old rat testicles exposed to 900-MHz EMF in the prenatal term may be adversely affected, and this effect persists after birth. <http://www.ncbi.nlm.nih.gov/pubmed/24095929?dopt=Abstract> [OS, DD, CI]
- 6. Analysis of rat testicular proteome following 30-days exposure to 900 MHz electromagnetic field radiation.** Heat shock proteins, superoxide dismutase, peroxiredoxin-1 and other proteins related to misfolding of proteins and/or stress were identified. These results demonstrate significant effects of radio-frequency modulated electromagnetic fields (RF-EMF) exposure on proteome, particularly in protein species in the rodent testis, and suggest that a 30 d exposure to EMF radiation induces non-thermal stress in testicular tissue. <http://www.ncbi.nlm.nih.gov/pubmed/25146694?dopt=Abstract> [OS, EA]

7. **Effects of microwaves (950 MHz mobile phone) on morphometric and apoptotic changes of rabbit epididymis.** This study showed that the microwaves with the frequency of 950 MHz can have negative impacts on morphometric and apoptotic changes of rabbit epididymis.
<http://www.ncbi.nlm.nih.gov/pubmed/25060044?dopt=Abstract> [CI, AP]
8. **Selenium Reduces Mobile Phone (900 MHz)-Induced Oxidative Stress, Mitochondrial Function, and Apoptosis in Breast Cancer Cells** Exposure to mobile phone-induced electromagnetic radiation (EMR) may affect biological systems by increasing free oxygen radicals, apoptosis, and mitochondrial depolarization levels although selenium may modulate the values in cancer.
<http://www.ncbi.nlm.nih.gov/pubmed/24965080?dopt=Abstract> [OS, AP, EM]
9. **Effects of mobile phone radiation (900 MHz radiofrequency) on structure and functions of rat brain.** Discussion: Thus our findings indicate extensive neurodegeneration on exposure to radio waves. Increased production of reactive oxygen species due to exhaustion of enzymatic and non-enzymatic antioxidants and increased lipid peroxidation are indicating extensive neurodegeneration in selective areas of CA1, CA3, DG, and cerebral cortex. This extensive neuronal damage results in alterations in behavior related to memory and learning.
<http://www.ncbi.nlm.nih.gov/pubmed/24861496?dopt=Abstract> [OS, CI, BM, MR]
10. **Biochemical Modifications and Neuronal Damage in Brain of Young and Adult Rats After Long-Term Exposure to Mobile Phone Radiations.** Bax/Bcl-2 ratio, caspase-3 activity, and tumor necrosis factor-alpha level were enhanced, whereas no DNA fragmentation was detected. The relative brain weight of young rats was greatly affected, and histopathological examination reinforced the neuronal damage. The study highlights the detrimental effects of mobile phone radiations on brain during young and adult ages. The interaction of these radiations with brain is via dissipating its antioxidant status and/or triggering apoptotic cell death. <http://www.ncbi.nlm.nih.gov/pubmed/24801773?dopt=Abstract> [OS, EA, AP]
11. **Cell oxidation-reduction imbalance after modulated radiofrequency radiation.** Test with 1800Mhz RF exposure. In exposed samples, ROS level significantly ($p < 0.05$) increased after 10 min of exposure. Decrease in ROS level was observed after 30-min treatment indicating antioxidant defence mechanism activation. In conclusion, under the given laboratory conditions, modulated RF radiation might cause impairment in cell oxidation-reduction equilibrium within the growing cells.
<http://www.ncbi.nlm.nih.gov/pubmed/25119294?dopt=Abstract> [OS]
12. **The influence of direct mobile phone radiation on sperm quality.** The number of spermatozoa with progressive movement in the group, influenced by electromagnetic radiation, is statistically lower than the number of spermatozoa with progressive movement in the group under no effect. The number of non-progressive movement spermatozoa was significantly higher in the group, which was influenced by cell phone radiation. The DNA fragmentation was also significantly higher in this group. A correlation exists between mobile phone radiation exposure, DNA-fragmentation level and decreased sperm motility. <http://www.ncbi.nlm.nih.gov/pubmed/24982785> [DD, SE]
13. **The effect of radiofrequency radiation generated by a Global System for Mobile Communications source on cochlear development in a rat model.** Results: Distortion product otoacoustic emission tests revealed no significant difference among the groups, but electron microscopic evaluation revealed significant differences among the groups with regard to the number of normal, apoptotic and necrotic cells. Conclusion: The findings indicated cellular structural damage in the cochlea caused by radiofrequency radiation exposure during cochlear development in the rat model.
<http://www.ncbi.nlm.nih.gov/pubmed/24784924?dopt=Abstract> [AP, CI]
14. **Effect of exposure and withdrawal of 900-MHz-electromagnetic waves on brain, kidney and liver oxidative stress and some biochemical parameters in male rats.** In conclusion, electromagnetic field emitting from mobile phone might produce impairments in some biochemicals changes and oxidative stress in brain, liver and renal tissue of albino rats. These alterations were corrected by withdrawal.
<http://www.ncbi.nlm.nih.gov/pubmed/24712749?dopt=Abstract> [OS, EA]
15. **Oxidative changes and apoptosis induced by 1800-MHz electromagnetic radiation in NIH/3T3 cells.** Results indicate that an 1800-MHz EMR enhances ROS formation and promotes apoptosis in NIH/3T3 cells <http://www.ncbi.nlm.nih.gov/pubmed/24665905?dopt=Abstract> [OS, DD, AP]
16. **Maternal mobile phone exposure alters intrinsic electrophysiological properties of CA1 pyramidal neurons in rat offspring.** Exposure to mobile phones adversely affects the cognitive performance of both female and male offspring rats
<http://www.ncbi.nlm.nih.gov/pubmed/24604340?dopt=Abstract> [BM, MR]

17. **Spatial learning, monoamines and oxidative stress in rats exposed to 900MHz electromagnetic field in combination with iron overload.** No significant differences regarding learning and memory were observed in the Morris water maze and eight-arm radial maze between the groups. However, exposed rats from group 1 (electromagnetic field) and group 2 (electromagnetic field + iron) showed significantly impaired results in the object exploration test in comparison to the sham exposed rats. <http://www.ncbi.nlm.nih.gov/pubmed/24144546?dopt=Abstract> [OS, BM]
18. **Study of Oxidative Stress in Human Lens Epithelial Cells Exposed to 1.8 GHz Radiofrequency Fields** - In all exposed cell cultures, the level of reactive oxygen species and the lipid peroxidation were significantly increased compared to the corresponding sham exposed cell cultures, while the cell viability, the gene expression and the protein expression were significantly decreased. <http://www.ncbi.nlm.nih.gov/pubmed/23991100?dopt=Abstract> [OS, GE]
19. **Mobile phone radiation induces mode-dependent DNA damage in a mouse spermatocyte-derived cell line: a protective role of melatonin.** The levels of DNA damage were significantly increased following exposure to MPR in the listen, dialed and dialing modes. <http://www.ncbi.nlm.nih.gov/pubmed/23952262?dopt=Abstract> [DD]
20. **Circadian alterations of reproductive functional markers in male rats exposed to 1800 MHz radiofrequency field.** Via these measurements, we confirmed the existence of circadian rhythms in sham-exposed animals. However, rats exposed to RF exhibited a disruption of circadian rhythms, decreased testosterone levels, lower daily sperm production and sperm motility, down-regulated activity of γ -GT and ACP, as well as altered mRNA expression of cytochrome P450 and StAR. All of these observations were more pronounced when rats were exposed to RF at ZT0. Thus, our findings indicate potential adverse effects of RF exposure on male reproductive functional markers, in terms of both the daily overall levels as well as the circadian rhythmicity. <http://www.ncbi.nlm.nih.gov/pubmed/24117058?dopt=Abstract> [CR, SE, GE, EA]
21. **Investigation of the Effects of 2.1 GHz Microwave Radiation on Mitochondrial Membrane Potential ($\Delta\Psi$ m), Apoptotic Activity and Cell Viability in Human Breast Fibroblast Cells.** The results of this study showed that 2.1 GHz W-CDMA modulated MW radiation-induced apoptotic cell death via the mitochondrial pathway. <http://www.ncbi.nlm.nih.gov/pubmed/23723005?dopt=Abstract> [AP, ME]
22. **Evaluation of the cytogenotoxic damage in immature and mature rats exposed to 900 MHz radio frequency electromagnetic fields.** The exposure of RF-EMF leads to cytotoxic and genotoxic damage in immature and mature rats. More sensitive studies are required to elucidate the possible carcinogenic risk of EMF exposure in humans, especially children. <http://www.ncbi.nlm.nih.gov/pubmed/23718180?dopt=Abstract> [DD, AP, CI]
23. **Effect of low level microwave radiation exposure on cognitive function and oxidative stress in rats.** The study aimed to evaluate the effects of 900 MHz MW radiation exposure on cognitive function and oxidative stress in blood of Fischer rats. Results showed significant impairment in cognitive function and increase in oxidative stress, as evidenced by the increase in levels of MDA (a marker of lipid peroxidation) and protein carbonyl (a marker of protein oxidation) and unaltered GSH content in blood. Thus, the study demonstrated that low level MW radiation had significant effect on cognitive function and was also capable of leading to oxidative stress. <http://www.ncbi.nlm.nih.gov/pubmed/23720885?dopt=Abstract> [OS, BM]
24. **Effects of intensive cell phone (philips genic 900) use on the rat kidney tissue.** Considering the damage in rat kidney tissue caused by EMR-emitting cell phones, high-risk individuals should take protective measures. <http://www.ncbi.nlm.nih.gov/pubmed/23801472?dopt=Abstract> [CI]
25. **Effect of 950 MHz UHF Electromagnetic radiation on biomarkers of oxidative damage, metabolism of UFA and antioxidants in the liver of young rats of different ages.** For rats of 30 days, no OS, but it is genotoxic to the livers of ER to total body irradiation. <http://www.ncbi.nlm.nih.gov/pubmed/23789976?dopt=Abstract> [DD, EA]
26. **Detection of Low Level Microwave Radiation Induced Deoxyribonucleic Acid Damage Vis-à-vis Genotoxicity in Brain of Fischer Rats.** Experiments were performed on male Fischer rats exposed to microwave radiation for 30 days at three different frequencies: 900, 1800 and 2450 MHz. We concluded that low SAR microwave radiation exposure at these frequencies may induce DNA strand breaks in brain tissue. <http://www.ncbi.nlm.nih.gov/pubmed/23833433?dopt=Abstract> [DD]

27. **Stimulation of the brain with radiofrequency electromagnetic field pulses affects sleep-dependent performance improvement negatively.** Pulse-modulated radiofrequency electromagnetic fields (RF EMF, carrier frequency 900 MHz) are capable to modulate these electroencephalographic (EEG) characteristics of sleep. The changes in the time course of SWA during the exposure night may reflect an interaction of RF EMF with the renormalization of cortical excitability during sleep, with a negative impact on sleep-dependent performance improvement. <http://www.ncbi.nlm.nih.gov/pubmed/23482083?dopt=Abstract> [SP]
28. **The exposure of adult rats to EMR may cause disturbances in monoamine neurotransmitters and this may underlie many of the adverse effects reported after EMR including memory, learning, and stress.** Adult rats were exposed daily to EMR (frequency 1800 MHz). The exposure of adult rats to EMR may cause disturbances in monoamine neurotransmitters and this may underlie many of the adverse effects reported after EMR including memory, learning, and stress. <http://www.ncbi.nlm.nih.gov/pubmed/23852905?dopt=Abstract> [BM, MR]
29. **Exposure to 1800MHz Radiofrequency Electromagnetic Radiation Induces Oxidative DNA Base Damage in a Mouse Spermatoocyte-Derived Cell Line.** The authors conclude that exposure to radiofrequency electromagnetic fields causes a DNA damage in male germ cells via oxidative stress. <http://www.emf-portal.de/viewer.php?l=e&aid=21674> [OS, DD]
30. **Effect of 900 MHz radiofrequency radiation on oxidative stress in rat brain and serum.** Our results suggest that there is a significant increase in brain lipid and protein oxidation after electromagnetic radiation (EMR) exposure and that garlic has a protective effect against this oxidative stress. <http://www.ncbi.nlm.nih.gov/pubmed/23301880?dopt=Abstract> [OS, EA]
31. **Effect of 3G Cell Phone Exposure with Computer Controlled 2-D Stepper Motor on Non-thermal Activation of the hsp27/p38MAPK Stress Pathway in Rat Brain.** Result shows that microwave radiation emitted from 3G mobile phone significantly induced DNA strand breaks in brain. <http://www.ncbi.nlm.nih.gov/pubmed/23949848?dopt=Abstract> [OS, DD, EM, EA, AP]
32. **Effect Of Microwave Radiation On The Retina Of Mice Embryos.** Exposure to a frequency of 950 MHz and exposure to a frequency of 1800 MHz. The mean body length and body weight were significantly decreased when compared to the control group, cells of the retinal tissue lost their normal arrangement and became aggregated in the inner and outer layer of the retina. <http://www.emf-portal.de/viewer.php?l=e&aid=23338> [ME, CI]
33. **Effect of 900MHz electromagnetic fields emitted from cellular phones on fracture healing: an experimental study on rats.** Results of this study demonstrate that EMF at 900 MHz of frequency emitted from cellular phones has a significantly negative effect on bone fracture healing in a rat tibia model. <http://www.ncbi.nlm.nih.gov/pubmed/23999516?dopt=Abstract> [RH]
34. **The toxic effects of mobile phone radiofrequency (940 MHz) on the structure of calf thymus DNA.** Collectively, these experiments indicate that exposure to an electromagnetic radiofrequency field can alter the structure of DNA irreversibly. <http://www.ncbi.nlm.nih.gov/pubmed/23164448?dopt=Abstract> [DD]
35. **Overproduction of free radical species in embryonal cells exposed to low intensity radiofrequency radiation.** The exposure resulted in a significant persistent overproduction of superoxide and nitrogen oxide in embryo cells during all period of analyses. Exposure of developing quail embryos to extremely low intensity RF-EMR of GSM 900 MHz during at least one hundred and fifty-eight hours leads to a significant overproduction of free radicals/reactive oxygen species and oxidative damage of DNA in embryo cells. <http://www.ncbi.nlm.nih.gov/pubmed/24084462?dopt=Abstract> [OS, DD]
36. **The protective effect of autophagy on mouse spermatoocyte derived cells exposure to 1800MHz radiofrequency electromagnetic radiation.** Intracellular ROS levels significantly increased in a dose- and time-dependent manner after cells were exposed to RF. <http://www.ncbi.nlm.nih.gov/pubmed/24813634?dopt=Abstract> [OS]
37. **Male reproductive health under threat: Short term exposure to radiofrequency radiations emitted by common mobile jammers.** The motility of sperm samples exposed to jammer RF radiation for 2 or 4 h were significantly lower than those of sham-exposed samples. <http://www.ncbi.nlm.nih.gov/pubmed/24082653?dopt=Abstract> [SE]
38. **The effects of mobile phones on apoptosis in cerebral tissue: an experimental study on rats.** In the study group of 10 rats; mobile phones that spread EMW at a frequency between 1900-2100 MHz. Our results showed that the electro-magnetic waves emitted by the mobile phones may have effect on apoptosis. <http://www.ncbi.nlm.nih.gov/pubmed/24763879?dopt=Abstract> [AP, GE]

- 39. Effect of mobile phone use on salivary concentrations of protein, amylase, lipase, immunoglobulin A, lysozyme, lactoferrin, peroxidase and C-reactive protein of the parotid gland.** Salivary flow rate and parotid gland salivary concentrations of protein were significantly higher on the right side compared to the left in those that predominantly held mobile phones on the right side. In addition, there was a decrease in concentrations of amylase, lipase, lysozyme, lactoferrin and peroxidase. <http://www.ncbi.nlm.nih.gov/pubmed/24739140?dopt=Abstract> [EA]
- 40. DNA damage but not linked cellular dysfunction.** Cell Type-Dependent Induction of DNA Damage by 1800 MHz Radiofrequency Electromagnetic Fields Does Not Result in Significant Cellular Dysfunctions. <http://www.ncbi.nlm.nih.gov/pubmed/23355902?dopt=Abstract> [OS, DD]
- 41. GSM 900 MHz cellular phone radiation can either stimulate or depress early embryogenesis in Japanese quails depending on the duration of exposure.** An exposure for 158 hours significantly decreased the number of differentiated somites and resulted in a significant increase of DNA strand breaks compared to the control group. The authors conclude that mobile phone-exposure can stimulate or depress the embryogenesis of Japanese quails and that this effect could depend on the exposure duration. <http://www.emf-portal.de/viewer.php?l=e&aid=22134> [DD]
- 42. Transient and cumulative memory impairments induced by GSM 1.8 GHz cell phone signal in a mouse model.** One-way analysis of variance revealed statistically significant impairments of both types of memory gradually accumulating, with more pronounced effects on the spatial memory. The impairments persisted even 2 weeks after interruption of the 8 weeks daily exposure, whereas the memory of mice as detected by both tasks showed a full recovery approximately 1 month later. <http://www.ncbi.nlm.nih.gov/pubmed/23320614?dopt=Abstract> [MR]
- 43. Effect of electromagnetic irradiation produced by 3G mobile phone on male rat reproductive system in a simulated scenario.** Testicular function is particularly susceptible to the radiation emitted by EMFs. Significant decrease in sperm count, increase in the lipid peroxidation damage in sperm cells, reduction in seminiferous tubules and testicular weight and DNA damage were observed following exposure to EMF in male albino rats. The results suggest that mobile phone exposure adversely affects male fertility. <http://www.ncbi.nlm.nih.gov/pubmed/25241589?dopt=Abstract> [SE, DD]
- 44. Differential Pro-Inflammatory Responses of Astrocytes and Microglia Involve STAT3 Activation in Response to 1800 MHz Radiofrequency Fields.** RF exposure induced differential pro-inflammatory responses in astrocytes and microglia, characterized by different expression and release profiles of IL-1 β , TNF- α , IL-6, PGE2, nitric oxide (NO), inducible nitric oxide synthase (iNOS) and cyclooxygenase 2 (COX2). Results demonstrated that RF exposure differentially induced pro-inflammatory responses in microglia and astrocytes <http://www.ncbi.nlm.nih.gov/pubmed/25275372?dopt=Abstract> [IN, EA]
- 45. Exposure to 1800 MHz radiofrequency radiation impairs neurite outgrowth of embryonic neural stem cells.** Neurite outgrowth of eNSC differentiated neurons was inhibited after 4 W/kg RF-EMF exposure for 3 days. Additionally, the mRNA and protein expression of the proneural genes Ngn1 and NeuroD, which are crucial for neurite outgrowth, were decreased after RF-EMF exposure. The expression of their inhibitor Hes1 was upregulated by RF-EMF exposure. These results together suggested that 1800 MHz RF-EMF exposure impairs neurite outgrowth of eNSCs. <http://www.ncbi.nlm.nih.gov/pubmed/24869783> [GE]

WiFi (2.4Ghz - 2450Ghz) Exposure Studies

- 46. Increased DNA oxidation (8-OHdG) and protein oxidation (AOPP) by Low level electromagnetic field (2.45 GHz) in rat brain and protective effect of garlic.** Conclusions: It may be concluded that low level EMF at 2.45 GHz MWR increases the DNA damage in both brain tissues and plasma of the rats whereas it increases protein oxidation only in plasma. It may also be argued that the use of garlic decreases these effects. <http://www.ncbi.nlm.nih.gov/pubmed/24844368> [OS, DD]
- 47. Structural and ultrastructural study of rat testes influenced by electromagnetic radiation.** Pulsed electromagnetic field at frequency of 2.45 GHz and mean power density 2.8 mW/cm²) by 3-h daily applications for 3 wk. Except for relatively unchanged Sertoli cells, some locations of basal compartment of seminiferous epithelium contained shrivelled Sertoli cells with dark cytoplasm. These areas showed degenerative features including necrotizing and shrivelled spermatogonia surrounded by empty irregular spaces, and undulating basement membrane. The intertubular spaces were enlarged but interstitial Leydig cells did not show any marked morphological changes. Evidence demonstrates the adverse effects of EMR on testicular parenchyma in rats. <http://www.ncbi.nlm.nih.gov/pubmed/24839928?dopt=Abstract> [CI]

- 48. Electromagnetic radiation (Wi-Fi) and epilepsy induce calcium entry and apoptosis through activation of TRPV1 channel in hippocampus and dorsal root ganglion of rats.** In results of whole cell patch-clamp experiments, treatment of DRG with Ca²⁺ channel antagonists [thapsigargin, verapamil + diltiazem, 2-APB, MK-801] indicated that Wi-Fi exposure induced Ca²⁺ influx via the TRPV1 channels. In conclusion, epilepsy and Wi-Fi in our experimental model is involved in Ca²⁺ influx and oxidative stress-induced hippocampal and DRG death through activation of TRPV1 channels, and negative modulation of this channel activity by CPZ pretreatment may account for the neuroprotective activity against oxidative stress.
<http://www.ncbi.nlm.nih.gov/pubmed/24792079?dopt=Abstract> [OS, AP, CA]
- 49. Effects of olive leave extract on metabolic disorders and oxidative stress induced by 2.45 GHz WIFI signals.** Our investigations suggested that RF exposure induced a diabetes-like status through alteration of oxidative response. Olive leaves extract was able to correct glucose metabolism disorder by minimizing oxidative stress induced by RF in rat tissues.
<http://www.sciencedirect.com/science/article/pii/S1382668913001609> [OS, GM]
- 50. The effects of long-term exposure to a 2450 MHz electromagnetic field on growth and pubertal development in female Wistar rats.** Exposure to 2450 MHz EMF, particularly in the prenatal period, resulted in postnatal growth restriction and delayed puberty in female Wistar rats. Increased TOS and OSI values in the brain and ovary tissues can be interpreted as a sign of chronic stress induced by EMF.
<http://www.ncbi.nlm.nih.gov/pubmed/24460416?dopt=Abstract> [OS]
- 51. Wi-Fi (2.45 GHz)- and Mobile Phone (900 and 1800 MHz)-Induced Risks on Oxidative Stress and Elements in Kidney and Testis of Rats During Pregnancy and the Development of Offspring.** In conclusion, Wi-Fi- and mobile phone-induced EMR caused oxidative damage by increasing the extent of lipid peroxidation and the iron level, while decreasing total antioxidant status, copper, and GSH values. Wi-Fi- and mobile phone-induced EMR may cause precocious puberty and oxidative kidney and testis injury in growing rats.
<http://www.ncbi.nlm.nih.gov/pubmed/24101576?dopt=Abstract> [OS, CI]
- 52. Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings.** Of the 39 participants who claimed to experience some electrical hypersensitivity, 36% claimed they also reacted to a cordless phone and experienced heart symptoms and, of these, 64% were classified as having some degree of electrohypersensitivity (EHS) based on their HRV response. Novel findings include documentation of a delayed response to radiation.
<http://informahealthcare.com/doi/abs/10.3109/15368378.2013.776437> [HR]
- 53. Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation.** Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility.
<http://www.ncbi.nlm.nih.gov/pubmed/22112647> [DD, SE]

Epidemiological/Case Studies (Mobile Phone, Radar, etc.)

- 54. Mobile phone use and health symptoms in children.** MP use was associated with a significantly increased adjusted odds ratio (AOR) for headaches and migraine and Children who regularly used MPs were also considered to have a health status worse than it was 1 year ago.
<http://www.ncbi.nlm.nih.gov/pubmed/25115529?dopt=Abstract> [HA, SI]
- 55. Mobile phone use and brain tumours in the CERENAT case-control study.** The positive association was statistically significant in the heaviest users when considering life-long cumulative duration (≥ 896 h, OR 2.89; CI 1.41-5.93 for gliomas; OR 2.57; CI 1.02-6.44 for meningiomas) and number of calls for gliomas ($\geq 18,360$ calls, OR 2.10, CI 1.03-4.31). Among heavy mobile phone users (≥ 896 h) increased risks were observed for gliomas (OR 2.89, CI 1.41-5.93), temporal tumors (OR 3.94, CI 0.81-19.08), occupational use (OR 3.27, CI 1.45-7.35) and urban mobile phone use (OR 8.20, CI)
<http://www.ncbi.nlm.nih.gov/pubmed/24816517?dopt=Abstract> [BT]
- 56. Lifestyle Risk Factors Associated with Threatened Miscarriage: A Case-Control Study.** An association of threatened miscarriage with computer usage (>4 hours/day: OR 6.03, CI 2.82-12.88), mobile phone use (>1 hour/day: OR 2.94, CI 1.32-6.53)
<http://omicsgroup.org/journals/lifestyle-risk-factors-associated-with-threatened-miscarriage-a-casecontrol-study-jfiv.1000123.pdf> [MC]

57. **Association between mobile phone use and semen quality: a systemic review and meta-analysis.** Evidence from current studies suggests potential harmful effects of mobile phone use on semen parameters. <http://www.ncbi.nlm.nih.gov/pubmed/24700791?dopt=Abstract> [SE]
58. **Association between vestibular schwannomas and mobile phone use.** Tumors may coincide with the more frequently used ear of mobile phones and tumor volume that showed strong correlation with amount of mobile phone use, thus there is a possibility that mobile phone use may affect tumor growth. <http://www.ncbi.nlm.nih.gov/pubmed/23975478?dopt=Abstract> [BT, TP]
59. **Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study.** We observed that the incidence of most of the symptoms was related to exposure levels-independently of the demographic variables and some possible risk factors. Concerns about adverse effects from exposure, despite being strongly related with sleep disturbances, do not influence the direct association between exposure and sleep. <http://www.ncbi.nlm.nih.gov/pubmed/24381254?dopt=Abstract> [IS, BM, IR]
60. **The relationship between adolescents' well-being and their wireless phone use: a cross-sectional study.** Using a wired cellphone headset was associated with tinnitus (adjusted OR 1.8, CI 1.0-3.3), while wireless headsets were associated with headache (adjusted OR 2.2, CI 1.1-4.5), feeling down/depressed (adjusted OR 2.0, CI 1.1-3.8), and waking in the night (adjusted OR 2.4, CI 1.2-4.8). Several cordless phone frequencies bands were related to tinnitus, feeling down/depressed and sleepiness at school, while the last of these was also related to modulation. <http://www.ncbi.nlm.nih.gov/pubmed/24148357?dopt=Abstract> [TN, HA, IS]
61. **Multifocal Breast Cancer in Young Women with Prolonged Contact between Their Breasts and Their Cellular Phones.** All patients regularly carried their smartphones directly against their breasts in their brassieres for up to 10 hours a day, for several years, and developed tumors in areas of their breasts immediately underlying the phones. All patients had no family history of breast cancer, tested negative for BRCA1 and BRCA2, and had no other known breast cancer risks. <http://www.ncbi.nlm.nih.gov/pubmed/24151509?dopt=Abstract> [BC]
62. **Health effects of living near mobile phone base transceiver station (BTS) antennae: a report from Isfahan, Iran.** The results showed that most of the symptoms such as nausea, headache, dizziness, irritability, discomfort, nervousness, depression, sleep disturbance, memory loss and lowering of libido were statistically significant in the inhabitants living near the BTS antenna (<300 m distances) compared to those living far from the BTS antenna (>300 m). <http://www.ncbi.nlm.nih.gov/pubmed/23781985?dopt=Abstract> [HA, IS, BM, MR]
63. **Changes in brain glioma incidence and laterality correlates with use of mobile phones--a nationwide population based study in Israel.** We found a statistically significant decrease in LGG's over 30-years period that correlates with introducing of mobile phones technology and a shift in laterality towards left-sided tumors, the latter occurred in both low and high-grade gliomas. <http://www.ncbi.nlm.nih.gov/pubmed/23317269> [BT]
64. **Use of mobile and cordless phones and survival of patients with glioma.** Decreased survival of glioma cases with long-term and high cumulative use of wireless phones was found. A survival disadvantage for astrocytoma grade IV, but a survival benefit for astrocytoma grade I-II was observed which could be due to exposure-related tumour symptoms leading to earlier diagnosis and surgery in that patient group. <http://www.ncbi.nlm.nih.gov/pubmed/23095687?dopt=Abstract> [BT]
65. **Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997-2003 and 2007-2009 and use of mobile and cordless phones.** OR increased per 100 h cumulative use and per year of latency for mobile phones and cordless phones, though the increase was not statistically significant for cordless phones. The percentage tumour volume increased per year of latency and per 100 h of cumulative use, statistically significant for analogue phones. This study confirmed previous results demonstrating an association between mobile and cordless phone use and acoustic neuroma. <http://www.ncbi.nlm.nih.gov/pubmed/23877578?dopt=Abstract> [BT]
66. **Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems.** Model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. <http://www.ncbi.nlm.nih.gov/pubmed/21716201> [TP, OS]
67. **Lifestyle and semen quality: role of modifiable risk factors -** using a cell phone more than 10 years decreased the percentage of motile sperm cells (p = 0.02). <http://www.ncbi.nlm.nih.gov/pubmed/24074254?dopt=Abstract> [SE]

68. **Effect of mobile telephones on sperm quality: A systematic review and meta-analysis** Mobile phone exposure was associated with reduced sperm motility and viability. <http://www.sciencedirect.com/science/article/pii/S0160412014001354> [SE]
69. **The semen quality of the mobile phone users.** Results suggest that the sperm DNA fragmentation could represent the only parameter significantly altered in the subjects who use the mobile phone for more than 4 h/day and in particular for those who use the device in the pocket of the trousers. <http://www.ncbi.nlm.nih.gov/pubmed/23722985?dopt=Abstract> [SE, DD]
70. **Connection between Cell Phone use, p53 Gene Expression in Different Zones of Glioblastoma Multiforme and Survival Prognoses.** Forty-one out of 63 patients (65%) with the highest level of cell phone use (≥ 3 hours/day) had higher mutant type p53 expression in the peripheral zone of the glioblastoma; the difference was statistically significant ($P=0.034$). Results from the present study on the use of mobile phones for ≥ 3 hours a day show a consistent pattern of increased risk for the mutant type of p53 gene expression in the peripheral zone of the glioblastoma, and that this increase was significantly correlated with shorter overall survival time. <http://www.ncbi.nlm.nih.gov/pubmed/25276320?dopt=Abstract> [GE, TP, BT]
71. **Decreased Survival of Glioma Patients with Astrocytoma Grade IV (Glioblastoma Multiforme) Associated with Long-Term Use of Mobile and Cordless Phones.** Use of wireless phones in the >20 years latency group (time since first use) yielded an increased hazard ratio (HR) = 1.7, 95% confidence interval (CI) = 1.2-2.3 for glioma. For astrocytoma grade IV (glioblastoma multiforme; $n = 926$) mobile phone use yielded HR = 2.0, 95% CI = 1.4-2.9 and cordless phone use HR = 3.4, 95% CI = 1.04-11 in the same latency category. The hazard ratio for astrocytoma grade IV increased statistically significant per year of latency for wireless phones, HR = 1.020, 95% CI = 1.007-1.033, but not per 100 h cumulative use, HR = 1.002, 95% CI = 0.999-1.005 www.ncbi.nlm.nih.gov/pubmed/25325361?dopt=Abstract [BT]
72. **Associations between specific technologies and adolescent sleep quantity, sleep quality, and parasomnias.** Frequent weekday technology use at bedtime was associated with significant adverse effects on multiple sleep parameters. <http://www.ncbi.nlm.nih.gov/pubmed/24394730?dopt=Abstract> [SP]

Novel Studies using RF or review of RF research

73. **Noninvasive radiofrequency treatment effect on mitochondria in pancreatic cancer cells.** RF fields treatment changed the morphology of mitochondria in cancer cells, altered polarization of the mitochondrial membrane, substantially impaired mitochondrial respiration, and increased reactive oxygen species production, indicating RF-induced stress on the mitochondria. This suggests that RF-induced stress can damage mitochondria and induce elimination of damaged organelles via autophagy. <http://www.ncbi.nlm.nih.gov/pubmed/24986120?dopt=Abstract> [OS, EM, CI]
74. **Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects.** Pathophysiological responses to EMFs may be as a result of nitric oxide-peroxynitrite-oxidative stress path-way of action. A single such well-documented example, EMF induction of DNA single-strand breaks in cells, as measured by alkaline comet assays, is reviewed here. Such single-strand breaks are known to be produced through the action of this pathway. Data on the mechanism of EMF induction of such breaks are limited; what data are available support this proposed mechanism. Other Ca^{2+} mediated regulatory changes, independent of nitric oxide, may also have roles. This article reviews, then, a substantially supported set of targets, VGCCs, whose stimulation produces non-thermal EMF responses by humans/higher animals with downstream effects involving Ca^{2+} /calmodulin-dependent nitric oxide increases, which may explain therapeutic and pathophysiological effects. <http://onlineibrary.wiley.com/doi/10.1111/jcmm.12088/pdf> [OS, DD, CA, EA]
75. **MicroRNAs: Novel Mechanism Involved in the Pathogenesis of Microwave Exposure on Rats' Hippocampus.** Studies from our group and others showed that microwave-induced structural and functional injury of hippocampus, accompanied with alteration of gene and protein expression. <http://www.ncbi.nlm.nih.gov/pubmed/24748327?dopt=Abstract> [GE, EA, CI]

Other Microwave Frequencies or Microwave Frequency not specified

76. **Neural Cell Apoptosis Induced by Microwave Exposure Through Mitochondria-dependent Caspase-3 Pathway.** Wistar rats were exposed to 2.856 GHz for 5 min and 15 min. The results showed chromatin condensation and apoptotic body formation in neural cells 6h after microwave exposure. Moreover, the mitochondria membrane potential decreased, DNA fragmentation increased, leading to an increase in the apoptotic cell percentage.
<http://www.ncbi.nlm.nih.gov/pubmed/24688304?dopt=Abstract> [EM, DD, AP]
77. **Impairment of long-term potentiation induction is essential for the disruption of spatial memory after microwave exposure.** Wistar rats were exposed to a 2.856 GHz pulsed microwave field. This study suggested that impairment of LTP induction and the damages of hippocampal structure, especially changes of synapses, might contribute to cognitive impairment after microwave exposure.
<http://www.ncbi.nlm.nih.gov/pubmed/23786183?dopt=Abstract> [MR, CI]
78. **Spatial memory and learning performance and its relationship to protein synthesis of Swiss albino mice exposed to 10 GHz microwaves.** It can be concluded from the current study that exposure to microwave radiation caused decrements in the ability of mice to learn the special memory task, this may be due to simultaneous decrease in protein levels in the brain of mice.
<http://www.ncbi.nlm.nih.gov/pubmed/23952535?dopt=Abstract> [EA, MR]
79. **Reduction of Phosphorylated Synapsin I (Ser-553) Leads to Spatial Memory Impairment by Attenuating GABA Release after Microwave Exposure in Wistar Rats.** Both microwave exposure and p-Syn I silencing reduced GABA release and maximal reduction was found for the combination of the two, indicating a synergetic effect. <http://www.ncbi.nlm.nih.gov/pubmed/24743689?dopt=Abstract> [GE, EA, MR]
80. **Microwave radiation induces injury to GC-2spd cells** Microwave radiation at 10 and 30 mW/cm² may cause injury to GC-2spd cells, which is manifested by decreased content of intracellular cAMP, reduced activity of cell proliferation, and increased rate of cell apoptosis
<http://www.ncbi.nlm.nih.gov/pubmed/24738454?dopt=Abstract> [AP, EA, CI]
81. **Adverse health effects of occupational exposure to radiofrequency radiation in airport surveillance radar operators - symptoms resemble radiowave sickness (EHS).** Altogether these results indicate that occupational exposure to radar microwave radiations may be linked to some adverse health effects. <http://www.ncbi.nlm.nih.gov/pubmed/24082641?dopt=Abstract> [HA, IN, MR]
82. **A new problem in inflammatory bladder diseases: Use of mobile phones** Conclusion: Intensive use of mobile phones has negative impact on bladder tissue as well as the other organs. Keeping a minimum level of mobile phone use makes it easy to be kept under control of diseases in which inflammation is an etiologic factor. <http://www.ncbi.nlm.nih.gov/pubmed/25251956?dopt=Abstract> [IN]
83. **Prevalence of fatigue reported by physiotherapists operating diathermy equipment for microwave.** The results demonstrate a significant and independent association between occupational exposure of physical therapists to radiation of microwave diathermy and prevalence of fatigue.
<http://www.ncbi.nlm.nih.gov/pubmed/25272253?dopt=Abstract> [FA]
84. **Alteration of glycine receptor immunoreactivity in the auditory brainstem of mice following three months of exposure to radiofrequency radiation at SAR 4.0 W/kg.** Auditory brainstem response (ABR) analysis also revealed a significant threshold elevation of in the exposed (E4) group, which may be associated with auditory dysfunction. The present study suggests that the auditory brainstem region is susceptible to chronic exposure to RF radiation, which may affect the function of the central auditory system. <http://www.ncbi.nlm.nih.gov/pubmed/24866721> [AD]

Microwave effect on Blood Brain Barrier (Specific frequency not specified)

85. **Activation of VEGF/Flk-1-ERK Pathway Induced Blood-Brain Barrier Injury After Microwave Exposure.** Our results showed that microwave radiation caused intercellular tight junctions to broaden and fracture with decreased TEER values and increased HRP permeability. After microwave exposure, activation of the VEGF/Flk-1-ERK pathway and Tyr phosphorylation of occludin were observed, along with down-regulated expression and interaction of occludin with zonula occludens-1 (ZO-1).
<http://www.ncbi.nlm.nih.gov/pubmed/25195697?dopt=Abstract> [BB, EA]

- 86. Altered expression of matrix metalloproteinases and tight junction proteins in rats following PEMF-induced BBB permeability change.** Compared with the sham group, PEMF exposure led to increased permeability of the BBB to EB, which was prolonged after exposure. BBB permeability became progressively more severe, and recovered at 6 h.
<http://www.ncbi.nlm.nih.gov/pubmed/22998827?dopt=Abstract> [BB]

RF Oxidative Stress (no specific details on frequencies used)

- 87. Low intensity radiofrequency radiation: a new oxidant for living cells** Notwithstanding the non-ionizing nature of RFR, profound mutagenic effects and features of significant oxidative stress in living cells under low intensity RFR exposure were detected using various biological models [18,19].
<http://www.scopemed.org/fulltextpdf.php?mno=154583> [OS, DD, BT]
- 88. Confirmation of hydroxyl radicals (\bullet OH) generated in the presence of TiO₂ supported on AC under microwave irradiation.** The results showed that the (\bullet)OH could be generated under MW combined with loaded TiO₂/AC. Also, anatase TiO₂/AC can generate more (\bullet)OH radicals than rutile TiO₂/AC under MW irradiation. <http://www.ncbi.nlm.nih.gov/pubmed/24960308?dopt=Abstract> [OS, EA]
- 89. Changes in mitochondrial functioning with electromagnetic radiation of ultra-high frequency as revealed by electron paramagnetic resonance methods.** (i) Abnormalities in the mitochondrial ETC of liver and aorta cells are more pronounced for animals radiated in a pulsed mode; (ii) the alterations in the functioning of the mitochondrial ETC cause increase of superoxide radicals generation rate in all samples, formation of cellular hypoxia, and intensification of the oxide-initiated metabolic changes; and (iii) electron paramagnetic resonance methods could be used to track the qualitative and quantitative changes in the mitochondrial ETC caused by the UHF EMR.
<http://www.ncbi.nlm.nih.gov/pubmed/24597749?dopt=Abstract> [OS, EM, CI]
- 90. Spin Biochemistry Modulates Reactive Oxygen Species (ROS) Production by Radio Frequency Magnetic Fields.** This study demonstrates the interplay between O₂^{•-} and H₂O₂ production when influenced by RF magnetic fields and underscores the subtle effects of low-frequency magnetic fields on oxidative metabolism, ROS signaling, and cellular growth.
<http://www.ncbi.nlm.nih.gov/pubmed/24681944?dopt=Abstract> [OS]

ELF added to show symptoms of EMR exposure appear to occur across a large range of the non-ionising spectrum.

Dirty electricity, chronic stress, neurotransmitters and disease. Dirty electricity, also called electrical pollution, is high-frequency voltage transients riding along the 50 or 60 Hz electricity provided by the electric utilities. It is generated by arcing, by sparking and by any device that interrupts current flow, especially switching power supplies. It has been associated with cancer, diabetes and attention deficit hyperactivity disorder in humans.
<http://www.ncbi.nlm.nih.gov/pubmed/23323864?dopt=Abstract>

Changes in gene and protein expression in magnetic field-treated human glioma cells. The results of gene expression analysis showed a significant up-regulation of five and down-regulation of 25 genes in cells exposed to the magnetic field compared to sham exposure. Protein expression analysis indicated that the expression rates of ten identified proteins were significantly altered. Three of these showed an increase and seven a decrease in their expression rate, following the exposure compared to sham exposure. However, no obvious relationship between the affected genes and proteins could be found. <http://www.ncbi.nlm.nih.gov/pubmed/20021071?dopt=Abstract>

The Influence of 50 Hz Magnetic Field on Liver Function. All investigated liver values showed significant increases in groups 4 and 5 compared to sham exposure (group 1). For alanine aminotransferase and aspartate aminotransferase, significant higher values could already be measured in group 3 (0.6 mT). Liver lipid peroxidation was significantly increased in groups 3, 4 and 5, while the glutathione levels were significantly decreased in these groups compared to sham exposure, indicating oxidative stress. <http://www.rjb.ro/articles/205/mibra.pdf>

Occupational electromagnetic field exposures associated with sleep quality: a cross-sectional study. The findings showed that daily occupational EMF exposure was positively associated with poor sleep quality. It implies EMF exposure may damage human sleep quality rather than sleep duration.
<http://www.ncbi.nlm.nih.gov/pubmed/25340654?dopt=Abstract>

Extremely low-frequency magnetic fields can impair spermatogenesis recovery after reversible testicular damage induced by heat.

Magnetic field exposure during the spermatogenesis recovery induced changes in testis components volume, cell ultrastructure and histomorphometrical parameters. Control animals had a reestablished and active spermatogenesis at 60 d after heat shock, while animals exposed to magnetic field still showed extensive testicular degeneration. Magnetic field exposure did not change the plasma testosterone. In conclusion, extremely low-frequency magnetic field may be harmful to fertility recovery in males affected by reversible testicular damage.

<http://www.ncbi.nlm.nih.gov/pubmed/23781997?dopt=Abstract>

Summary

90 RF Studies referenced. The following observations and effects were noted

| | | |
|-----------|---|--|
| [AD] (1) | = | Auditory dysfunction |
| [AP] (13) | = | Apoptosis (Cell Death) |
| [BC] (1) | = | Breast Cancer |
| [BM] (8) | = | Behavioural Modification/Cognitive Function Impairment |
| [BT] (8) | = | Brain Tumours |
| [CA] (2) | = | Calcium Influx/Efflux |
| [CI] (16) | = | Cell Irregularities/Cell Damage |
| [CR] (1) | = | Circadian Rhythm Disruption |
| [DD] (21) | = | DNA Damage/Mutagenic/Genotoxic |
| [EA] (19) | = | Altered Enzyme Activity/Protein Damage/Altered Protein Levels |
| [EM] (6) | = | Effects Mitochondria |
| [FA] (1) | = | Fatigue |
| [GE] (7) | = | Altered Gene Expression |
| [GM] (1) | = | Altered Glucose Metabolism |
| [HA] (4) | = | Headaches |
| [HRV] (1) | = | Heart Rate Variability |
| [IN] (2) | = | Inflammation |
| [IS] (3) | = | Insomnia |
| [MC] (1) | = | Miscarriage (pregnancy) |
| [MR] (9) | = | Memory Retention/Impairment issues |
| [OS] (32) | = | Oxidative Stress/ROS/Super Oxides, Free Radicals, lipid peroxidation |
| [RH] (1) | = | Impaired/Reduced Healing |
| [SE] (10) | = | Sperm Effects/Sperm Damage - Viability/Motility issues |
| [SP] (2) | = | Sleep Performance Issues |
| [TN] (1) | = | Tinnitus |
| [TP] (3) | = | Tumour Promoter |

There are many studies, implicating oxidative stress and free radical breakdown products in generating pathophysiological effects in the presence of EMF exposure.

It is true that some of the biological effects are indeterminate as to whether they will lead to long term health effects. Altered gene and protein expression can occur naturally as a result of cells dealing with any number of environmental changes. Without doing long term studies it is not possible to know what the effect may translate to in many cases.

Apoptosis also occurs naturally as cells become damaged or have functional problems however the incidence of apoptosis also correlates with the level of accumulated injury. (Higami Y et al. 2000) Increased Apoptosis may also be a contributor to premature aging.

Behavioural modification and cognitive functional impairments are temporary in nature when exposures are of short duration but what about if exposures are chronic and long term or when an exposed child's brain is developing? There is a real possibility that chronic exposure could lead to the early onset of dementia/Alzheimer's disease which at this stage is irreversible.

Other effects like insomnia, headaches and tinnitus could be considered as nuisance effects however "*Annoyance or discomfort may not be pathological per se but, if substantiated, can affect the physical and mental well being of a person and the resultant effect should be **considered as a potential health hazard.***" (ICNIRP 2002 statement). Insomnia (lack of good sleep), if persistent may lead to a host of cascading health problems that can lead to a premature death.

DNA damage is something that is very concerning especially in sperm as this can lead to congenital defects in later generations.

Inflammation also has negative effects if it is persistent. Chronic inflammation can destroy brain cells, can induce auto immune reactions that lead to the development of allergies, damage intestinal lining, cause eczema, stroke etc.

Brain cancer, breast cancer are most definitely health problems that are invariably fatal resulting in dramatically shortened lives. Although the evidence is classified as "limited" at this time it is building.