Powerfrequency EMFs and Health Risks

This article is separated into 12 sections, each of which can be individually downloaded. It is a 'work in progress' incorporating new information whenever time permits.

Section 10

Obesity, neurological and psychological effects, pain, thyroid, animal and other effects

1. Introduction; electricity consumption; measuring meaningful exposure; static electric field from high voltage direct current transmission; precautionary recommendations; EMFs interacting with the environment or other substances; geomagnetic field (GMF) changes; a French study in 2009; residential exposure; mitigating biological effects; campaigning organisations
2. Occupational exposure; occupational research
3. Cancer; leukaemia; Sources of magnetic field exposure and cancer risk; brain cancer; breast cancer; neuroblastoma; other cancer; immune system effects; tamoxifen, doxorubicin and other drug effects; similarities to other chemical effects
4. Cellular changes and potential mechanisms; DNA breaks and changes; EEG changes; other cellular changes; potential mechanisms for interaction between exogenous EMFs and biological processes; free radical effects; effects on other cellular processes; airborne pollutant effects; other potential synergistic effects
5. MRI; contrast enhancement; individual experiences of reactions; MRI vs CT; cardiac scan; the European Physical Agents Directive; research
6. Electronic surveillance systems in shops, airports, libraries, etc.
7. Light at Night and Melatonin; circadian rhythm disruption; clock genes; plant, animal and insect effects
8. General reproductive effects; miscarriage and other effects of female exposure; powerfrequency exposure and male sperm; protective treatments
9. Other effects; ageing; amyotrophic lateral sclerosis (ALS); animal effects; anxiety; asthma; autism; bacteria; behaviour changes; birth defects; effects on blood; bone changes; brain damage; cardiovascular effects; dementia; developmental effects; depression and suicide; EEG changes; energy metabolism; eye effects; gastric effects; genetic defects; hearing effects; heart; insulin and electric fields; interference problems; kidney effects; learning and memory effects; lung, spleen and liver; medical implants; mental health problems; nervous system; neurobehavioural effects; neurodegenerative effects
10. Other effects; obesity; olfactory effects; other neurological and psychological effects; pain perception; Parkinson's disease; protective effects of EMFs; skin;

sleep; synergistic effects; teeth; thyroid; weight change; some experimental problems; government advisory bodies

11. Positive health effects; apoptosis; cancer treatment; cell survival and differentiation; wound healing

12. References – 937 references

Obesity

Prenatal exposure to high magnetic fields was associated with an increased risk of being obese in offspring. Participating women carried a meter measuring MF levels during pregnancy and733 of their children were followed up to 13 years of age. The researchers (DK Li 2012) concluded that "*maternal exposure to high MF during pregnancy may be a new and previously unknown factor contributing to the world-wide epidemic of childhood obesity/overweight.*"

Olfactory effects

Reyes-Guerrero (2010) found that EMFs affected gene expression in the olfactory bulb of female, but not male rats. It was a biphasic effect which increased during diestrous and decreased during oestrous, clearly a hormonal effect.

Other neurological and psychological effects

Acute exposure to 60 Hz magnetic fields changed the learning ability of rats (Lai 1998, Cui 2012). The 1998 study found that such an exposure also affected motor performance. In another experiment (Fu 2008), spatial recognition was seen to be impaired by exposure to ELF magnetic fields in mice running a Y-maze, though their motor activity was not affected. Interestingly, Liu (2008) found that chronic exposure to ELF MF improved long-term memory without affecting short-term memory or motor activity. Lai hypothesised that the magnetic fields affected the cholinergic systems. Choline is a chemical precursor or "building block" needed to produce the neurotransmitter acetylcholine, and research suggests that memory, intelligence and mood are mediated at least in part by acetylcholine metabolism in the brain.

The study by Chung (2015) demonstrated that exposure to ELF-MFs may evoke the changes in the levels of biogenic amines, amino acid and NO neurotransmitters in the brain although the extent and property vary with the brain areas.

Duan (2014) found that ELF-EMF exposure increased JNK1/2 phosphorylation through the activated ASK1, which plays a pivotal role in hippocampal neuronal cell death, thus causing cognitive impairment.

Singh & Lai (1998) found both DNA-protein and DNA-DNA crosslinks are formed in brain cells of rats after acute exposure to a 60 Hz magnetic field.

Newly hatched chicks that had been exposed in the egg to magnetic fields had disrupted memory formation compared with unexposed chicks, particularly when the chicks were stressed and isolated (Sun 2010).

Capone (2009) found that pulsed EMFs could produce functional changes in the human brain. EEG changes have been found as a response to exposure to magnetic fields by Carrubba (2008a) and Carrubba & Marino (2008b). The team found that the stimulus-related change in brain electrical activity persisted whilst the stimulus was present. They also found changes when the

subjects were exposed to light and sound. They were unsure as to whether these changes would have a metabolic effect. In two other studies, the team found EEG changes in all of the subjects (2008c) and all but one of the subjects (2007b), which would not have been detected using the traditional linear method of analysis, time averaging. Carrubba (2010) also found exposure to magnetic fields, both at initiation and cessation produced immediate changes in brain electrical activity, suggesting that the fields were detected like ordinary stressors.

The hippocampus which is important in regulating emotions, behaviour, motivation, and memory functions, may be impaired by the negative impacts of EMFs (Teimori 2016).

In a laboratory experiment Graham & M Cook (1999) found that individuals exposed to intermittent 60-Hz magnetic fields showed alterations in traditional EEG sleep parameters indicative of a pattern of poor and disrupted sleep.

Significant changes in different EEG bands caused by locally exposing to ELF-MF in different points of the brain were observed. The changes in the EEG bands were not limited necessarily to the exposure point (Shafiei 2012).

C Cook (2005, 2009) found that alpha activity changed over the occipital-parietal regions of the brain after 5 minutes exposure to ELF magnetic fields.

Chronic exposure (4 hours a day) to ELF magnetic fields was found to create anxiety-like behaviour in laboratory rats by Liu (2008, 2010). Continuous exposure to extremely low frequency magnetic fields significantly induced stress and anxiety-related behaviour in rats (Korpinar 2012).

The nitric oxide pathway seems to be involved in conditions other than depression (see section 9). Exposure to ELF MFs were found to induce obsessive compulsive disorder-like behaviour in mice and the effect appeared to be associated with nitric oxide synthase activation (Salunke 2014).

A study by French (2009) looking at sensations produced by fluctuations in electromagnetic field exposure or the presence of infrasound, found that anomalous sensations were related to measures on the Persinger Personal Philosophy Inventory. The team had used Temporal Lobe Signs (TLS) items only, which are typically associated with temporal lobe epilepsy. This may indicate a physical sensitivity in this part of the brain to electromagnetic field or infrasound variability.

Pain perception

A single exposure of mice to a magnetically shielded environment has been found to attenuate opioid induced analgesia. Repeated exposures of 1 h per day for 10 consecutive days had a more pronounced effect, a maximum analgesic response occurring over days 4-6 of exposure. The results obtained on day 5 were similar to those from a 5 mg/kg dose of morphine (Prato 2005).

Pain sensitivity is, at least in part, affected by magnetic fields, and light can reduce the effective shielding quality of such fields (Koziak 2006).

Mice were found to be sensitive to magnetic fields as low as 0.033 μT, where these reduced the effect of analgesics by 60% (Prato 2013).

Parkinson's disease

Parkinson's disease (PD) is a neurodegenerative disorder characterized by changes in dopaminergic neurons associated with both genetic and environmental factors. Occupational or residential exposure to electromagnetic fields (EMFs) has been recently associated with an increased risk of neurodegenerative diseases; Benassi (2016) proposes that extremely low frequency magnetic field (ELF-MF) may contribute to the development of neurodegenerative diseases, as its interaction with biological systems directly impairs activity in specific areas of the brain.

Protective effects of certain EMFs

An incoherent magnetic field could completely inhibit the effects induced by an extremely low frequency magnetic field of equal or lower intensity (W Sun 2008).

Skin

Biological effects of ELF-EMFs in epidermal keratinocytes were found to be cell type specific (Huang 2014). Exposure to a 0.05 mT and 0.1 mT magnetic field for 1 or 2 hours (but not 4 hours) resulted in significantly increased oxidative stress in human keratinocytes (Calcabrini 2016), thus reducing the capacity for skin healing.

Manni (2002, 2004) found that 50 Hz electromagnetic fields modified cell morphology and interfered with initiation of the signal cascade pathway, in differentiation and cellular adhesion of normal keratinocytes.

Sleep

Workers in electricity substations took longer to fall asleep, slept for less time and had poorer quality of sleep than control subjects (Barsam 2012).

Easy access to electricity and artificial light triggers a measurable reduction in sleep independent of the season (de la Iglesia 2015). Two hunter-gatherer groups in Argentina, one with access to electricity and the other without, were assessed with respect to sleep quantity. In summer, the group with electricity slept for 40 minutes less on average, and in winter for approximately an hour less. De la Iglesia commented *"All the effects we found are probably an underestimation of what we would see in highly industrialised societies where our access to electricity has tremendously disrupted our sleep."*

Synergistic effects

Luukkonen (2011) found that previous exposure to magnetic fields altered cellular responses (including DNA damage, DNA repair rate and micronucleus formation in neuroblastoma cells) to menadione, a potential toxin, and that increased toxicity resulted from this interaction. The effects weren't found following exposure to magnetic fields alone.

The number of apurinic/apyrimidinic sites in human glioma cells induced by MMS or H2O2 is enhanced by exposure to ELF magnetic fields at 5 millitesla (mT). This may occur because such exposure can enhance the activity or lengthen the lifetime of radical pairs (Koyama 2008).

Teeth

Problems with enamel mineralisation were found in a study by Kargul (2011) but as the magnetic field exposures used were 100 and 500μT, it is difficult to see whether this has significance for people. Ince (2012) found that ELF electromagnetic fields together with manganese had a significant effect on the levels of elements in rat teeth, specifically, calcium, zinc, magnesium and phosphorus.

Thyroid

Anselmo (2009) found that rats on a substandard diet had decreased T4 and T3 concentrations when exposed to powerfrequency magnetic fields. It is unclear whether this would produce hypothyroidism, but in countries and population subgroups where malnutrition is most common, reduction in exposure to magnetic fields should be considered as a health promotional measure.

The results of a study by Rajkovic (2005) indicate certain alterations of thyroid and cutaneous mast cells in rats exposed to EMF.

Weight change

Experiments on mice by both Cao [2006] and Hashish [2007] show that mice exposed to power frequency EMFs gradually lost weight, or did not gain weight during pregnancy, or offspring born to exposed dams did not put on weight in comparison with the offspring of unexposed dams. The Hashish study showed that along with the lack of weight gain, there were several other indicators of physiological disturbances, including a decrease in lymphocyte levels.

Some experimental problems

It seems that the tendency of researchers to use cells in a laboratory, where they are not part of a complex living system, and expose them to levels of radiation that would not be encountered in normal living and working, to take one example (of many available) such as Morehouse & Owen (2000) with the lowest exposure level of 12.5 microtesla, seems designed to find no effects. This is a problem that will not go away, until we look more at real people in real settings, however complicated this makes the research. Simplifying the research procedure, purely for reducibility, does not make good science.

Government advisory bodies

The late Dr Ross Adey, one of the world's most respected and senior research scientists stated *"The laboratory evidence for non-thermal effects of powerfrequency fields now constitutes a major body of scientific literature in peer-reviewed journals. It is my personal view that to continue to ignore this work in the course of standard setting is irresponsible to the point of being a public scandal."*

In view of the amount of evidence that supports a link between environmental EMFs and childhood leukaemia, a Cross-Party Inquiry (consisting of MPs from the 3 main political parties) was set up and reported in July 2007.

The report also mentioned the First Interim Assessment of SAGE – the Stakeholder Advisory Group on ELF EMF (published in April 2007), from which the Inquiry draws extensively and a report from WHO – World Health Organisation (published in June 2007). Both of these other bodies recommended the adoption of very low cost measures to reduce public EMF exposure.

The Cross Party Inquiry reported that roughly 0.4% of homes in the UK (around 80,000 homes) have EMF readings of 0.4 μT or above (the level at which it is accepted that health risks are increased). About half of these 'high field homes' are caused by nearby overhead power lines; the rest are caused by net currents, household wiring and electrical appliances.

The Inquiry's recommendations were that the UK Government:-

1. Recognise the potential risks to children's health caused by exposure to EMF and introduce a moratorium on the building of new homes and schools within at least 60 metres of existing High Voltage Overhead Transmission Lines (HVOTL) of 275 kV and 400 kV and on the building of new HVOTL within 60 metres of existing homes and schools and the same within 30 metres from 132 kV, 110 kV and 66 kV lines. The Inquiry also recommends that the Government consider the case for extending this distance to 200 metres for the highest voltage lines and pro-rata for lower voltages.

2. Channel increased funds into research into the association between childhood leukaemia and EMF, to elucidate possible biological mechanisms by increasing the budget (in 2007, roughly a quarter of the £1.1 million annual budget) of the Department of Health's Radiation Research Programme (managed by the Health Protection Agency).

3. Immediately implement SAGE's recommendation to provide more information to the public on the potential risks of EMF exposure, disseminate the SAGE report and the findings of the Cross-Party Inquiry widely in Parliament, enabling the relevant Select Committees (Health, Science and Technology, and Trade and Industry) to decide whether to examine in detail Government policy on EMF exposure and public health. Communicate the findings and recommendations of SAGE and this Inquiry to devolved authorities in Scotland, Wales and Northern Ireland, to help inform debate and policy making across the UK.

4. Protect home owners by allowing them access to information on either i) the proximity of a property (of 60 metres or less) to HVOTL or planned HVOTL or ii) EMF levels inside a property for sale and to implement the measures recommended by the SAGE report to reduce EMFs in the home from household wiring (e.g. recommending 'radial' circuits as standard, as opposed to 'ring main' circuits) and appliances (recommending that equipment manufacturers should investigate whether fields from equipment could be reduced at low cost).

5. Consider the potential health risks of EMF exposure as part of the Government's Energy Review and give full consideration to alternative options, such as local generation, which could contribute to a reduced future need for new HVOTL.

6. Introduce new conditions on licences for electricity transmission and distribution (granted by the Gas and Electricity Markets Authority, GEMA) requiring new and current licence holders to take steps to protect the public from adverse health effects caused by EMF exposure.

Whilst the Inquiry recommended a building moratorium, it was recognised that this would have planning implications. They suggested that the Government could amend the legislation on granting consent for overhead powerlines to:

- Include a requirement for the Secretary of State to consider public health in relation to EMF exposure

- Make Environmental Impact Assessments mandatory for all new HVOTL of 132 kV and above

- Extend the requirements of the EIA Environmental Statement to explicitly consider human health in relation to EMF

- Remove General Permitted Development Rights for upgrades/modification to existing power lines of 132 kV or above within 60 metres of homes and schools, so that Section 37 (of the Electricity Act 1989) consent is also required for these lines