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 8

Reproduction

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

12. References – 937 references

General reproductive effects

A review of studies of EMF exposure (Asghari 2016), both pulsed and continuous (Solek 2017), and effects on both male and female reproduction systems concluded that electromagnetic fields can have destructive effects on sex hormones, gonadal function, foetal development, and pregnancy. The authors suggested that people must be aware of the negative effects of EMFs and recommended that they stay as far away as possible from their origin because of the risks associated with exposure.

Trying to identify what may be the cause of the EMF effect on reproductive organs or gestation can be difficult, as it may be more complex than some of the studies allow for which may be one of the reasons why there are conflicting findings (Lewis 2016).

Magnetic fields were found to decrease reproduction by up to 4.3% in a study by Panagopoulos (2013). The effect increased with increasing field intensities. The decline in reproductive capacity was found to be due to severe DNA damage (DNA fragmentation) and consequent cell death induction.

Light at night inhibited reproductive hormone secretion (Schoech 2013), although not in a consistent fashion between the sexes.

Miscarriage and other effects of female exposure

The California report linked miscarriage with powerfrequency magnetic fields.

The survey carried out in Stoke on Trent, referred to in "Powerfrequency EMFs & Health Risks 3: Cancer", was the second one carried out near two different high-voltage powerlines. Both surveys found highly significant links between proximity to the powerline and the incidence of miscarriage. Auger (2012) found more than a doubling in incidence of term stillbirth for women living closer to 25 metres from a powerline compared to those living more than 100 metres away.

D-K Li (2002, 2017), Lee (2002) and Shamsi Mahmoudabadi (2013) found that exposure to EMFs during pregnancy was linked to an increased risk of miscarriage. Maternal pineal melatonin readily crosses the placenta in women. As melatonin protects nuclear DNA from oxidative damage, low levels may lead to foetal cellular damage which may then be aborted by the body's normal mechanisms of getting rid of non-viable foetuses. This may be one of the mechanisms to explain the higher risk of miscarriage in women exposed to sudden changes in magnetic field levels. Lee's study found that the link was especially strong where there were high 'transient' fields, that is, where field levels changed rapidly in a short period of time. This type of exposure can happen in e.g. electric train travel; working near or passing through anti-theft pillars in shops, etc. Q Wang (2013) found that miscarriage incidence was shown to be positively associated with the maximum alley MF exposure, where the alley was in front of the subjects' houses. Li (2002) also found an increased risk of miscarriage with magnetic field exposure, especially at an early stage of pregnancy (less than 10 weeks) or for women with pre-existing pregnancy problems, especially where the exposure was unusual. Mezei (2006) suggested that the association between maximum magnetic fields and miscarriage are possibly the result of behavioural differences between women with healthy pregnancies and women who experience miscarriages. It is clear that a problematic medical history of pregnancy problems could be a confounder.

Aksen (2006) and Aydin (2009) found changes in the ovary and uterus after exposure to EMFs for over 50 days. Changes in hormone levels in first trimester cells were found after 72 hours of exposure to 0.4 µT (Sun 2010).

Exposure to electromagnetic fields reduced the fertilization rate in an experiment on boar sperm and negatively affected early embryo development when sow oviducts were irradiated (Bernabò 2010). They also altered sperm motility and reduced fertility in rabbits (Roychoudhury 2009), and mice (de Bruyn & de Jager 2010). Exposure to electromagnetic fields during embryonic development caused changes in egg cells affecting their differentiation and maturation, resulting in decreased ovarian reserve leading to infertility or reduced fertility (Ahmadi 2016). Prenatal exposure had many adverse effects on the development of embryos (Su (2014), Bekhite 2016), Makarov & Khmelinskii 2016). Bakacak (2015) and Khaki (2016) concluded that EMF has harmful effects on ovarian follicles or the development of the follicles (Cecconi 2000).

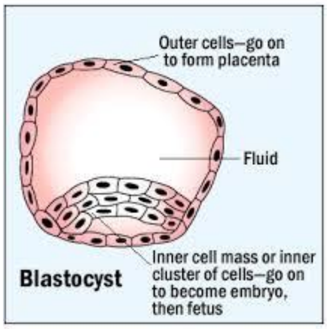
Testicular degeneration in a subset of experimental rats was found by Tenorio (2012) as a result of magnetic field exposure. This may indicate individual susceptibility, which could lead to subfertility or infertility.

A study by Cech (2007, 2008) demonstrated, modelling a woman at 30 weeks pregnancy, that foetal exposure could exceed ICNIRP guidelines, even though the mother's exposure was below them. They suggested that a revision of reference levels might be necessary. They were not looking at potential specific health outcomes, but it may be that these high levels could shed light on some of the findings of other studies.

Tonni (2008) suspected electromagnetic exposure *in utero* to be responsible for rare cancer development.

But women trying to get pregnant have also become aware of the fact that the core problems of male fertility start in the womb. There is a 'window' of testicular development that begins in the growing foetus and ends in the first 6 months after birth. Problems during this time may mean that the baby boy may not be able to produce children. Animal studies by Tenorio (2011, 2012) showed testicular degeneration or developmental delay in a subset of rats exposed to EMFs. The magnitude of the degenerative process varied between those individuals affected, indicating different individual sensitivity to EMF.

Han (2010) found that watching TV during the first 3 months of pregnancy may increase the risk of embryo growth ceasing significantly, in particular for high-risk pregnant women with embryo-growth ceasing history.



Bayat (2012) found that ELF-EMFs changed the number and cellular composition of blastocysts (a structure formed in the early development of mammals, possessing an inner cell mass (ICM) which subsequently forms the embryo).

Living close (within 50 metres) to a residential ELF-EMF source (high voltage cables, overhead power lines, substations or towers) during pregnancy was associated with suboptimal growth in utero, more strongly for females than males (de Vocht 2014, 2014b).

Growth was stimulated in mice exposed to magnetic fields, born of mothers who had likewise been exposed, there was also a possible acceleration of aging (Vallejo & Hidalgo 2012).

Aksen (2006) found changes in the ovary (also Roushangar & Rad 2007) and uterus after exposure to EMFs for over 50 days. Experiments with mice by Hong (2003) and Cao (2006) found that low frequency EMF exposure had some adverse effects on reproduction, including miscarriage, foetal loss and malformation and developmental delay in the offspring. Roshangar (2014) found that exposure to EMF during the developmental period could affect both oocyte differentiation and folliculogenesis and may result in reduced fertility, by decreasing ovarian reservoir.

A study by Cech (2007) demonstrated, modelling a woman at 30 weeks pregnancy, that ***foetal exposure*** could ***exceed*** ICNIRP guidelines, when ***the mother's exposure*** was ***below*** them. They suggested that a revision of reference levels might be necessary. They were not looking at potential specific health outcomes, but it may be that these high levels could shed light on some of the findings of other studies.

Borhani (2011) found that EMF exposure in the preimplantation stage in pregnant mice could have detrimental effects on female mouse fertility and embryo development. Beraldi (2003) found that IVF-derived embryos are more sensitive than natural breeding-generated embryos to ELF-MF, and that this sensitivity occurs earlier in development.

In a mouse study by Gerardi (2016), the average number of offspring per birth was significantly lower in exposed dams compared to the control group and a significantly lower average daily gain of body weight per mouse was observed in exposed pups compared to the control group 7 and 11 days after birth, resulting in a significant reduction of the average body weight per nest.

Pregnant rats were exposed to low levels of magnetic fields (St-Pierre 2008, Fournier 2012). The adult progeny, exposed to 30-50 nanotesla fields displayed learning impairments and showed anomalies in the development of the hippocampus. Exposure to weaker or stronger intensities of the same magnetic fields did not interfere with hippocampal development or behaviour. These findings suggest that there are windows of prenatal exposure to magnetic fields that can result in subtle but permanent alterations in hippocampal microstructure and function that can have lasting effects on behaviour. Sakhnini (2012) also found a pronounced deficit in the learning abilities of the prenatal exposed groups.

EMF exposure affected the production of prolactin in pregnant cows (Rodriguez 2004). Prolactin enables female mammals to produce milk, and also plays an essential role in metabolism, regulation of the immune system, and pancreatic development.

Exposure of Drosophila melanogaster (fruit fly) females at all the development stages weakened the oviposition of these insects in their subsequent generations (Gonet 2009).

Bellieni (2012) found that the induced current in a laptop's power supply, exceeded ICNIRP levels in adults and the unborn babies of pregnant mothers.

Powerfrequency exposure and male sperm

As many as one in five healthy young men between the ages of 18 and 25 produce abnormal sperm counts. Only 5 to 15% of their sperm is good enough to be classed as 'normal' under World Health organisation rules, proving that infertility is not just a female problem. Indeed, among those experiencing difficulty with conception, a male fertility problem is considered important in about 40% of couples.

Why should EMFs affect the movement of sperm? One study points to a possible explanation. Lishko (2010) showed that human sperm move to the egg in an electrically created pathway. This may well be affected by external EMFs. Mice, often used as experimental subjects have much larger sperm (relatively speaking) than humans, so they may not be affected as much, and could explain some of the different laboratory findings. Liu (2015) found that alterations of genomewide methylation and DNMTs expression may play an important role in the biological effects of 50 Hz ELF-EMF exposure.

Rajaei (2009) and Luo (2013) found degeneration and shrinkage of testicular tissue along with a significant increase in apoptotic rate in cells exposed to electromagnetic pulses.

A study by Li (2010) found that men who are exposed to levels of magnetic fields of only 0.16 microtesla (μT) for six or more hours a day were four times as likely to have substandard sperm. VDUs and computers used in a work environment were significantly associated with male infertility (El-Helaly 2010). In offices, the power cables could run underneath the front of desks, and it may be a good idea to move them further from the body in order to reduce EMF exposure.

Kim (2009) found cell apoptosis (cell death) in mouse testicular germ cells from exposure to 14μT 60 Hz magnetic fields. This is a long way above typical background exposure, but is also considerably below ICNIRP guidance levels. Lee's review (2014) concluded *"there is increasing evidence that EL-EMF exposure is involved with germ cell apoptosis in testes"* including proposing the possible mechanism of germ cell apoptosis. Sert (2002) had found that exposure of male rats to a 50 Hz magnetic field could have detrimental effects on testes and sperm, possibly due to a disruption of cell membranes in testes' tissue. Zhang's results (2009) indicate that testicle tissues are damaged by long-term exposure to ELF electromagnetic fields. Tenorio (2011) found a delay in testicular development in offspring born to rats exposed to 60 Hz fields during pregnancy, and for up to 21 days postnatally.

Exposure to electromagnetic fields reduced the fertilization rate in an experiment on boar sperm and negatively affected early embryo development when sow oviducts were irradiated (Bernabò 2010). They also altered sperm motility and reduced fertility in rabbits (Roychoudhury 2009), and mice (de Bruyn & de Jager 2010). Testicular degeneration in a subset of experimental rats was found by Tenorio (2012) as a result of magnetic field exposure. This may indicate individual susceptibilty, which could lead to subfertility or infertility. Significant reductions in sperm count and testosterone were found by Al-Akhras (2006) who concluded that long term exposure to extremely low frequency could have adverse effects on mammalian fertility and reproduction. In a previous study Al-Akhras (2001) had found that fertility was significantly reduced when both male and female rats were exposed before mating and then mated with an unexposed rat.

A study by Li (2010) found that men who are exposed to levels of magnetic fields of only 0.16 microtesla (μT) for six or more hours a day were four times as likely to have substandard sperm. Compromised sperm function leading to a reduction in fertilization rate in boars (Bernabò 2010) and rabbits (Roychoudhury 2009) and mice (Cao 2009, de Bruyn & de Jager 2010) were found when they were exposed to low frequency electromagnetic fields.

Tenorio (2014) found that ELF magnetic field exposure may be harmful to fertility recovery in males affected by reversible testicular damage. Magnetic field exposure induced changes in testis components volume, cell ultrastructure and histomorphometrical parameters.

YW Kim (2009) found cell apoptosis (cell death) in mouse testicular germ cells from exposure to 14μT 60 Hz magnetic fields. This is a long way above typical chronic background exposure, but is also considerably below the guidance levels allowed in the UK. Lee had found the same effect at lower field levels (2004). Zhang's results (2009) indicate that testicle tissues are damaged by long-term exposure to ELF electromagnetic fields. Hong (2005) and Duan (2015) found DNA damage in testicular cells after EMF exposure. Testosterone levels were significantly lower and changes in testes tissues were found in guinea pigs exposed to ELF EMFs (Aydin 2007, Farkhad 2007). Chronic exposure to EMF could decrease male plasma testosterone and T/E2 ratio, and it might possibly affect reproductive functions in males (Z Wang 2016). Zare (2007) found that extremely low frequency magnetic fields could affect the morphology of the liver, kidney and testes of guinea pigs, including atrophied seminiferous tubules and interstitial tissue was found as well as a change in level of Leydig cells (Forgács 2004). Ahangarpour (2009) found an increased level of FSH following chronic exposure to alternating magnetic fields (AMFs), suggesting damage to the seminiferous tubules. Their results suggest that AMFs probably cause dysfunction in the gonadal axis at the hypothalamic-pituitary level in male rats.

In a study by Qi (2015) the diameter of seminiferous tubules was significantly reduced in mice exposed to a 50 Hz magnetic field which could have a detrimental effect on male fertility. The authors also found an increase in incidence of chronic myeloid leukaemia (CML).

Exposure to EMF may result in pathological changes that lead to sub fertility and infertility, concluded Khaki (2008).

HS Kim (2014) found that continuous exposure to a 60 Hz MF might affect duration- and dose-dependent biological processes including apoptotic cell death and spermatogenesis in the male reproductive system. These effects were found at very much higher levels than members of the general population will be exposed to but may be found in some occupational environments.

SS Li (2013) found that short-term ELF-EMF exposure may decrease the reproductive ability of male Drosophila melanogaster.

Static magnetic fields significantly affected the number of sperm abnormalities (Tablado 1998).

Heat is known to damage sperm and reduce fertility. It is worth avoiding the use of saunas and electric blankets if you are a would-be father. These may also emit powerfrequency radiation, so there could be a synergistic effect. It has also been linked to subsequent child's risk of brain tumours (Bunin 2006). Heat damages the genetic material within sperm, which means cancer-causing genetic mutations are passed on to any offspring.

One study by Iorio (2011) found that exposure to ELF EMFs improved sperm motility, suggesting that the stimulatory effect was due to mitochondrial oxidative phosphorylation.

It was found that electromagnetic radiation negatively affected Daphnia fertility. On the average, fertility of the Daphnia in the experimental unit was 26.32% compared to the control. The age of puberty in the experiment increased twice in comparison with the control (Malinina & Somov 2003).

Protective treatments

Pre-treatment of mice with L-carnitine or CoQ10 1h before exposure to magnetic field caused a significant recovery of mice testes damage induced by high magnetic field (Ramadan 2002).