

The Adverse Effects of Electromagnetic fields on Reproduction

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.

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.

Electromagnetic fields (EMFs) are produced by the distribution and use of electricity (low frequency) and mobile telephone and wireless technology (high frequency, radiofrequency or microwaves). There has been increasing concern that EMFs are not as safe as they were first thought to be. Exposure limits were put in place by the government to prevent us getting electric shocks, or being cooked. No acknowledgement by the regulators has been made that health effects are possible from very low levels of exposure.

However, in 1979 Wertheimer & Leeper showed an association between very low levels of magnetic fields and an increased risk of developing childhood leukaemia. Since then, most scientists have questioned the limits set by the government as being too high and, increasingly research is showing that there are significant health effects at low levels of electromagnetic fields (EMFs).

In this article we concentrate on the effects of low and high frequency EMFs on reproduction. We summarise some of the research findings below. The research situation changes frequently, so this is just a 'snapshot' in time.

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.

One paper discussed the effect on growing foetuses of exposure to high and low frequency electromagnetic fields without differentiation between them. Williams & Fletcher ([2010](#)) concluded that *"The fetus is most susceptible to radiation during organogenesis (2-7 weeks after conception) and in the early fetal period (8-15 weeks after conception). Noncancer health effects have not been detected at any stage of gestation after exposure to ionizing radiation of less than 0.05 Gy (5 rad). Spontaneous abortion, growth restriction, and mental retardation may occur at higher exposure levels."*

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

Radiofrequency (microwave) (RF) exposure and reproductive effects

Mobile phones or phone-type exposure and male sperm

Susa & Pavicić (2007) reviewed research into the effects of RF on reproduction. They concluded *“A number of in vivo and in vitro studies indicated that RF fields could interact with charged intracellular macromolecular structures. Results of several laboratory studies on animal models showed how the RF fields could affect the mammalian reproductive system and sperm cells. Inasmuch as, in normal physiological conditions spermatogenesis is a balanced process of division, maturation and storage of cells, it is particularly vulnerable to the chemical and physical environmental stimuli. Especially sensitive could be the cytoskeleton, composed of charged proteins; actin, intermedial filaments and microtubules. Cytoskeleton is a functional and structural part of the cell that has important role in the sperm motility, and is actively involved in the morphologic changes that occur during mammalian spermiogenesis.”*

Sperm counts in UK men have fallen by 29% in the last decade. Mobile phones have been used, increasingly, in the last decade and a half. In the annual meeting of the American Society for Reproductive Medicine as early as October 2006, US researchers and doctors in Mumbai, India, reported that the more men used a mobile phone, the worse their sperm count and the poorer the quality of their sperm would be, also reported in the research by Agarwal (2008) and Falzone (2011). Using the phone for more than 4 hours a day caused a 25% drop in the number of sperm produced and only 20% of these looked normal. In a study of males attending an infertility clinic in Poland, Wdowiak (2007) found an increase in the percentage of sperm cells of abnormal structure and a decrease in sperm movement associated with the duration of exposure to mobile phone radiation. Jurewicz (2013) found that using a mobile phone for more than 10 years decreased the percentage of motile sperm cells.

In a study by Mailankot (2009), rats exposed to mobile phones emissions for 1 hour a day for 28 days had impaired semen quality and the authors believed this may impair male fertility. Kesari (2010) found a decrease in sperm count and an increase in apoptosis (Kesari & Behari 2009) after 2 hours a day for 35 days. Celik (2012) found no significant changes after 3 months in the testes parameters they investigated. They did conclude that because of the changes observed, significant changes may occur if the study period were to be extended, though Dasdag (1999) had found changes in the testicular tissue and seminiferous tubular diameter of rats after one month's exposure for 2 hours a day.

Atasoy (2013) found DNA damage and decreased enzyme activity in the testes as a result of RF exposure. They concluded *“These findings raise questions about the safety of radiofrequency exposure from Wi-Fi Internet access devices for growing organisms of reproductive age, with a potential effect on both fertility and the integrity of germ cells.”*

Naziroğlu (2013) found that oxidative stress from exposure to WiFi and mobile phone-induced EMF radiation is a significant mechanism affecting male and female reproductive systems, though not necessarily resulting in infertility.

A study by Lukac (2011) indicated a negative time-dependent effect of 1800 MHz RF-EMW radiation on bovine spermatozoa motility. Radiofrequency EMFs produced genotoxicity through oxidative DNA base damage in male germ cells (Liu 2013).

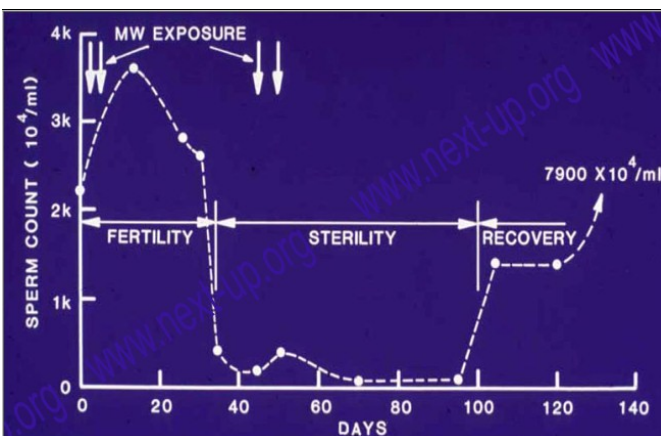
Although we cannot assume that what happens to animals in a laboratory experiment, will also happen to human beings living their normal lives, rat biology is surprisingly similar in many ways to human. If the same thing *is* true for human beings, it may well be worth while considering taking precautions in case. A review of 11 studies of human males showed that

mobile phone use is possibly associated with a number of deleterious effects on the spermatozoa (Dama & Bhat [2013](#)).

Sperm head abnormalities were found as a result of exposure from mobile phone base stations (Otitoloju [2010](#)). The effects were dose-dependent.

Two studies looking at occupational exposure to RF in the Norwegian navy (Møllerløyken [2008](#), Baste [2008](#)) showed an increased risk of infertility in men exposed to radiofrequency fields; the higher the exposure, the greater the risk for infertility. Where children were born to exposed men, there were a greater number of girls born than boys. Ye ([2007](#)) found that radar radiation damages sperm quality, as shown in the reduction of sperm motility and elevation of sperm abnormality. Male RF heater operators experienced changes in semen quality and hormonal differences including a slightly higher mean follicle-stimulating hormone level (Grajewski [2000](#)).

We cannot recommend that men carry a phone in their front trouser pockets. Fejes ([2005](#)), Aitken ([2005](#)), Eroglu ([2006](#)), Yan ([2007](#)), Agarwal ([2008](#), [2009](#)), Falzone ([2008](#)) Gutsch (2011) and Ghanbari ([2014](#)) concluded that usage of mobile phones, exposure to mobile phone signals, or storage of a mobile phone close to the testes affected sperm counts, movement, viability and structure. *"In addition to these acute adverse effects of electromagnetic radiation (EMR) on sperm motility, long-term EMR exposure may lead to behavioural or structural changes of the male germ cell. These effects may be observed later in life, and they are to be investigated more seriously."*



The graph on the left is taken from a study by C K Chou (from an article in Chinese). It shows clearly that the effect of microwave exposure on sperm persists for a considerable time, not just for the duration of the exposure.

De Iuliis ([2009](#)) found not only changes in movement and vitality of human spermatozoa exposed to radiofrequency EMFs, but also DNA fragmentation. Avendano ([2012](#)) also found these effects on in vitro samples of sperm exposed for 4 hours to a wireless internet-connected laptop. Changes in DNA may not only affect any children born after such a change, DNA changes can be inheritable, and the changes may affect future generations in ways that are completely unpredictable. Such fragmentation is not always found (Ogawa [2009](#), Sommer [2009](#)).

A review of the studies by Desai ([2009](#)) concluded that RF EMFs from mobile phones might affect the fertilising potential of sperm. It was concluded that microwave exposure could adversely affect male fertility (Kumar [2011](#), [2012](#)) though the mechanism remains unclear (Falzone [2010](#)). A review of studies (La Vignera [2012](#)) on human sperm and human exposure to RFs concluded that RF reduced sperm concentration, motility, morphology and vitality, and the damage was directly related to the length of mobile phone use.

Fructose is an important component in semen that facilitates sperm movement. A significant drop in fructose levels was observed in rabbits exposed to pulsed radio frequency emitted by a mobile phone kept in the standby position, affecting sperm motility (Salama [2009](#)). Another study (Salama [2010](#)) showed that standby signals could affect testicular function and structure,

although some of the results could do with careful checking, as there seem some odd claims. The team also found changes in sexual behaviour including ejaculatory success (Salama [2010](#)).

Kesari ([2011](#)) and Kumar ([2011](#)) found many changes in fertility patterns following mobile phone exposure, which seemed to arise as a result of increased reactive oxygen species (ROS). Kesari ([2012](#)) believes that the reduction in testosterone, the increase in caspase-3 and distortion in spermatozoa could be caused by an overproduction of ROS under mobile phone radiation exposure. The study concludes that there is a significant effect of microwave radiations on the reproductive pattern in male rats. Meo ([2010](#)) also found a reduction in testosterone levels which they felt could have devastating implications for reproductive and general health.

Reproductive hormone levels were disturbed as a result of RF-EMF exposure which could possibly affect reproductive functions. Testosterone and inhibin B concentrations as a fertility marker and spermatogenesis were decreased significantly (Sepehrimanesh [2013](#)).

Rats exposed to RF exhibited a disruption of circadian rhythms, decreased testosterone levels, lower daily sperm production and sperm motility, depending at which point in the circadian rhythm they were exposed (Qin [2014](#)).

Radiofrequency electromagnetic fields such as that from a mobile phone had a negative effect on testicular architecture and enzymatic activity (Al-Damegh [2012](#)) in rats.

Panagopoulos (2004) found that exposure to voice messages decreases the reproductive capacity of both male and female *Drosophila Melanogaster* by 50%-60%, whereas the corresponding nonspeaking field emission decreases the reproductive capacity by 15%-20%. The authors suggested that this field-radiation decreases the rate of cellular processes during gonad development in insects.

However, research does not always find evidence of effects. In a study by Ribeiro ([2007](#)), rats exposed to GSM phone radiation at just over 1800 MHz showed no changes in testicular function, neither were there effects on rat spermatogenesis found by Lee ([2011](#)) as a result of CDMA and WCDMA exposure simultaneously combined.

In view of the fact that foetal testicular development occurs in the first 6 months of pregnancy, it may be worth pregnant women being very careful where they carry a mobile when not in use.

Radiofrequency exposure and effects on ovaries

Gul ([2009](#)) found that intrauterine exposure to RF radiation had a toxic effect on rat ovaries, and concluded that *"the microwaves of mobile phones might decrease the number of follicles in rats by several known and, no doubt, countless unknown mechanisms."*

A Chinese study (Xu [2009](#)) showed toxic changes to female rats' reproductive organs with exposure to RF radiation. However, the frequency (30 MHz) used experimentally is likely to be from military radar and uncommonly encountered, and at signal levels where an individual, to be exposed, would have to be working nearby, or in the main beam.

Margaritis ([2013](#)) found that RF EMFs had statistically significant effects on *Drosophila* flies regarding fecundity and cell death. The EMF sources included GSM 900/1800 MHz mobile phone, 1880-1900 MHz DECT wireless base unit, DECT wireless handset, mobile phone-DECT handset combination, 2.44 GHz wireless network (WiFi), 2.44 GHz blue tooth, 92.8 MHz FM generator, 27.15 MHz baby monitor, 900 MHz CW RF generator and microwave oven's 2.44 GHz RF and magnetic field components.

Radiofrequency exposure and effects during pregnancy

Han (2010) found that watching TV and using a mobile phone 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. Lee (2009) found that a combined exposure to CDMA and WCDMA RF had no effect on developing mouse foetuses.

Ferreira (2006) found that exposure to RF during pregnancy resulted in damage to the tissue that makes blood cells, though the mechanism was unknown. A study by Haghani (2013) found that prenatal mobile phone exposure results in altered electrophysiological properties of Purkinje neurons, in the cerebellum in the brain of rat offspring. The authors were uncertain as to whether the changes were severe enough to alter cerebellum-dependent functional tasks.

Deaths of embryos after exposure in the egg rose from 16% (unexposed eggs) to 75% (exposed to mobile phone electric field (Grigoriev 2003)).

Some laboratory experiments use creatures further away on the evolutionary ladder from us than rats. This may make the experiments non-comparable to human experience; but the fact that there is a change at all in the biology of living systems may give us pause for thought.

De Pomerai found changes in growth rate and maturation in the reproductive stage of nematode worms, when the larvae were exposed to weak microwave fields (2002), and in an experiment on flies, Dr Reba Goodman of Columbia University found that 2 hours mobile phone exposure for 10 days caused significant changes in reproductive genes and cell division (Blank & Goodman 1997).

Magras & Xenos (1997) carried out a series of experiments following 5 successive matings of mice exposed to RF throughout their lifetimes. They found a progressive decrease in the number of newborns per dam was observed, which ended in irreversible infertility.

General reproductive effects

Trying to identify what may be the cause of the 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.

Panagopoulos' team (2007) found that when looking at the reproductive capacity of flies, 900 MHz radiation was more bioactive than 1800 MHz. It is interesting that the experiment included only head exposure. It may be that positioning the radiating source nearer to gonads may have had a different effect, explaining some of the conflicting findings in different studies.

Powerfrequency exposure and reproductive problems

Powerfrequency exposure and male sperm

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 2010) were found when they were exposed to low frequency electromagnetic fields.

Tenorio (2013) 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 14 μ T 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) 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 (Farkhad 2007).

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.

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 (2010) found that exposure to ELF EMFs improved sperm motility, suggesting that the stimulatory effect was due to mitochondrial oxidative phosphorylation.

Protective treatments

Pretreatment 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).

Miscarriage, foetal damage, and other findings

Two surveys carried out in Stoke on Trent, near two different high-voltage powerlines found highly significant links between proximity to the powerlines and the incidence of miscarriage.

D-K Li (2002), Lee (2002) and Shamsi Mahmoudabadi (2013) found that exposure to EMFs during pregnancy was linked to an increased risk of miscarriage. 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.

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.

Minor skeletal foetal anomalies and increased skeletal ossification, possibly indicating an accelerated prenatal development was found in rats exposed to magnetic fields, at higher levels than are normally found (Mevisen 1994).

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 www.emfields.org

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. Farrell ([1997](#)) found that weak EMFs could induce morphological abnormalities in developing chick embryos, but that the genetic composition of the breeding stock determined the susceptibility of any given flock to EMF-induced abnormalities.

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.