

Discussing mobile phone safety with young people

Abstract

The UK Chief Medical Officers recommend that children and young people under the age of 16 years use mobile phones for essential purposes only. But many young people use their mobile or smart phones throughout the day and keep them switched on close to their bodies during the night. Simple steps to reduce exposure to the electromagnetic fields emitted from wireless gadgets may help to protect long-term health. Raising awareness of wireless technology safety allows young people to make informed choices and to take responsibility for this area of their health and wellbeing.

Key words

■ Mobile phone ■ Wireless ■ Health ■ Safety
 ■ Young people ■ Health promotion

Most teenagers now own a mobile or smart phone, as do an increasing number of those aged 5 years and up (Ofcom, 2011). Teenagers appear to prefer texting to calling. In the US, in 2010, an average teenager would send more than 3000 texts and spend 646 minutes speaking on his/her phone per month (Nielsen, 2010). Use also includes accessing the internet, e-mailing, taking photos, playing games, listening to music and downloading files or applications. The UK Chief Medical Officers (DH, 2011) and NHS Choices (2010) recommend that children and young people use a mobile phone only if absolutely necessary or for essential purposes, and to keep calls short. Either these messages are not getting through, or they are to a great extent being ignored.

Children and young people are considered to be at increased risk of any potential adverse effects from the microwave, radiofrequency electromagnetic fields emitted from mobile communication devices. Children are predicted to absorb more microwaves into their brains and bodies than adults do (around 900% more into bone marrow (Christ et al, 2010)). Young people's bodies are still developing, their cells are dividing more, they have thinner skulls and their brains are more conductive.

In May 2011, the Council of Europe called on governments to put in place information and awareness-raising campaigns on the risks of potentially harmful long-term biological effects of radiofrequency electromagnetic fields on human health, especially targeting children, teenagers and young people of reproductive age (see *Further information*).

Discussions with young people in school could begin with asking how they currently use their gadgets (if they have them), providing some evidence for safety concerns, and positive steps that could be taken to reduce microwave exposures. Suggestions are listed in *Table 1*.

Evidence for safety concerns Decreased fertility

Several studies have found that as men's use of a mobile phone increases, their sperm count, sperm motility, sperm viability and numbers with normal shape decreases (Vignera et al, 2011). For example, Agarwal et al (2008) found a 19% decrease in normal sperm shape, a 31% decrease in sperm count and a 13% decrease in motility for men who used a mobile phone for 2–4 hours a day compared to non-users. Human sperm in the laboratory also respond to mobile phone electromagnetic fields with decreased motility, viability and increased free radicals (or oxidative stress). Even exposures to a mobile phone signal for 5 minutes decreases sperm motility (15% increase in non-motile sperm (Erogul et al, 2006)). Mobile phone electromagnetic fields can also damage human sperm DNA, the genetic material used to produce the next generation of children (De Iulii et al, 2009). Low strength signals from a mobile phone in standby for several hours a day can decrease sperm count (61%), sperm motility (11%) and the diameter of the seminiferous tubules in rabbits after 8–10 weeks (the time taken for new sperm to develop (Salama et al, 2010)). In standby a mobile phone still emits radiofrequency pulses to communicate with nearby base stations. Avendaño et al (2010) found that human sperm placed next to a Wi-Fi-enabled laptop for 4 hours had fragmented DNA and an increase in sperm immotility. *[The 6 fertility percentages above have been calculated by the author from the data available in the articles as referenced. Other data are quoted directly by the author from the referenced articles.]*

Several fertility researchers, including De Iulii et al (2009) and Avendaño et al (2010) have recommended that males should not keep their phones in their trouser pocket or hold their phones or wireless computers near to reproductive organs. The Radiation Research Trust has a 'Save the Male' campaign, calling for men not to keep their mobile phones in their pockets (*Figure 1*).

The Vienna Medical Association has warned that sending text messages under the school desk could damage fertility (Wiener Ärztekammer, 2005). A recent survey and census of mobile phone use by pupils in schools (aged 10–14

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years) found that a large proportion of young people were ignoring the mobile phone rules (Redmayne et al, 2011). A total of 43% of the pupils admitted to the private use of a mobile phone in class and 42% reported texting from inside a pocket up to 120 times a day. Furthermore, 54% of pupils carried a mobile phone switched on in their pocket for at least 6 hours a day. The authors stated that (Redmayne et al, 2011):

‘There is sufficient evidence, supported by recommendations from fertility researchers and governmental bodies, to make it advisable for schools to have and enforce policies that remove cell phones from students’ pockets during school.’

For this teachers would need to be aware of and support school policy. School nurses could assist by explaining safety concerns to students, parents and teachers.

For females, there is the potential for damage to DNA in the ovaries following microwave exposures, although data is lacking. Divan et al (2010) found that using a mobile phone while pregnant was associated with an increased risk of behavioural problems in the children at age 7 years; mobile phones can increase foetal heart rates in utero (Rezk et al, 2008). In rats, mobile phone-like exposures during pregnancy have altered organ development (Pyrpasopoulou et al, 2004), decreased the number of cells in some brain regions (Odaci et al, 2008) and reduced the number of ovarian follicles in female offspring (Gul et al, 2009). Injection of blood serum from microwave-treated rats into pregnant rats increased offspring mortality and delayed development (Lyaginskaja et al, 2010).

Changes in the brain

Electroencephalogram (EEG) recordings have shown that mobile phones can alter human brain activity. Signals from Wi-Fi transmitters also alter electrical activity in the brain of young adults and decrease a measure of attention in young men when carrying out a memory task (Papageorgiou et al, 2011; Maganioti et al, 2010). Electrical activity is not only central to brain function, but it also influences brain development.

Results from studies with mobile phones on human cognition have been mixed, with some finding decreased reaction times, some improved responses and others no effect (Fragopoulou and Margaritis, 2010). In animals, controlled mobile phone exposures over time have been found to decrease learning and memory abilities (Fragopoulou and Margaritis, 2010), even from as little as 2 hours a week (Nittby et al, 2008). A single 2 hour exposure to a mobile phone was associated with damaged neurones in the brain of rats, and an increased movement of molecules into the brain through the blood-brain-barrier (Salford et al, 2010).

There is evidence that mobile communication technologies may have adverse effects on brain development, cognition and long-term brain health.



Figure 1. 'Save the Male' campaign poster

Blood and electrohypersensitivity

Mobile phone signals can trigger a range of immune responses (Johansson, 2009) as well as other changes within the blood and circulatory system. For example, mobile phones can decrease the ability of human haemoglobin to carry oxygen in the blood by altering its molecular structure (Mousavy et al, 2009).

Havas et al (2010) found that some individuals experience abnormally high and irregular heart rates close to cordless phone base stations (Havas et al, 2010). Some people describe increased sensitivity to electromagnetic fields (electrohypersensitivity), with symptoms such as headaches, dizziness, nausea and rashes. While there are differing views on electrohypersensitivity in the scientific literature, there is evidence of clear responses to an electromagnetic field under carefully controlled and blind conditions (McCarty et al, 2011). Further, well-designed studies are needed to better understand this heterogeneous condition. It is worth being aware that some young people may feel ill close to wireless communication technologies.

Tumours

In May, the World Health Organization, International Agency for Research on Cancer, classified radiofrequency radiation as a possible human carcinogen (Baan et al, 2011).

A number of studies now find an increased risk of certain head tumours associated with the use of mobile phones for greater than 10 years (Hardell, 2010).

Table 1. Safety tips for students

- Limit your use of a mobile, smart or cordless phone as much as possible. Use a wired landline phone or wired internet connection when you can. Wired is safest.
- Completely switch off mobile or smart phones and Wi-Fi transmitters when not in use. Wi-Fi can be switched off on a laptop, tablet computer, or notebook when it is not needed, as can wireless routers.
- Keep your phone away from you. If you use a mobile phone for calls, use an air tube headset or speakerphone mode. Mobile phone manuals ask you to keep phones away from the head and body. Texting is safer, but hold the phone away from you.
- Do not carry your mobile/smart phone on your body, in your pockets or bra. You could put it in a bag. Do not place your phone under your pillow at night or keep it next to your bed unless it is completely switched off (not in standby). Do not place Wi-Fi-enabled computers on your lap, sit away from them.
- Not at full power. When dialling a number, using a mobile in a moving vehicle, or when the signal is poor, the phone is transmitting at full power. Hold the phone away from you until a connection is made. Wait until you have a strong reception before making a call.
- Help to look after your friends and family. Call them on their wired landline number, to reduce their use of wireless phones. Cordless phone base stations emit microwaves 24 hours a day, even when the phone is not in use. Place the base station away from where you sit, sleep or spend a lot of your time (or replace with a wired one). Do not give younger children your mobile or smart phone to use. Try to keep a few metres away from others while on a wireless phone.

Sources: Based on NHS Choices (2010), Vienna Medical Association (Wiener Ärztekammer, 2005), International Commission for Electromagnetic Safety (2010) and the Environmental Health Trust (2010)

Significant increases have been found for cancers of glial cells in the brain, cancers of the auditory nerve, cancers of the salivary glands and eyes (Hardell, 2010; Yakymenko et al, 2011). Hardell and colleagues found increased tumour risks from both mobile phone and cordless phone use for more than 10 years, but the highest risks were in young people who had used a wireless phone for at least a year and who started under the age of 20 years. In a recently reported Danish study, no increased risks of brain tumours were found for early

Key Points

- Discussing mobile phone safety with young people allows them to make informed choices.
- Positive steps can be taken to reduce exposure to microwave electromagnetic fields.
- School nurses can support and recommend safe technology policies in schools by explaining health concerns to students, parents and teachers.

mobile phone subscribers (Frei et al, 2011), although the study had serious limitations (BMJ, 2011).

Heated debates have taken place over methodological errors and possible study biases. Ongoing studies aim to address some of these issues. Yakymenko et al (2011) concluded that:

‘... a number of reports revealed that under certain conditions the irradiation by low intensity microwaves can substantially induce cancer progression in humans and in animal models.’

Mobile phone radiation and other microwaves have damaged human and animal DNA in approximately 50% of studies (Ruediger, 2009). Even at a distance of up to 90 cm a mobile phone signal can damage DNA and fertility in fruit flies (Panagopoulos et al, 2010).

We do not yet know whether texting or using Wi-Fi will increase the risk of cancer. That DNA damage can occur in human cells next to a wireless laptop raises the possibility that Wi-Fi may also be potentially carcinogenic (Avendaño et al, 2010).

Conclusions

More research is needed into the safety of microwave-emitting technologies. We need to understand more about long-term effects and the safety of low-strength signals. We need to understand further why wireless communication technologies affect the body only under certain conditions and not others, as some studies have found no effects.

There are strong social pressures to use ‘smart’ technologies, as well as effective marketing campaigns, and economic, political and commercial drivers. This is a complex and controversial area where potential conflicts of interest need to be taken into account. The precautionary principle is to be used when there is scientific uncertainty, but enough evidence to justify taking action to protect human health, when doing nothing may potentially result in serious harm.

Discussing safer practices with young people is not intended to alarm or worry them, but to help them take positive actions where they can. We do not have control over all microwave exposures in our environment but even small steps may make a substantial difference in health outcomes. Keeping the transmitters in the gadgets away from the body and switched off whenever possible could help. Young people need to know that it is OK to choose wired communication technologies as their future health and wellbeing is important.

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- Agarwal A, Deepinder F, Sharma RK, Ranga G, Li J (2008) Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. *Fertility and Sterility* **89**(1): 124–8
- Avendaño C, Mata A, Juarez Villanueva AM, Martínez VS, Sanchez Sarmiento CA (2010) Laptop expositions affect motility and induce DNA fragmentation in human spermatozoa in vitro by a non-thermal effect: a preliminary report. American Society for Reproductive Medicine 66th Annual Meeting: 0–249
- Baan R, Grosse Y, Lauby-Secretan B et al (2011) Carcinogenicity of radiofrequency electromagnetic fields. *Lancet Oncol* **12**(7): 624–6
- BMJ (2011) Rapid responses. www.bmj.com/content/343/bmj.d6387/reply#bmj_el_271850 (accessed 3 November 2011)
- Department of Health (2011) Mobile phones and base stations. www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_124899.pdf (accessed 4 October 2011)
- Christ A, Gosselin M-C, Christopoulou M, Kühn S, Kuster N (2010) Age-dependent tissue-specific exposure of cell phone users. *Phys Med Biol* **55**: 1767–83
- De Iuliis GN, Newey RJ, King BV, Aitken RJ (2009) Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. *PLoS One* **4**: e6446
- Divan HA, Kheifets L, Obel C, Olsen J (2010) Cell phone use and behavioural problems in young children. *J Epidemiol Community Health* (Epub ahead of print)
- Environmental Health Trust (2010) Ten things you can do to reduce the cancer risk from cell phones. www.disconnectbook.com/cell-phone/10-things-you-can-do-to-reduce-the-cancer-risk-from-cell-phones/ (accessed 2 November 2011)
- Erogul O, Oztas E, Yildirim I, et al (2006) Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study. *Arch Med Res* **37**: 840–43
- Fragopoulou AF, Margaritis LH (2010) Is cognitive function affected by mobile phone radiation exposure? *Eur J Oncol Library* **5**: 261–72
- Frei P, Poulsen AH, Johansen C, Olsen JH, Steding-Jessen M, Schüz J (2011) Use of mobile phones and risk of brain tumours: update of Danish cohort study. *BMJ* **343**: d6387
- Gul A, Celebi H, Ugras S (2009) The effects of microwave emitted by cellular phones on ovarian follicles in rats. *Arch Gynecol Obstet* **280**: 729–33
- Hardell L (2010) Wireless phone use and brain tumour risk. *Eur J Oncol Library* **5**: 363–78
- Havas M, Marrongelle J, Pollner B, Kelley E, Rees CRG, Tully L (2010) Provocation study using heart rate variability shows microwave radiation from 2.4GHz cordless phone affects autonomic nervous system. *Eur J Oncol Library* **5**: 273–300
- International Commission for Electromagnetic Safety (2010) Campaign for safer cell phone use. www.icems.eu/public_education.htm (accessed 3 November 2011)
- Johansson O (2009) Disturbance of the immune system by electromagnetic fields—A potentially underlying cause for cellular damage and tissue repair reduction which could lead to disease and impairment. *Pathophysiology* **16**(2–3): 157–77
- Lyaginskaja AM, Grigoriev YG, Osipov VA, Grigoriev OA, Shafirkin A V (2010) Study of the influence of blood serum from rats exposed to low-level electromagnetic fields on pregnancy and fetal and offspring development. *Biophysics* **55**(6): 1059–66
- McCarty DE, Carrubba S, Chesson AL, Frilot C, Gonzalez-Toledo E, Marino AA (2011) Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. *Int J Neurosci* (Epub ahead of print)
- Maganioti AE, Papageorgiou CC, Hountala CD, Kypriaiou MA,

Further information

Council of Europe

Council of Europe (2011) Resolution 1815 (2011) The potential dangers of electromagnetic fields and their effect on the environment. <http://assembly.coe.int/Mainf.asp?link=/Documents/AdoptedText/ta11/eRES1815.htm> (accessed 4 October 2011)

NHS Choices

NHS Choices (2010) Mobile phone safety—Recommendations. www.nhs.uk/Conditions/Mobile-phone-safety/Pages/Recommendations.aspx (accessed 4 October 2011)

wifiinschools.org.uk

wifiinschools.org.uk (2011) Wireless technologies and young people. A resource for schools. <http://wifiinschools.org.uk/resources/wireless+technologies+and+young+people+Oct2011.pdf> (accessed 4 October 2011)

- Rabavilas AD, Papadimitriou GN (2010) Wi-Fi electromagnetic fields exert gender related alterations on EEG. 6th International workshop on biological effects of electromagnetic fields. www.istanbul.edu.tr/6internatwshopbioeffemf/cd/pdf/poster/WI-FI%20ELECTROMAGNETIC%20FIELDS%20EXERT%20GENDER.pdf (accessed 4 October 2011)
- Mousavy SJ, Riazi GH, Kamarei M, et al (2009) Effects of mobile phone radiofrequency on the structure and function of the normal human haemoglobin. *Int J Biol Macromol* **44**: 278–85
- NHS Choices (2010) Mobile phone safety—Recommendations. www.nhs.uk/Conditions/Mobile-phone-safety/Pages/Recommendations.aspx (accessed 4 October 2011)
- Nielsen.com (2010) U.S. Teen Mobile Report: Calling Yesterday, Texting Today, Using Apps Tomorrow. http://blog.nielsen.com/nielsenwire/online_mobile/u-s-teen-mobile-report-calling-yesterday-texting-today-using-apps-tomorrow/ (accessed 4 October 2011)
- Nittby H, Grafstrom G, Tian DP et al (2008) Cognitive impairment in rats after long-term exposure to GSM-900 mobile phone radiation. *Bioelectromagnetics* **29**: 219–32
- Odaci E, Bas O, Kaplan S (2008) Effects of exposure to a 900MHz electromagnetic field on the dentate gyrus: a stereological and histopathological study. *Brain Res* **1238**: 224–9
- Ofcom (2011) Children and parents: media use and attitudes report. http://stakeholders.ofcom.org.uk/binaries/research/media-literacy/oct2011/Children_and_parents.pdf (accessed 2 November 2011)
- Panagopoulos DJ, Chavdoula ED, Margaritis LH (2010) Bioeffects of mobile telephony radiation in relation to its intensity or distance from the antenna. *Int J Radiat Biol* **86**(5): 345–57
- Papageorgiou CC, Hountala CD, Maganioti AE et al (2011) Effects of Wi-Fi signals on the P300 component of event-related potentials during an auditory Hayling task. *J Integr Neurosci* **10**(2): 189–202
- Pyrpasopoulou A, Kotoula V, Cheva A et al (2004) Bone morphogenic protein expression in newborn kidneys after prenatal exposure to radiofrequency radiation. *Bioelectromagnetics* **25**: 216–27
- Redmayne M, Smith E, Abramson MJ (2011) Adolescent in-school cell phone habits: A census of rules, survey of their effectiveness, and fertility implications. *Reprod Toxicol* (Epub ahead of print)
- Rezk AY, Abdulqawi K, Mustafa RM, Abo El-Azm TM, Al-Inany H (2008) Fetal and neonatal responses following maternal exposure to mobile phones. *Saudi Med J* **29**(2): 218–23
- Ruediger HW (2009) Genotoxic effects of radiofrequency electromagnetic fields. *Pathophysiology* **16**(2–3): 89–102
- Salama N, Kishimoto T, Kanayama H (2010) Effects of exposure to a mobile phone on testicular function and structure in adult rabbit. *Int J Androl* **33**(1): 88–94
- Salford LG, Nittby H, Brun A, Eberhardt J, Malmgren L, Persson BRR (2010) Effects of microwave radiation upon the mammalian blood-brain barrier. *Eur J Oncol Library* **5**: 333–55
- Wiener ärzttekammer (2005) Vienna Medical Association Press Release. www.emfacts.com/weblog/index.php?p=172; www2.aek-wien.at/dlcentre/uploads/plakat_handy_englisch.pdf (accessed 4 October 2011)
- Vignera SL, Condorelli RA, Vicari E, D'Agata R, Calogero AE (2011) Effects of the exposure to mobile phones on male reproduction: a review of the literature. *J Androl* (Epub ahead of print)
- Yakymenko I, Sidorik E, Kyrylenko S, Chekhun V (2011) Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. *Exp Oncol* **33**(2): 62–70