



Health Physics Society
Specialists in Radiation Safety

Mobile Telephones

Kenneth R. Foster, University of Pennsylvania

To date, no adverse health effects have been established for mobile phone use. However, epidemiology data regarding long-term (more than 10 years) use of mobile phones (also known as “wireless” or “cell” phones) are sparse and unreliable and do not permit conclusions to be drawn about possible risks from long-term use of mobile phones.

Technical Background

Wireless telephone systems operate in the radiofrequency (RF) portion of the electromagnetic spectrum (Figure 1). The exact frequency at which a handset operates depends on the company, the geographic location, and other factors. Most wireless telephone services operate at frequencies between 850 and 2,000 MHz, al-

though other frequency ranges are coming into use as governments set aside additional spectrum for wireless communications.

Other familiar equipment uses *RF energy** in this general frequency range, typically at low power levels. This includes wireless Internet (Wi-Fi) routers and Bluetooth systems used to connect devices to personal computers.

Mobile phones emit radiation, in the technical sense that the RF energy travels from the handset into space. However, this radiation has insufficient energy to disrupt chemical bonds (its *photons* cannot ionize atoms) so it is called *nonionizing*. Similarly, infrared light from a heat lamp or microwaves in a microwave oven are forms of nonionizing radiation. By contrast, x rays (like those from hospital imaging

THE ELECTROMAGNETIC SPECTRUM

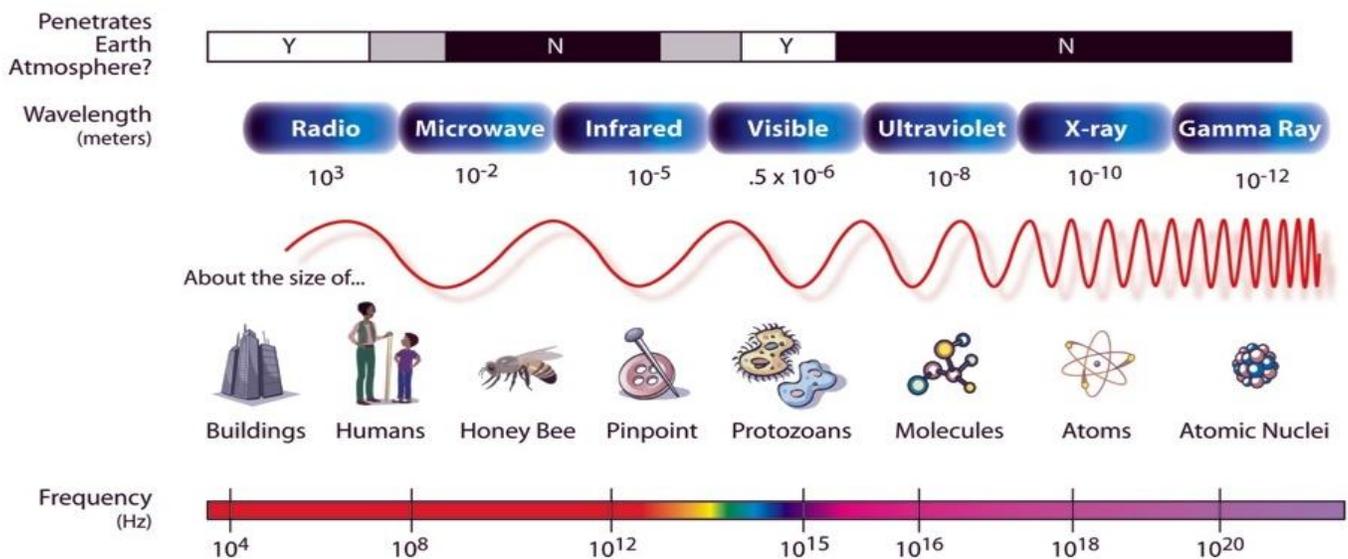


Figure 1

Courtesy of NASA and the American Society for Photobiology (http://www.kumc.edu/POL/ASP_Home/aspkids/aspkids.html)

*Words in italics are defined in the Glossary on page 4.

equipment) and particles (like those from nuclear reactions) are forms of *ionizing radiation*. Ionizing radiation can disrupt chemical bonds and is a cause of damage to tissue. The potential biological effects and hazards of nonionizing (radiofrequency) and ionizing (x ray) radiation are different.

Health Effects

The question of adverse health effects from mobile phones has been studied by scientists and health agencies since the early 1990s. In response to public concerns, industry and governments have supported numerous animal and human studies, and there is now a large amount of scientific literature.

These reports agree that available evidence does not show that use of mobile phones or exposure to emissions from their base stations (cell towers) causes brain cancer or any other health effect. The literature is not entirely consistent though. Overall epidemiology study results are negative, but there is a scattering of weak associations between long-term use of mobile phones and some forms of brain tumors. Health agencies are undecided about the significance of such findings.

It is well established that excessive exposure to RF energy at high power levels is potentially hazardous, principally due to excessive heating of tissue. Hazards include skin burns and other thermal damage to tissue, *cataracts*, and physiological effects resulting from excessive heat deposition in the body. Mobile phones, however, operate at *power* levels that are far too low to result in such thermal hazards.

To guard against hazards from excessive exposure to RF energy, exposure guidelines have been developed by the IEEE (formerly the Institute of Electrical and Electronics Engineers, Inc.) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The IEEE's most recently revised standard was published in March 2010 (IEEE 2010). The ICNIRP guidelines, published in 1998, are endorsed by the World Health Organization (ICNIRP 1998).



photo courtesy of Mary A. Walchuk

Both the IEEE and ICNIRP guidelines are principally designed to protect against thermal hazards. They were developed after careful review of the scientific literature to identify all potential hazards of RF energy to humans from acute (short-term) or chronic (long-term, low-level) exposure. Both IEEE and ICNIRP have acknowledged some reported biological effects from RF energy at exposures below their guidelines. However, both bodies consider some of these reports unusable when developing exposure guidelines due to technical problems with the studies such as inadequate exposure assessment, the inability of a study to be independently confirmed, or lack of apparent health significance of a reported effect.

Brain Cancer and Use of Mobile Phones

The issue most frequently discussed is a possible link between RF exposure and brain cancer.

The most extensive and best designed of the epidemiology studies is a series called Interphone, administered by the International Agency for Research on Cancer.

Together, the Interphone studies encompassed 13 countries with a combined population of over 46 million people aged between 30 and 59 who resided in the study areas and who were diagnosed with one of several kinds of tumors in the head (either cancerous or noncancerous) between 2000 and 2004. These studies compared approximately 6,400 patients with one of four kinds of tumors, including brain tumors, with approximately 7,600 healthy controls (Cardis et al. 2007).

In May 2010, the summary (combined) results of the Interphone study were published, focusing on two brain tumors (glioma and meningioma) (Interphone 2010). The study concluded: "Overall, no increase in risk of glioma or meningioma was observed with use of mobile phones. There were suggestions of an increased risk of glioma at the highest exposure levels, but biases and error prevent a causal interpretation. The possible effects of long-term heavy use of mobile phones require further

investigation.” Because of the difficulty in determining a subject’s exposure given the rapidly evolving nature of the technology, such studies will be difficult to do and will probably always be open to varying interpretation. Nevertheless, the failure of this large and well-planned study to detect increased risk after shorter-term use (less than 10 years) is reassuring.

Long-term animal studies involving extended exposures to RF energy provide “no consistent evidence that exposures to RF energy at non-thermal intensities causes or promotes cancer” (Moulder et al. 2005) and there is no accepted mechanism by which RF fields at levels produced by mobile phones can produce biological effects apart from those caused by heating (Foster 2000). Both considerations have led health agencies to be cautious in accepting the weak statistical associations that appear in some of the epidemiology studies as evidence that exposure to mobile phones actually caused disease.

Recent Expert Assessments

1. The European Commission Scientific Committee on Emerging and Newly Identified Health Risks (2007)

[N]o health effect has been consistently demonstrated [from RF energy exposure] at exposure levels below the ICNIRP limits established in 1998. The data for this evaluation is limited, especially for long-term, low-level exposure.

2. Swedish Radiation Protection Authority (2008)

Short-term use of mobile phones does not appear to be associated with brain or head and neck cancer risks in adults. Other outcomes have not been studied. In particular, for acoustic neuroma there is a concern about long-term mobile phone use.

3. International Commission on Non-Ionizing Radiation Protection (2009)

Results of epidemiological studies to date give no consistent or convincing evidence of a causal relation between RF exposure and any adverse health effect. On the other hand, these studies have too many deficiencies to rule out an association.

These analyses, together with other previous reviews by expert groups and health agencies, show there is no clear evidence for health hazards from exposures to RF

fields below international (IEEE or ICNIRP) exposure guidelines. The reports note gaps in the scientific evidence, for example, regarding long-term use of mobile phones (>10 years), particularly as related to effects on children.

Electromagnetic Hypersensitivity (EHS) and Mobile Phones

Investigations of EHS have failed to find a basis for the symptoms and *provocation studies* have been unable to link the symptoms to actual exposure to electromagnetic fields.

This is further strengthened by recent studies (Cinel et al. 2008 and Hillert et al. 2008) reporting that symptoms from mobile phone use described by EHS sub-

jects were correlated with the subjects’ beliefs that they were being exposed, not that they actually were being exposed. The World Health Organization (WHO 2005) concluded that EHS symptoms are “certainly real and can vary widely in their severity [but] EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to [electromagnetic field] exposure . . . nor is it clear that it represents a single medical problem.”

The present state of knowledge on the possible health risks of mobile phones is summarized by a recent (mid-2010) statement by the World Health Organization: “To date, no adverse health effects have been established for mobile phone use. Studies are ongoing to assess potential long-term effects of mobile phone use” (WHO 2010).



Glossary

Cataracts

An opacity of the crystalline lens of the eye, or of the capsule of the lens, or of both, producing more or less impairment of sight, but never complete blindness. (Oxford English Dictionary)

Ionizing Radiation

Radiation whose photons or particles have enough energy to ionize or remove an electron from an atom.

Nonionizing Radiation

Radiation whose photons do not have enough energy to directly ionize or remove an electron from an atom.

Power

The rate of energy change per unit of time.

Photon

The elementary particle that carries an electromagnetic field.

Provocation Study

Provocation studies are those where the subject is purposely exposed to the agent being tested, but they are not aware of when they are being exposed and when they are not being exposed).

Radiofrequency Energy (RF)

A frequency in the range used for telecommunication; greater than that of the highest audio-frequency and less than that of the shortest infra-red waves (i.e., between about 10^4 and 10^{11} or 10^{12} Hz). (Oxford English Dictionary)

References

Cardis E, Richardson L, Deltour I, Armstrong B, Feychting M, Johansen C, Kilkeny M, McKinney P, Modan B, Sadetzki S, Schüz J, Swerdlow A, Vrijheid M, Auvinen A, Berg G, Blettner M, Bowman J, Brown J, Chetrit A, Christensen HC, Cook A, Hepworth S, Giles G, Hours M, Iavarone I, Jarus-Hakak A, Klæboe L, Krewski D, Lagorio S, Lönn S, Mann S, McBride M, Muir K, Nadon L, Parent M-E, Pearce N, Salminen T, Schoemaker M, Schlehofer B, Siemiatycki J, Taki M, Takebayashi T, Tynes T, van Tongeren M, Vecchia P, Wiart J, Woodward A, Yamaguchi N. The INTERPHONE study: Design, epidemiological methods, and description of the study population. *European Journal of Epidemiology* 22(9):647-664; 2007.

Cinel C, Russo R, Boldini A, Fox E. Exposure to mobile phone electromagnetic fields and subjective symptoms: A double-blind study. *Psychosomatic Medicine* 70(3):345-348; 2008.

European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Possible effects of electromagnetic fields (EMF) on human health. 21 March 2007. Available at: http://ec.europa.eu/health/ph_risk/committees/04_scenihp/docs/scenihp_o_007.pdf. Accessed 18 May 2010.

Foster KR. Thermal and nonthermal mechanisms of interaction of radio-frequency energy with biological systems. *IEEE Transactions on Plasma Science* 28(1):15-23; 2000.

Hillert L, Akerstedt T, Lowden A, Wiholm C, Kuster N, Ebert S, Boutry C, Moffat SD, Berg M, Arnetz BB. The effects of 884 MHz GSM wireless communication signals on headache and other symptoms: An experimental provocation study. *Bioelectromagnetics* 29(3):185-196; 2008.

Institute of Electrical and Electronics Engineers. IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz. New York: Institute of Electrical and Electronics Engineers; 2010.

International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Phys 74:494-522; 1998.

International Commission on Non-Ionizing Radiation Protection. Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz). ICNIRP publication ICNIRP 16/2009 (2009). Available at: <http://www.icnirp.de/documents/RFReview.pdf>. Accessed 19 May 2010.

The INTERPHONE Study Group. Brain tumour risk in relation to mobile telephone use: Results of the INTERPHONE international case-control study. Int J Epidemiol; May 2010. Available at: http://www.oxfordjournals.org/our_journals/ije/press_releases/freepdf/dyq079.pdf. Accessed 18 May 2010.

Moulder JE, Foster KR, Erdreich LS, MacNamee JP. Mobile phones, mobile phone base stations and cancer: A review. International Journal of Radiation Biology 81:189-203; 2005.

Swedish Radiation Protection Authority (SSI). Recent research on EMF and health risks: Fifth annual report from SSI's Independent Expert Group on Electromagnetic Fields, 2007. March 2008. Available at: http://www.who.int/peh-emf/publications/reports/SWEDENssi_rapp_2007.pdf. Accessed 18 May 2010.

World Health Organization. Fact Sheet 296 Electromagnetic fields and public health: Electromagnetic hypersensitivity. December 2005. Available at: <http://www.who.int/mediacentre/factsheets/fs296/en/index.html>. Accessed 18 May 2010.

World Health Organization. Fact Sheet 193 Electromagnetic fields and public health: Mobile phones. May 2010. Available at: <http://www.who.int/mediacentre/factsheets/fs193/en/index.html>. Accessed 19 May 2010.

Resources for more information

Ettelt S, Nolte E, McKee M, Haugen OA, Karlberg I, Klazinga N, Ricciardi W, Teperi J. Evidence-based policy? The use of mobile phones in hospital. Journal of Public Health 28(4):299-303; 2006.

Lahkola A, Auvinen A, Raitanen J, Schoemaker MJ, Christensen HC, Feychting M, Johansen C, Klæboe L, Lönn S, Swerdlow AJ, Tynes T, Salminen T. Mobile phone use and risk of glioma in 5 North European countries. International Journal of Cancer 120:1,769-1,775; 2007.

Sheppard AR, Swicord ML, Balzano Q. Quantitative evaluations of mechanisms of radiofrequency interactions with biological molecules and processes. Health Phys 95:365-396; 2008.

World Health Organization. Fact Sheet 304 Electromagnetic fields and public health: Base stations and wireless technologies. May 2006. Available at: <http://www.who.int/mediacentre/factsheets/fs304/en/>. Accessed 18 May 2010.

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