Government or Government-Affiliated Resources Reviewed on the
HEALTH EFFECTS OF
NON-IONIZING RADIATION
By the Maine CDC
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Comparisons of Common Sources of Non-Ionizing Radiation

Item	Frequency in GHz	Power (max) in Watts	Power (average) Watts
Smart meter	2.4	1	0.100
G router	2.4	1	depends on use
N router	2.4 or 5.0	1	depends on use
Cordless Phone	2.4	0.25	0.010
Cell Phone	1.9	3	depends on use
FM Radio Tower	0.1	100,000	100,000
Cell Phone Tower	0.8 to 1.99	48,000	depends on use/loc

GHz = 10^9 Hz

RF Safety, FEDERAL COMMUNICATIONS COMMISSION (FCC), August 2010

Frequently asked questions about the safety of radiofrequency (RF) and microwave emissions from transmitters and facilities regulated by the FCC

For further information on these (and other) topics please refer to OET Bulletin 56. You may also contact the FCC's RF Safety Program at rfsafety@fcc.gov or 1-888-225-5322

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WHAT ARE "RADIOFREQUENCY" AND MICROWAVE RADIATION?

Electromagnetic radiation consists of waves of electric and magnetic energy moving together (*i.e.*, radiating) through space at the speed of light. Taken together, all forms of electromagnetic energy are referred to as the electromagnetic "spectrum." Radio waves and microwaves emitted by transmitting antennas are one form of electromagnetic energy. They are collectively referred to as "radiofrequency" or "RF" energy or radiation. Note that the term “radiation” does not mean “radioactive.” Often, the terms "electromagnetic field" or "radiofrequency field" may be used to indicate the presence of electromagnetic or RF energy.

The RF waves emanating from an antenna are generated by the movement of electrical charges in the antenna. Electromagnetic waves can be characterized by a wavelength and

a frequency. The wavelength is the distance covered by one complete cycle of the electromagnetic wave, while the frequency is the number of electromagnetic waves passing a given point in one second. The frequency of an RF signal is usually expressed in terms of a unit called the "hertz" (abbreviated "Hz"). One Hz equals one cycle per second. One megahertz ("MHz") equals one million cycles per second.

Different forms of electromagnetic energy are categorized by their wavelengths and frequencies. The RF part of the electromagnetic spectrum is generally defined as that part of the spectrum where electromagnetic waves have frequencies in the range of about 3 kilohertz (3 kHz) to 300 gigahertz (300 GHz). Microwaves are a specific category of radio waves that can be loosely defined as radiofrequency energy at frequencies ranging from about 1 GHz upward. (Back to Index)

WHAT IS NON-IONIZING RADIATION?

"Ionization" is a process by which electrons are stripped from atoms and molecules. This process can produce molecular changes that can lead to damage in biological tissue, including effects on DNA, the genetic material of living organisms. This process requires interaction with high levels of electromagnetic energy. Those types of electromagnetic radiation with enough energy to ionize biological material include X-radiation and gamma radiation. Therefore, X-rays and gamma rays are examples of ionizing radiation.

The energy levels associated with RF and microwave radiation, on the other hand, are not great enough to cause the ionization of atoms and molecules, and RF energy is, therefore, is a type of non-ionizing radiation. Other types of non-ionizing radiation include visible and infrared light. Often the term "radiation" is used, colloquially, to imply that ionizing radiation (radioactivity), such as that associated with nuclear power plants, is present. Ionizing radiation should not be confused with the lower-energy, non-ionizing radiation with respect to possible biological effects, since the mechanisms of action are quite different. (Back to Index)

HOW IS RADIOFREQUENCY ENERGY USED?

Probably the most important use for RF energy is in providing telecommunications services. Radio and television broadcasting, cellular telephones, personal communications services (PCS), pagers, cordless telephones, business radio, radio communications for police and fire departments, amateur radio, microwave point-to-point links and satellite communications are just a few of the many telecommunications applications of RF energy. Microwave ovens are an example of a non-communication use of RF energy. Radiofrequency radiation, especially at microwave frequencies, can transfer energy to water molecules. High levels of microwave energy will generate heat in water-rich materials such as most foods. This efficient absorption of microwave energy via water molecules results in rapid heating throughout an object, thus allowing food to be cooked more quickly in a microwave oven than in a conventional oven. Other important non-communication uses of RF energy include radar and industrial heating and

sealing. Radar is a valuable tool used in many applications range from traffic speed enforcement to air traffic control and military surveillance. Industrial heaters and sealers generate intense levels of RF radiation that rapidly heats the material being processed in the same way that a microwave oven cooks food. These devices have many uses in industry, including molding plastic materials, gluing wood products, sealing items such as shoes and pocketbooks, and processing food products. There are also a number of medical applications of RF energy, such as diathermy and magnetic resonance imaging (MRI). (Back to Index)

HOW IS RADIOFREQUENCY RADIATION MEASURED?

An RF electromagnetic wave has both an electric and a magnetic component (electric field and magnetic field), and it is often convenient to express the intensity of the RF environment at a given location in terms of units specific to each component. For example, the unit "volts per meter" (V/m) is used to express the strength of the electric field (electric "field strength"), and the unit "amperes per meter" (A/m) is used to express the strength of the magnetic field (magnetic "field strength"). Another commonly used unit for characterizing the total electromagnetic field is "power density." Power density is most appropriately used when the point of measurement is far enough away from an antenna to be located in the "far-field" zone of the antenna.

Power density is defined as power per unit area. For example, power density is commonly expressed in terms of watts per square meter (W/m2), milliwatts per square centimeter (mW/cm2), or microwatts per square centimeter (μW/cm2). One mW/cm2 equals 10 W/m2, and 100 μW/cm2 equal one W/m2. With respect to frequencies in the microwave range, power density is usually used to express intensity of exposure.

The quantity used to measure the rate at which RF energy is actually absorbed in a body is called the "Specific Absorption Rate" or "SAR." It is usually expressed in units of watts per kilogram (W/kg) or milliwatts per gram (mW/g). In the case of exposure of the whole body, a standing ungrounded human adult absorbs RF energy at a maximum rate when the frequency of the RF radiation is in the range of about 70 MHz. This means that the "whole-body" SAR is at a maximum under these conditions. Because of this "resonance" phenomenon and consideration of children and grounded adults, RF safety standards are generally most restrictive in the frequency range of about 30 to 300 MHz. For exposure of parts of the body, such as the exposure from hand-held mobile phones, "partial-body" SAR limits are used in the safety standards to control absorption of RF energy (see later questions on mobile phones). (Back to Index)

WHAT BIOLOGICAL EFFECTS CAN BE CAUSED BY RF ENERGY?

Biological effects can result from exposure to RF energy. Biological effects that result from heating of tissue by RF energy are often referred to as "thermal" effects. It has been known for many years that exposure to very high levels of RF radiation can be harmful due to the ability of RF energy to heat biological tissue rapidly. This is the principle by which microwave ovens cook food. Exposure to very high RF intensities can result in

heating of biological tissue and an increase in body temperature. Tissue damage in humans could occur during exposure to high RF levels because of the body's inability to cope with or dissipate the excessive heat that could be generated. Two areas of the body, the eyes and the testes, are particularly vulnerable to RF heating because of the relative lack of available blood flow to dissipate the excess heat load.

At relatively low levels of exposure to RF radiation, *i.e.*, levels lower than those that would produce significant heating; the evidence for production of harmful biological effects is ambiguous and unproven. Such effects, if they exist, have been referred to as "non-thermal" effects. A number of reports have appeared in the scientific literature describing the observation of a range of biological effects resulting from exposure to low-levels of RF energy. However, in most cases, further experimental research has been unable to reproduce these effects. Furthermore, since much of the research is not done on whole bodies (*in vivo*), there has been no determination that such effects constitute a human health hazard. It is generally agreed that further research is needed to determine the generality of such effects and their possible relevance, if any, to human health. In the meantime, standards-setting organizations and government agencies continue to monitor the latest experimental findings to confirm their validity and determine whether changes in safety limits are needed to protect human health. (Back to Index)

CAN PEOPLE BE EXPOSED TO LEVELS OF RADIOFREQUENCY RADIATION THAT COULD BE HARMFUL?

Studies have shown that environmental levels of RF energy routinely encountered by the general public are typically far below levels necessary to produce significant heating and increased body temperature. However, there may be situations, particularly in workplace environments near high-powered RF sources, where the recommended limits for safe exposure of human beings to RF energy could be exceeded. In such cases, restrictive measures or mitigation actions may be necessary to ensure the safe use of RF energy. (Back to Index)

CAN RADIOFREQUENCY RADIATION CAUSE CANCER?

Some studies have also examined the possibility of a link between RF exposure and cancer. Results to date have been inconclusive. While some experimental data have suggested a possible link between exposure and tumor formation in animals exposed under certain specific conditions, the results have not been independently replicated. Many other studies have failed to find evidence for a link to cancer or any related condition. The Food and Drug Administration has further information on this topic with respect to RF exposure from mobile phones at the following Web site: www.fda.gov/cellphones/ . (Back to Index)

WHAT RESEARCH IS BEING DONE ON RF BIOLOGICAL EFFECTS?

For many years, research into the possible biological effects of RF energy has been carried out in laboratories around the world, and such research is continuing. Past

research has resulted in a large number of peer-reviewed scientific publications on this topic. For many years the U.S. Government has sponsored research into the biological effects of RF energy. The majority of this work has been funded by the Department of Defense, due in part, to the extensive military interest in using RF equipment such as radar and other relatively high-powered radio transmitters for routine military operations. In addition, some U.S. civilian federal agencies responsible for health and safety, such as the Environmental Protection Agency (EPA) and the U.S. Food and Drug Administration (FDA), have sponsored and conducted research in this area. At the present time, most of the non-military research on biological effects of RF energy in the U.S. is being funded by industry organizations, although relatively more research by government agencies is being carried out overseas, particularly in Europe.

In 1996, the World Health Organization (WHO) established a program called the International EMF Project, which is designed to review the scientific literature concerning biological effects of electromagnetic fields, identify gaps in knowledge about such effects, recommend research needs, and work towards international resolution of health concerns over the use of RF technology. The WHO maintains a Web site that provides extensive information on this project and about RF biological effects and research (www.who.ch/peh-emf).

The FDA, the EPA and other federal agencies responsible for public health and safety have worked together and in connection with the WHO to monitor developments and identify research needs related to RF biological effects. More information about this can be obtained at the FDA Web site: www.fda.gov/cellphones/. (Back to Index)

WHAT LEVELS ARE SAFE FOR EXPOSURE TO RF ENERGY?

Exposure standards for radiofrequency energy have been developed by various organizations and countries. These standards recommend safe levels of exposure for both the general public and for workers. In the United States, the FCC has adopted and used recognized safety guidelines for evaluating RF environmental exposure since 1985. Federal health and safety agencies, such as the EPA, FDA, the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) have also been involved in monitoring and investigating issues related to RF exposure.

The FCC guidelines for human exposure to RF electromagnetic fields were derived from the recommendations of two expert organizations, the National Council on Radiation Protection and Measurements (NCRP) and the Institute of Electrical and Electronics Engineers (IEEE). Both the NCRP exposure criteria and the IEEE standard were developed by expert scientists and engineers after extensive reviews of the scientific literature related to RF biological effects. The exposure guidelines are based on thresholds for known adverse effects, and they incorporate prudent margins of safety. In adopting the most recent RF exposure guidelines, the FCC consulted with the EPA, FDA, OSHA and NIOSH, and obtained their support for the guidelines that the FCC is using.

Many countries in Europe and elsewhere use exposure guidelines developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The ICNIRP safety limits are generally similar to those of the NCRP and IEEE, with a few exceptions. For example, ICNIRP recommends somewhat different exposure levels in the lower and upper frequency ranges and for localized exposure due to such devices as hand-held cellular telephones. One of the goals of the WHO EMF Project (see above) is to provide a framework for international harmonization of RF safety standards. The NCRP, IEEE and ICNIRP exposure guidelines identify the same threshold level at which harmful biological effects may occur, and the values for Maximum Permissible Exposure (MPE) recommended for electric and magnetic field strength and power density in both documents are based on this level. The threshold level is a Specific Absorption Rate (SAR) value for the whole body of 4 watts per kilogram (4 W/kg).

In addition, the NCRP, IEEE and ICNIRP guidelines for maximum permissible exposure are different for different transmitting frequencies. This is due to the finding (discussed above) that whole-body human absorption of RF energy varies with the frequency of the RF signal. The most restrictive limits on whole-body exposure are in the frequency range of 30-300 MHz where the human body absorbs RF energy most efficiently when the whole body is exposed. For devices that only expose part of the body, such as mobile phones, different exposure limits are specified (see below).

The exposure limits used by the FCC are expressed in terms of SAR, electric and magnetic field strength and power density for transmitters operating at frequencies from 300 kHz to 100 GHz. The actual values can be found in either of two informational bulletins available at this Web site (OET Bulletin 56 or OET Bulletin 65), see listing for "OET Safety Bulletins." (Back to Index)

WHY HAS THE FCC ADOPTED GUIDELINES FOR RF EXPOSURE?

The FCC authorizes and licenses devices, transmitters and facilities that generate RF radiation. It has jurisdiction over all transmitting services in the U.S. except those specifically operated by the Federal Government. However, the FCC's primary jurisdiction does not lie in the health and safety area, and it must rely on other agencies and organizations for guidance in these matters.

Under the National Environmental Policy Act of 1969 (NEPA), all Federal agencies are required to implement procedures to make environmental consideration a necessary part of an agency's decision-making process. Therefore, FCC approval and licensing of transmitters and facilities must be evaluated for significant impact on the environment. Human exposure to RF radiation emitted by FCC-regulated transmitters is one of several factors that must be considered in such environmental evaluations. In 1996, the FCC revised its guidelines for RF exposure as a result of a multi-year proceeding and as required by the Telecommunications Act of 1996.

Facilities under the jurisdiction of the FCC having a high potential for creating significant RF exposure to humans, such as radio and television broadcast stations, satellite-earth

stations, experimental radio stations and certain cellular, PCS and paging facilities are required to undergo routine evaluation for compliance with RF exposure guidelines whenever an application is submitted to the FCC for construction or modification of a transmitting facility or renewal of a license. Failure to show compliance with the FCC's RF exposure guidelines in the application process could lead to the preparation of a formal Environmental Assessment, possible Environmental Impact Statement and eventual rejection of an application. Technical guidelines for evaluating compliance with the FCC RF safety requirements can be found in the FCC's OET Bulletin 65 (see "OET Safety Bulletins" listing elsewhere at this Web site).

Low-powered, intermittent, or inaccessible RF transmitters and facilities are normally "categorically excluded" from the requirement of routine evaluation for RF exposure. These exclusions are based on calculations and measurement data indicating that such transmitting stations or devices are unlikely to cause exposures in excess of the guidelines under normal conditions of use. The FCC's policies on RF exposure and categorical exclusion can be found in Section 1.1307(b) of the FCC's Rules and Regulations [47 CFR 1.1307(b)]. It should be emphasized, however, that these exclusions are not exclusions from compliance, but, rather, only exclusions from routine evaluation. Transmitters or facilities that are otherwise categorically excluded from evaluation may be required, on a case-by-case basis, to demonstrate compliance when evidence of potential non-compliance of the transmitter or facility is brought to the Commission's attention [see 47 CFR 1.1307(c) and (d)]. (Back to Index)

HOW SAFE ARE MOBILE AND PORTABLE PHONES?

In recent years, publicity, speculation, and concern over claims of possible health effects due to RF emissions from hand-held wireless telephones prompted various research programs to investigate whether there is any risk to users of these devices There is no scientific evidence to date that proves that wireless phone usage can lead to cancer or a variety of other health effects, including headaches, dizziness or memory loss. However, studies are ongoing and key government agencies, such as the Food and Drug Administration (FDA) continue to monitor the results of the latest scientific research on these topics. Also, as noted above, the World Health Organization has established an ongoing program to monitor research in this area and make recommendations related to the safety of mobile phones.

The FDA, which has primary jurisdiction for investigating mobile phone safety, has stated that it cannot rule out the possibility of risk, but if such a risk exists, "it is probably small." Further, it has stated that, while there is no proof that cellular telephones can be harmful, concerned individuals can take various precautionary actions, including limiting conversations on hand-held cellular telephones and making greater use of telephones with hands-free kits where there is a greater separation distance between the user and the radiating antenna. The Web site for the FDA's Center for Devices and Radiological Health provides further information on mobile phone safety: www.fda.gov/cellphones/.

The Government Accounting Office (GAO) prepared a report of its investigation into safety concerns related to mobile phones. The report concluded that further research is needed to confirm whether mobile phones are completely safe for the user, and the report recommended that the FDA take the lead in monitoring the latest research results.

The FCC's exposure guidelines specify limits for human exposure to RF emissions from hand-held mobile phones in terms of Specific Absorption Rate (SAR), a measure of the rate of absorption of RF energy by the body. The safe limit for a mobile phone user is an SAR of 1.6 watts per kg (1.6 W/kg), averaged over one gram of tissue, and compliance with this limit must be demonstrated before FCC approval is granted for marketing of a phone in the United States. Somewhat less restrictive limits, *e.g.*, 2 W/kg averaged over 10 grams of tissue, are specified by the ICNIRP guidelines used in Europe and most other countries.

Measurements and analysis of SAR in models of the human head have shown that the 1.6 W/kg limit is unlikely to be exceeded under normal conditions of use of cellular and PCS hand-held phones. The same can be said for cordless telephones used in the home. Testing of hand-held phones is normally done under conditions of maximum power usage, thus providing an additional margin of safety, since most phone usage is not at maximum power. Information on SAR levels for many phones is available electronically through the FCC's Web site and database (see next question). (Back to Index)

HOW CAN I OBTAIN THE SPECIFIC ABSORPTION RATE (SAR) VALUE FOR MY MOBILE PHONE?

As explained above, the Specific Absorption Rate, or SAR, is the unit used to determine compliance of cellular and PCS phones with safety limits adopted by the FCC. The SAR is a value that corresponds to the rate at which RF energy absorbed in the head of a user of a wireless handset. The FCC requires mobile phone manufacturers to demonstrate compliance with an SAR level of 1.6 watts per kilogram (averaged over one gram of tissue).

Information on SAR for a specific cell phone model can be obtained for almost all cellular telephones by using the FCC identification (ID) number for that model. The FCC ID number is usually printed somewhere on the case of the phone or device. In many cases, you will have to remove the battery pack to find the number. Once you have the number proceed as follows. Go to the following website: Equipment Authorization. Click on the link for “FCC ID Search”. Once you are there you will see instructions for inserting the FCC ID number. Enter the FCC ID number (in two parts as indicated: "Grantee Code" is comprised of the first three characters, the "Equipment Product Code" is the remainder of the FCC ID). Then click on "Start Search." The grant(s) of equipment authorization for this particular ID number should then be available. Click on a check under "Display Grant" and the grant should appear. Look through the grant for the section on SAR compliance, certification of compliance with FCC rules for RF exposure or similar language. This section should contain the value(s) for typical or maximum SAR for your phone.

For portable phones and devices authorized since June 2, 2000, maximum SAR levels should be noted on the grant of equipment authorization. For phones and devices authorized between about mid-1998 and June 2000, detailed information on SAR levels is typically found in one of the "exhibits" associated with the grant. Therefore, once the grant is accessed in the FCC database, the exhibits can be viewed by clicking on the appropriate entry labeled "View Exhibit." Electronic records for FCC equipment authorization grants were initiated in 1998, so devices manufactured prior to this date may not be included in our electronic database.

Although the FCC database does not list phones by model number, there are certain non-government Web sites such as www.cnet.com that provide information on SAR from specific models of mobile phones. However, the FCC has not reviewed these sites for accuracy and makes no guarantees with respect to them. In addition to these sites, some mobile phone manufacturers make this information available at their own Web sites. Also, phones certified by the Cellular Telecommunications and Internet Association (CTIA) are now required to provide this information to consumers in the instructional materials that come with the phones.

If you want additional consumer information on safety of cell phones and other transmitting devices please consult the information available below at this Web site. In particular, you may wish to read or download our OET Bulletin 56 (see "OET RF Safety Bulletins" listing) entitled: "Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields." If you have any problems or additional questions you may contact us at: rfsafety@fcc.gov or you may call: 1-888-225-5322. You may also wish to consult a consumer update on mobile phone safety published by the U.S. Food and Drug Administration (FDA) that can be found at: www.fda.gov/cellphones/. (Back to Index)

DO "HANDS-FREE" EAR PIECES FOR MOBILE PHONES REDUCE EXPOSURE TO RF EMISSIONS? WHAT ABOUT MOBILE PHONE ACCESSORIES THAT CLAIM TO SHIELD THE HEAD FROM RF RADIATION?

"Hands-free" kits with ear pieces can be used with cell phones for convenience and comfort. In addition, because the phone, which is the source of the RF emissions, will not be placed against the head, absorption of RF energy in the head will be reduced. Therefore, it is true that use of an ear piece connected to a mobile phone will significantly reduce the rate of energy absorption (or "SAR") in the user's head. On the other hand, if the phone is mounted against the waist or other part of the body during use, then that part of the body will absorb RF energy. Even so, mobile phones marketed in the U.S. are required to meet safety limit requirements regardless of whether they are used against the head or against the body. So either configuration should result in compliance with the safety limit. Note that hands-free devices using “Bluetooth” technology also include a wireless transmitter; however, the Bluetooth transmitter operates at a much lower power than the cell phone.

A number of devices have been marketed that claim to "shield" or otherwise reduce RF absorption in the body of the user. Some of these devices incorporate shielded phone cases, while others involve nothing more than a metallic accessory attached to the phone. Studies have shown that these devices generally do not work as advertised. In fact, they may actually increase RF absorption in the head due to their potential to interfere with proper operation of the phone, thus forcing it to increase power to compensate.(Back to Index)

CAN MOBILE PHONES BE USED SAFELY IN HOSPITALS AND NEAR MEDICAL TELEMETRY EQUIPMENT?

The FCC does not normally investigate problems of electromagnetic interference from RF transmitters to medical devices. Some hospitals have policies, which limit the use of cell phones, due to concerns that sensitive medical equipment could be affected. The FDA's Center for Devices and Radiological Health (CDRH) has primary jurisdiction for medical device regulation. FDA staff has monitored this potential problem and more information is available from the CDRH Web site: www.fda.gov/cdrh . (Back to Index)

ARE CELLULAR AND PCS TOWERS AND ANTENNAS SAFE?

Cellular radio services transmit using frequencies between 824 and 894 megahertz (MHz). Transmitters in the Personal Communications Service (PCS) use frequencies in the range of 1850-1990 MHz. Antennas used for cellular and PCS transmissions are typically located on towers, water tanks or other elevated structures including rooftops and the sides of buildings. The combination of antennas and associated electronic equipment is referred to as a cellular or PCS "base station" or "cell site." Typical heights for free-standing base station towers or structures are 50-200 feet. A cellular base station may utilize several "omni-directional" antennas that look like poles, 10 to 15 feet in length, although these types of antennas are less common in urbanized areas.

In urban and suburban areas, cellular and PCS service providers commonly use "sector" antennas for their base stations. These antennas are rectangular panels, *e.g.*, about 1 by 4 feet in size, typically mounted on a rooftop or other structure, but they are also mounted on towers or poles. Panel antennas are usually arranged in three groups of three each. It is common that not all antennas are used for the transmission of RF energy; some antennas may be receive-only.

At a given cell site, the total RF power that could be radiated by the antennas depends on the number of radio channels (transmitters) installed, the power of each transmitter, and the type of antenna. While it is theoretically possible for cell sites to radiate at very high power levels, the maximum power radiated in any direction usually does not exceed 50 watts.

The RF emissions from cellular or PCS base station antennas are generally directed toward the horizon in a relatively narrow pattern in the vertical plane. In the case of sector (panel) antennas, the pattern is fan-shaped, like a wedge cut from a pie. As with

all forms of electromagnetic energy, the power density from the antenna decreases rapidly as one moves away from the antenna. Consequently, ground-level exposures are much less than exposures if one were at the same height and directly in front of the antenna.

Measurements made near typical cellular and PCS installations, especially those with tower-mounted antennas, have shown that ground-level power densities are thousands of times less than the FCC's limits for safe exposure. This makes it extremely unlikely that a member of the general public could be exposed to RF levels in excess of FCC guidelines due solely to cellular or PCS base station antennas located on towers or monopoles.

When cellular and PCS antennas are mounted at rooftop locations it is possible that a person could encounter RF levels greater than those typically encountered on the ground. However, once again, exposures approaching or exceeding the safety guidelines are only likely to be encountered very close to and directly in front of the antennas. For sector-type antennas, RF levels to rear are usually very low. (Back to Index)

For further information on cellular services go to
http://wireless.fcc.gov/services/index.htm?job=service_home&id=cellular

ARE CELLULAR AND OTHER RADIO TOWERS LOCATED NEAR HOMES OR SCHOOLS SAFE FOR RESIDENTS AND STUDENTS?

As discussed above, radiofrequency emissions from antennas used for cellular and PCS transmissions result in exposure levels on the ground that are typically thousands of times below safety limits. These safety limits were adopted by the FCC based on the recommendations of expert organizations and endorsed by agencies of the Federal Government responsible for health and safety. Therefore, there is no reason to believe that such towers could constitute a potential health hazard to nearby residents or students.

Other antennas, such as those used for radio and television broadcast transmissions, use power levels that are generally much higher than those used for cellular and PCS antennas. Therefore, in some cases there could be a potential for higher levels of exposure to persons on the ground. However, all broadcast stations are required to demonstrate compliance with FCC safety guidelines, and ambient exposures to nearby persons from such stations are typically well below FCC safety limits. (Back to Index)

ARE EMISSIONS FROM RADIO AND TELEVISION BROADCAST ANTENNAS SAFE?

Radio and television broadcast stations transmit their signals via RF electromagnetic waves. There are thousands of radio and TV stations on the air in the United States. Broadcast stations transmit at various RF frequencies, depending on the channel, ranging from about 540 kHz for AM radio up to about 800 MHz for UHF television stations. Frequencies for FM radio and VHF television lie in between these two extremes.

Broadcast transmitter power levels range from a few watts to more than 100,000 watts. Some of these transmission systems can be a significant source of RF energy in the local environment, so the FCC requires that broadcast stations submit evidence of compliance with FCC RF guidelines.

The amount of RF energy to which the public or workers might be exposed as a result of broadcast antennas depends on several factors, including the type of station, design characteristics of the antenna being used, power transmitted to the antenna, height of the antenna and distance from the antenna. Note that the power normally quoted for FM and TV broadcast transmitters is the "effective radiated power" or ERP not the actual transmitter power mentioned above. ERP is the transmitter power delivered to the antenna multiplied by the directivity or gain of the antenna. Since high gain antennas direct most of the RF energy toward the horizon and not toward the ground, high ERP transmission systems such as used for UHF-TV broadcast tend to have less ground level field intensity near the station than FM radio broadcast systems with lower ERP and gain values. Also, since energy at some frequencies is absorbed by the human body more readily than at other frequencies, both the frequency of the transmitted signal and its intensity is important. Calculations can be performed to predict what field intensity levels would exist at various distances from an antenna.

Public access to broadcasting antennas is normally restricted so that individuals cannot be exposed to high-level fields that might exist near antennas. Measurements made by the FCC, EPA and others have shown that ambient RF radiation levels in inhabited areas near broadcasting facilities are typically well below the exposure levels recommended by current standards and guidelines. There have been a few situations around the country where RF levels in publicly accessible areas have been found to be higher than those recommended in applicable safety standards. As they have been identified, the FCC has required that stations at those facilities promptly bring their combined operations into compliance with our guidelines. Thus, despite the relatively high operating powers of many broadcast stations, such cases are unusual, and members of the general public are unlikely to be exposed to RF levels from broadcast towers that exceed FCC limits

Antenna maintenance workers are occasionally required to climb antenna structures for such purposes as painting, repairs, or lamp replacement. Both the EPA and OSHA have reported that in such cases it is possible for a worker to be exposed to high levels of RF energy if work is performed on an active tower or in areas immediately surrounding a radiating antenna. Therefore, precautions should be taken to ensure that maintenance personnel are not exposed to unsafe RF fields. (Back to Index)

HOW SAFE ARE RADIO ANTENNAS USED FOR PAGING AND "TWO-WAY" COMMUNICATIONS? WHAT ABOUT "PUSH-TO-TALK" RADIOS SUCH AS "WALKIE-TALKIES?"

"Land-mobile" communications include a variety of communications systems, which require the use of portable and mobile RF transmitting sources. These systems operate in several frequency bands between about 30 and 1000 MHz. Radio systems used by the

police and fire departments, radio paging services and business radio are a few examples of these communications systems. They have the advantage of providing communications links between various fixed and mobile locations.

There are essentially three types of RF transmitters associated with land-mobile systems: base-station transmitters, vehicle-mounted transmitters, and hand-held transmitters. The antennas and power levels used for these various transmitters are adapted for their specific purpose. For example, a base-station antenna must radiate its signal to a relatively large area, and therefore, its transmitter generally has to use higher power levels than a vehicle-mounted or hand-held radio transmitter. Although base-station antennas usually operate with higher power levels than other types of land-mobile antennas, they are normally inaccessible to the public since they must be mounted at significant heights above ground to provide for adequate signal coverage. Also, many of these antennas transmit only intermittently. For these reasons, base-station antennas are generally not of concern with regard to possible hazardous exposure of the public to RF radiation. Studies at rooftop locations have indicated that high-powered paging antennas may increase the potential for exposure to workers or others with access to such sites, *e.g.*, maintenance personnel. This could be a concern especially when multiple transmitters are present. In such cases, restriction of access or other mitigation actions may be necessary.

Transmitting power levels for vehicle-mounted land-mobile antennas are generally less than those used by base-station antennas but higher than those used for hand-held units. Some manufacturers recommend that users and other nearby individuals maintain some minimum distance (*e.g.*, 1 to 2 feet) from a vehicle-mounted antenna during transmission or mount the antenna in such a way as to provide maximum shielding for vehicle occupants. Studies have shown that this is probably a conservative precaution, particularly when the percentage of time an antenna is actually radiating is considered. Unlike cellular telephones, which transmit continuously during a call, two-way radios normally transmit only when the "push-to-talk" button is depressed. This significantly reduces exposure, and there is no evidence that there would be a safety hazard associated with exposure from vehicle-mounted, two-way antennas when the manufacturer's recommendations are followed.

Hand-held "two-way" portable radios such as walkie-talkies are low-powered devices used to transmit and receive messages over relatively short distances. Because of the low power levels used, the intermittency of these transmissions ("push-to-talk"), and due to the fact that these radios are held away from the head, they should not expose users to RF energy in excess of safe limits. Although FCC rules do not require routine documentation of compliance with safety limits for push-to-talk two-way radios as it does for cellular and PCS phones (which transmit continuously during use and which are held against the head), most of these radios are tested and the resulting SAR data are available from the FCC's Equipment Authorization database. Click on the link for "FCC ID Search <imbed hypertext link>.". (Back to Index)

HOW SAFE ARE MICROWAVE AND SATELLITE ANTENNAS?

Point-to-point microwave antennas transmit and receive microwave signals across relatively short distances (from a few tenths of a mile to 30 miles or more). These antennas are usually circular ("dish") or rectangular in shape and are normally mounted on a supporting tower, rooftop, sides of buildings or on similar structures that provide clear and unobstructed line-of-sight paths between both ends of a transmission path. These antennas have a variety of uses, such as relaying long-distance telephone calls, and serving as links between broadcast studios and transmitting sites.

The RF signals from these antennas travel in a directed beam from a transmitting antenna to the receiving antenna, and dispersion of microwave energy outside of this narrow beam is minimal or insignificant. In addition, these antennas transmit using very low power levels, usually on the order of a few watts or less. Measurements have shown that ground-level power densities due to microwave directional antennas are normally thousands of times or more below recommended safety limits. Moreover, microwave tower sites are normally inaccessible to the general public. Significant exposures from these antennas could only occur in the unlikely event that an individual were to stand directly in front of and very close to an antenna for a period of time.

Ground-based antennas used for satellite-earth communications typically are parabolic "dish" antennas, some as large as 10 to 30 meters in diameter, that are used to transmit ("uplink") or receive ("downlink") microwave signals to or from satellites in orbit around the earth. These signals allow delivery of a variety of communications services, including television network programming, electronic newsgathering and point-of-sale credit card transactions. Some satellite-earth station antennas are used only to receive RF signals (*i.e*., like the satellite television antenna used at a residence), and because they do not transmit, RF exposure is not an issue for those antennas.

Since satellite-earth station antennas are directed toward satellites above the earth, transmitted beams point skyward at various angles of inclination, depending on the particular satellite being used. Because of the longer distances involved, power levels used to transmit these signals are relatively large when compared, for example, to those used by the terrestrial microwave point-to-point antennas discussed above. However, as with microwave antennas, the beams used for transmitting earth-to-satellite signals are concentrated and highly directional, similar to the beam from a flashlight. In addition, public access would normally be restricted at uplink sites where exposure levels could approach or exceed safe limits.

Although many satellite-earth stations are "fixed" sites, portable uplink antennas are also used, *e.g*., for electronic news gathering. These antennas can be deployed in various locations. Therefore, precautions may be necessary, such as temporarily restricting access in the vicinity of the antenna, to avoid exposure to the main transmitted beam. In general, however, it is unlikely that a transmitting earth station antenna would routinely expose members of the public to potentially harmful levels of RF energy. (Back to Index)

ARE RF EMISSIONS FROM AMATEUR RADIO STATIONS HARMFUL?

There are hundreds of thousands of amateur radio operators ("hams") worldwide. Amateur radio operators in the United States are licensed by the FCC. The Amateur Radio Service provides its members with the opportunity to communicate with persons all over the world and to provide valuable public service functions, such as making communications services available during disasters and emergencies. Like all FCC licensees, amateur radio operators are required to comply with the FCC's guidelines for safe human exposure to RF fields. Under the FCC's rules, amateur operators can transmit with power levels of up to 1500 watts. However, most operators use considerably less power than this maximum. Studies by the FCC and others have shown that most amateur radio transmitters would not normally expose persons to RF levels in excess of safety limits. This is primarily due to the relatively low operating powers used by most amateurs, the intermittent transmission characteristics typically used and the relative inaccessibility of most amateur antennas. As long as appropriate distances are maintained from amateur antennas, exposure of nearby persons should be well below safety limits.

To help ensure compliance of amateur radio facilities with RF exposure guidelines, both the FCC and American Radio Relay League (ARRL) have issued publications to assist operators in evaluating compliance for their stations. The FCC's publication (Supplement B to OET Bulletin 65 can be viewed and downloaded elsewhere at this Web site (see "OET RF Safety Bulletins"). (Back to Index)

WHAT IS THE FCC'S POLICY ON RADIOFREQUENCY WARNING SIGNS? FOR EXAMPLE, WHEN SHOULD SIGNS BE POSTED, WHERE SHOULD THEY BE LOCATED AND WHAT SHOULD THEY SAY?

Radiofrequency warning or "alerting" signs should be used to provide information on the presence of RF radiation or to control exposure to RF radiation within a given area. Standard radiofrequency hazard warning signs are commercially available from several vendors. Appropriate signs should incorporate the format recommended by the Institute for Electrical and Electronics Engineers (IEEE) and as specified in the IEEE standard: IEEE C95.2-1999 (Web address: www.ieee.org). Guidance concerning the placement of signs can be found in IEEE Standard C95.7-2005. When signs are used, meaningful information should be placed on the sign advising affected persons of: (1) the nature of the potential hazard (*i.e.*, high RF fields), (2) how to avoid the potential hazard, and (3) whom to contact for additional information. In some cases, it may be appropriate to also provide instructions to direct individuals as to how to work safely in the RF environment of concern. Signs should be located prominently in areas that will be readily seen by those persons who may have access to an area where high RF fields are present. (Back to Index)

CAN IMPLANTED ELECTRONIC CARDIAC PACEMAKERS BE AFFECTED BY NEARBY RF DEVICES SUCH AS MICROWAVE OVENS OR CELLULAR TELEPHONES?

Over the past several years there has been concern that signals from some RF devices could interfere with the operation of implanted electronic pacemakers and other medical devices. Because pacemakers are electronic devices, they could be susceptible to electromagnetic signals that could cause them to malfunction. Some anecdotal claims of such effects in the past involved emissions from microwave ovens. However, it has never been shown that the RF energy from a properly operating microwave oven is strong enough to cause such interference.

Some studies have shown that mobile phones can interfere with implanted cardiac pacemakers if a phone is used in close proximity (within about 8 inches) of a pacemaker. It appears that such interference is limited to older pacemakers, which may no longer be in use. Nonetheless, to avoid this potential problem, pacemaker patients can avoid placing a phone in a pocket close to the location of their pacemaker or otherwise place the phone near the pacemaker location during phone use. Patients with pacemakers should consult with their physician or the FDA if they believe that they may have a problem related to RF interference. Further information on this is available from the FDA: www.fda.gov/cdrh . (Back to Index)

DOES THE FCC REGULATE EXPOSURE TO THE ELECTROMAGNETIC RADIATION FROM MICROWAVE OVENS, TELEVISION SETS AND COMPUTER MONITORS?

The Commission does not regulate exposure to emissions from these devices. Protecting the public from harmful radiation emissions from these consumer products is the responsibility of the U.S. Food and Drug Administration (FDA). Inquires should be directed to the FDA's Center for Devices and Radiological Health (CDRH), and, specifically, to the CDRH Office of Compliance at (301) 594-4654. (Back to Index)

DOES THE FCC ROUTINELY MONITOR RADIOFREQUENCY RADIATION FROM ANTENNAS?

The FCC does not have the resources or the personnel to routinely monitor the emissions for all of the thousands of transmitters that are subject to FCC jurisdiction. However, the FCC does have measurement instrumentation for evaluating RF levels in areas that may be accessible to the public or to workers. If there is evidence of potential non-compliance with FCC exposure guidelines for an FCC-regulated facility, staff from the FCC's Office of Engineering and Technology or the Enforcement Bureau can conduct an investigation, and, if appropriate, perform actual measurements. It should be emphasized that the FCC does not perform RF exposure investigations unless there is a reasonable expectation that the FCC exposure limits may be exceeded. Potential exposure problems should be brought to the FCC's attention by contacting the FCC at: 1-888-225-5322 or by e-mailing: rfsafety@fcc.gov. (Back to Index)

DOES THE FCC MAINTAIN A DATABASE THAT INCLUDES INFORMATION ON THE LOCATION AND TECHNICAL PARAMETERS OF ALL OF THE TRANSMITTER SITES IT REGULATES?

The Commission does not have a comprehensive, transmitter-specific database for all of the services it regulates. The Commission has information for some services such as radio and television broadcast stations, and many larger antenna towers are required to register with the FCC if they meet certain criteria. In those cases, location information is generally specified in terms of degrees, minutes, and seconds of latitude and longitude. In some services, licenses are allowed to utilize additional transmitters or to increase power without notifying the Commission. Other services are licensed by geographic area, such that the Commission has no knowledge concerning the actual number or location of transmitters within that geographic area.

The *FCC General Menu Reports* (GenMen) search engine unites most of the Commission's licensing databases under a single umbrella. Databases included are the Wireless Telecommunications Bureau's ULS, the Media Bureau's CDBS, COALS (cable data) and BLS, and the International Bureau's IBFS. Entry points or search options in the various databases include frequency, state/county, latitude/longitude, call sign and licensee name.

The FCC also publishes, generally on a weekly basis, bulk extracts of the various Commission licensing databases. Each licensing database has it own unique file structure. These extracts consist of multiple, very large files. OET maintains an index to these databases.

OET has developed a *Spectrum Utilization Study Software* tool-set that can be used to create a Microsoft Access version of the individual exported licensing databases and then create MapInfo "mid" and "mif" files so that radio assignments can be plotted. This experimental software is used to conduct internal spectrum utilization studies needed in the rulemaking process. While the FCC makes this software available to the public, no technical support is provided.

For further information on the Commission's existing databases, please contact Donald Campbell at donald.campbell@fcc.gov or 202-418-2405. (Back to Index)

WHICH OTHER FEDERAL AGENCIES HAVE RESPONSIBILITIES RELATED TO POTENTIAL RF HEALTH EFFECTS?

Certain agencies in the Federal Government have been involved in monitoring, researching or regulating issues related to human exposure to RF radiation. These agencies include the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), the National Telecommunications and Information Administration (NTIA) and the Department of Defense (DOD).

By authority of the Radiation Control for Health and Safety Act of 1968, the Center for Devices and Radiological Health (CDRH) of the FDA develops performance standards for the emission of radiation from electronic products including X-ray equipment, other medical devices, television sets, microwave ovens, laser products and sunlamps. The

CDRH established a product performance standard for microwave ovens in 1971 limiting the amount of RF leakage from ovens. However, the CDRH has not adopted performance standards for other RF-emitting products. The FDA is, however, the lead federal health agency in monitoring the latest research developments and advising other agencies with respect to the safety of RF-emitting products used by the public, such as cellular and PCS phones.

The FDA's microwave oven standard is an emission standard (as opposed to an exposure standard) that allows specific levels of microwave energy leakage (measured at five centimeters from the oven surface). The standard also requires ovens to have two independent interlock systems that prevent the oven from generating microwaves if the latch is released or if the door of the oven is opened. The FDA has stated that ovens that meet its standards and are used according to the manufacturer's recommendations are safe for consumer and industrial use. More information is available from: www.fda.gov/cdrh.

The EPA has, in the past, considered developing federal guidelines for public exposure to RF radiation. However, EPA activities related to RF safety and health are presently limited to advisory functions. For example, the EPA chairs an Inter-agency Radiofrequency Working Group, which coordinates RF health-related activities among the various federal agencies with health or regulatory responsibilities in this area.

OSHA is part of the U.S. Department of Labor, and is responsible for protecting workers from exposure to hazardous chemical and physical agents. In 1971, OSHA issued a protection guide for exposure of workers to RF radiation [29 CFR 1910.97]. However, this guide was later ruled to be only advisory and not mandatory. Moreover, it was based on an earlier RF exposure standard that has now been revised. At the present time, OSHA uses the IEEE and/or FCC exposure guidelines for enforcement purposes under OSHA's "general duty clause" (for more information see: www.osha.gov/SLTC/radiofrequencyradiation/).

NIOSH is part of the U.S. Department of Health and Human Services. It conducts research and investigations into issues related to occupational exposure to chemical and physical agents. NIOSH has, in the past, undertaken to develop RF exposure guidelines for workers, but final guidelines were never adopted by the agency. NIOSH conducts safety-related RF studies through its Physical Agents Effects Branch in Cincinnati, Ohio.

The NTIA is part of the U.S. Department of Commerce and is responsible for authorizing Federal Government use of the RF electromagnetic spectrum. Like the FCC, the NTIA also has NEPA responsibilities and has considered adopting guidelines for evaluating RF exposure from U.S. Government transmitters such as radar and military facilities. (Back to Index)

CAN LOCAL AND STATE GOVERNMENTAL BODIES ESTABLISH LIMITS FOR RF EXPOSURE?

In the United States, some local and state jurisdictions have also enacted rules and regulations pertaining to human exposure to RF energy. However, the Telecommunications Act of 1996 contained provisions relating to federal jurisdiction to regulate human exposure to RF emissions from certain transmitting devices. In particular, Section 704 of the Act states that, "No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions." Further information on FCC policy with respect to facilities siting is available from the FCC's Wireless Telecommunications Bureau (see http://wireless.fcc.gov/siting/). (Back to Index)

WHERE CAN I OBTAIN MORE INFORMATION ON POTENTIAL HEALTH EFFECTS OF RADIOFREQUENCY ENERGY?

Although relatively few offices or agencies within the Federal Government routinely deal with the issue of human exposure to RF fields, it is possible to obtain information and assistance on certain topics from the following federal agencies, all of which also have Internet Web sites.

FDA: For information about radiation from microwave ovens and other consumer and industrial products contact: Center for Devices and Radiological Health (CDRH), Food and Drug Administration. [http://www.fda.gov/cdrh/radhealth/]

EPA: The Environmental Protection Agency's Office of Radiation Programs is responsible for monitoring potential health effects due to public exposure to RF fields. Contact: Environmental Protection Agency, Office of Radiation and Indoor Air, Washington, D.C. 20460, (202) 564-9235. [Click on EPA's website: Frequent Questions on EMF, RF, & Other Nonionizing Radiation]

OSHA: The Occupational Safety and Health Administration's (OSHA) Health Response Team has been involved in studies related to occupational exposure to RF radiation. [http://www.osha.gov/SLTC/radiation_nonionizing/index.html]

NIOSH: The National Institute for Occupational Safety and Health (NIOSH) conducts research on RF-related safety issues in workplaces and recommends measures to protect worker health. Contact: NIOSH, Engineering and Physical Hazards Branch, Mail Stop R-5, 4676 Columbia Parkway, Cincinnati, Ohio 45226, or phone 1-513-841-4221. Toll-free public inquiries: 1-800-CDC-INFO (1-800-232-4636), or by email: cdcinfo@cdc.gov. Internet information on workplace RF safety: http://www.cdc.gov/niosh/topics/emf/#rffields.

NCI: The National Cancer Institute, part of the U.S. National Institutes of Health, conducts and supports research, training, health information dissemination, and other programs with respect to the cause, diagnosis, prevention, and treatment of cancer. Contact: NCI Public Inquiries Office, 6116 Executive Boulevard, Room 3036A,

Bethesda, MD 20892-8322.
[http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones]

Toll-free number: 1-800-4-CANCER (1-800-422-6237).

FCC: Questions regarding potential RF hazards from FCC-regulated transmitters can be directed to the Federal Communications Commission, Consumer & Governmental Affairs Bureau, 445 12th Street, S.W., Washington, D.C. 20554; Phone: 1-888-225-5322; E-mail: rfsafety@fcc.gov; or go to: www.fcc.gov/oet/rfsafety.

In addition to federal government agencies, there are other sources of information regarding RF energy and health effects. Some states and localities maintain non-ionizing radiation programs or, at least, some expertise in this field, usually in a department of public health or environmental control. The following table lists some representative Internet Web sites that provide information on this topic. However, the FCC neither endorses nor verifies the accuracy of any information provided at these sites. They are being provided for information only. (Back to Index)

- **Bioelectromagnetics Society:** http://www.bioelectromagnetics.org/
- **EPA's RadTown USA:** http://www.epa.gov/radtown/basic.html
- **International Commission on Non-Ionizing Radiation Protection (ICNIRP Europe):** http://www.icnirp.de/
- **IEEE Committee on Man & Radiation**: http://ewh.ieee.org/soc/embs/comar/
- **Microwave News:** http://www.microwavenews.com/
- **National Council on Radiation Protection & Measurements:** http://www.ncrponline.org/
- **NJ Dept Radiation Protection:** http://www.nj.gov/dep/rpp/nrs/index.htm
- **RFcom (Canada):** http://www.rfcom.ca/welcome/index.shtml
- **Wireless Industry (CTIA):** http://www.ctia.org/
- **World Health Organization (WHO):** http://www.who.ch/peh-emf
- **Germany's EMF Portal:** http://www.emf-portal.de/

For more information on this topic please note:

OET Bulletin 56*: Questions and Answers About the Biological Effects and Potential Hazards of Radiofrequency Radiation.*

Introduction to Radiation, HEALTH CANADA, April 2010

http://www.phac-aspc.gc.ca/publicat/cdic-mcc/29-1-supp/ar_02-eng.php

Radiation is energy in the form of particles or electromagnetic waves. Based on the effects it can produce in matter, two classes of radiation have been defined: ionizing and non-ionizing.[1a] Ionizing radiation has sufficient energy to remove electrons from atoms and break atomic bonds. Both classes can alter the genetic material (DNA) of a cell. Approximately 80% of our exposure to ionizing radiation is from *natural* sources, usually at very low dose rates, such as cosmic rays and naturally occurring radioactive elements in the Earth's crust and air.[2a] Most of the *artificial* (man-made) radionuclides (unstable nuclei of atoms) released into the global environment have come from nuclear weapons tests. Other artificial sources of ionizing radiation include nuclear facilities, uranium mines, mills and plants and X ray devices.

Non-ionizing radiation has lower energy than ionizing radiation and does not ordinarily have enough intensity to endanger living things from acute exposure. Exposure to non-ionizing radiation includes ultraviolet radiation (UVR) from the sun, radiofrequency radiation (radar, radio and television towers, mobile telephones) and extremely low frequency electric and magnetic fields (ELF EMF) from electrical wires and appliances. Although a portion of the ultraviolet spectrum has sufficient energy to ionize atoms, it is traditionally considered a non-ionizing form of radiation. Human exposure to ELF EMF has risen dramatically this century because of our increasing use of electricity, giving rise to concerns about the effects of long-term exposures. Also, over the past few years, the ozone layer—a thin veil of gas in the atmosphere that screens out harmful solar UVR—has become thinner, resulting in slightly more of the sun's harmful radiation reaching the Earth's surface.[3]

Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case–control study, May 2010, International Journal of Epidemiology

http://ije.oxfordjournals.org/content/39/3/675.full

Excerpts from the Interphone Study:

Background The rapid increase in mobile telephone use has generated concern about possible health risks related to radiofrequency electromagnetic fields from this technology.

Methods An interview-based case–control study with 2708 glioma and 2409 meningioma cases and matched controls was conducted in 13 countries using a common protocol.

Results A reduced odds ratio (OR) related to ever having been a regular mobile phone user was seen for glioma [OR 0.81; 95% confidence interval (CI) 0.70–0.94] and meningioma (OR 0.79; 95% CI 0.68–0.91), possibly reflecting participation bias or other methodological limitations. No elevated OR was observed ≥10 years after first phone use (glioma: OR 0.98; 95% CI 0.76–1.26; meningioma: OR 0.83; 95% CI 0.61–1.14). ORs were <1.0 for all deciles of lifetime number of phone calls and nine deciles of cumulative call time. In the 10th decile of recalled cumulative call time, ≥1640 h, the OR was 1.40

(95% CI 1.03–1.89) for glioma, and 1.15 (95% CI 0.81–1.62) for meningioma; but there are implausible values of reported use in this group. ORs for glioma tended to be greater in the temporal lobe than in other lobes of the brain, but the CIs around the lobe-specific estimates were wide. ORs for glioma tended to be greater in subjects who reported usual phone use on the same side of the head as their tumour than on the opposite side.

Conclusions 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.

Introduction

Mobile phone use has increased dramatically in many countries since its introduction in the early-to-mid 1980s. The expanding use of this technology has been accompanied by concerns about health and safety. In the late 1990s, several expert groups critically reviewed the evidence on health effects of low-level exposure to radiofrequency (RF) electromagnetic fields, and recommended research into the possible adverse health effects of mobile telephony.[1–4] As a result, the International Agency for Research on Cancer (IARC) coordinated a feasibility study in 1998 and 1999, which concluded that an international study of the relationship between mobile phone use and brain tumour risk would be feasible and informative.[5,6]

INTERPHONE was therefore initiated as an international set of case–control studies focussing on four types of tumours in tissues that most absorb RF energy emitted by mobile phones: tumours of the brain (glioma and meningioma), acoustic nerve (schwannoma) and parotid gland. The objective was to determine whether mobile phone use increases the risk of these tumours and, specifically, whether RF energy emitted by mobile phones is tumourigenic.

This article presents the results of analyses of brain tumour risk in relation to mobile phone use in all INTERPHONE study centres combined. Analyses of brain tumours in relation to mobile phone use have been reported from a number of cohort[7–9] and case–control studies, including several of the national components of INTERPHONE.[10–25] No studies, however, have included as many exposed cases, particularly long-term and heavy users of mobile phones, as this study.

Discussion

The INTERPHONE study is the largest case–control study of mobile phones and brain tumours conducted to date, including the largest numbers of users with at least 10 years of exposure and the greatest cumulative hours of use of any study. An exhaustive analysis of this large data set involved estimation of hundreds of ORs; rather than focus on the most extreme values, the interpretation should rest on the overall balance of evidence. The null hypothesis of no association would be expected to produce an approximately symmetric pattern of negative and positive log ORs. A skewed distribution could be due to a bias or to a true effect. Our results include not only a disproportionately high number of ORs <1, but also a small number of elevated ORs. This could be taken to indicate an underlying lack of association with mobile phone use, systematic bias from one or more sources, a few random but essentially meaningless increased ORs, or a small effect detectable only in a subset of the data.

For meningioma, there is little evidence to counter a global null hypothesis, and we conclude that INTERPHONE finds no signs of an increased risk of meningioma among users of mobile telephones.

For glioma, an increased OR was seen in analyses in the highest decile of cumulative call time, including tumours in the temporal lobe and subjects who reported having used the mobile phone mainly on the same side as where the tumour occurred. Still, the evidence for an increased risk of glioma among the highest users was inconclusive, as the increase could be due to one or more of the possible sources of error discussed below.

In the following sections, we explore possible explanations for the apparently decreased risk of meningioma and glioma for regular users compared with never regular users, and the apparently increased risk of glioma in a subset of users.

Decreased risk with ever regular use of a mobile phone

An apparently decreased risk of brain tumours with ever regular use of a mobile phone (relative to never regular use) has been seen in other studies.[18,23] Putting aside a genuine protective effect as implausible, we have considered other reasons for these observations.

Sampling bias

In all but two centres, a population-based design was used. This requires that the cases in the study were representative of all cases in the respective population and that the controls represented all non-cases, within matching strata. In practice, it is difficult to demonstrate that these conditions have been fulfilled in any case–control study. Cases may be missed due to lack of detection, misdiagnosis or incomplete registration (such problems may be more likely for meningioma than for glioma). It is uncertain whether the sampling frames used to select controls represented the study base in some countries. To the extent possible, we conducted sensitivity analyses that examined the effects of different recruitment strategies between centres; they did not show substantial changes in the results (Table 6).

Levels of participation

Constrained by the requirements of ethical review committees and facing the population's increasing reluctance to participate in interview studies, we attained participation rates of 78% among meningioma cases, 64% among glioma cases and 53% among controls.[26] Although such proportions are not unusually low, they raise the possibility of selection bias with respect to mobile phone use.

Controls in 11 centres and cases in 9 centres who refused the full interview were asked to respond to a brief non-respondent questionnaire on mobile phone use. The cases and controls who complied with this short inquiry reported a lower lifetime prevalence of ever regular use of a mobile phone than did respondents to the full interview, implying that information from those who participated in the full interview may overestimate prevalence among all eligible subjects. Because participation and refusal differed between cases and controls, such non-representativeness may have distorted the OR estimates.[30] Although caution is required in extrapolating from the findings of the sub-study, we estimated, in the more plausible scenarios, that non-participation bias may have led to a reduction in the ORs for regular use of 5–15%,[30] which is less than the observed

reductions below the null in the ORs in ever regular mobile phone users for meningioma (21%, 95% CI 32–9) and glioma (19%, 95% CI 30–6; Table 2).

Prodromal symptoms

Prodromal symptoms of a brain tumour could dissuade subjects from becoming phone users or reduce their use before diagnosis (reverse causation). Glioma is typically diagnosed quite soon after first symptoms. Although prodromal symptoms might result in lowered ORs among very recent users (e.g. <2 years since starting use), these are unlikely to explain the reduction in ORs observed among the vast majority of the users in our study population who started using mobile phones 2–10 years before disease onset.

Timing of interviews

As the use of mobile phones has become more common over time, the later interview dates of controls could have spuriously increased the prevalence of exposure in the control group. However, restricting analyses to matched sets in which the cases and controls were interviewed within 1 month of each other resulted in very little change in the OR for regular use ≥1 year in the past (Table 6) and hence seems unlikely to explain the low ORs overall. Further, the use of a common reference date for each case and its matched control should have minimized any bias induced by differential timing of interviews.

Confounding

Higher socio-economic status has been associated with a higher risk of brain cancer in some but not all relevant studies,[31,32] and with mobile phone use, particularly when the technology was new.[9] We adjusted for education level in all analyses, but acknowledge this is an imperfect indicator of SES. Otherwise, there are few well-established risk factors for brain tumours; analyses adjusting for measured potential confounders had little impact on the ORs (Appendix 1, Table 4, Supplementary data are available at *IJE* online).

Low overall risks among mobile phone users

The reduced OR for regular users compared with never regular users seems unlikely to reflect a genuine protective effect and makes our results difficult to interpret.[33] It could result from the sources of error discussed above, although based on the evidence we have regarding their magnitude and effects[30,34] they may not account fully for the observed reduction in risk.

It might be possible to correct, at least crudely, for assumed downwards bias in the ORs for mobile phone use by undertaking a series of analyses using the lowest category of users as the reference category for OR estimates in higher categories. Results of such an analysis of the mobile phone use variables in Table 2 are shown in the Table of Appendix 2 (see Supplementary data available at *IJE* online), accompanied by a discussion of the strengths and weaknesses of this approach. We have also done some work to characterize possible sources of bias[30,34] and are currently exploring the possibility of correcting the OR estimates mathematically for their effects.

Elevated risks of glioma among heavy users

There was some evidence of an elevated risk of glioma in the highest decile of cumulative call time, with the highest point estimates seen for tumours in the temporal lobe and for subjects who reported having used their mobile phone mainly on the same side as that on which the tumour occurred. We explore here possible interpretations of these findings.

Biases related to possible differential quality of exposure data

When compared with controls, glioma cases had a higher proportion of proxy respondents, a higher number of imputations for missing values, and a higher proportion of subjects judged by their interviewer to be non-responsive or having poor memory (data not shown). However, sensitivity analyses showed that these differences, on their own, did not explain the results seen in the highest decile of cumulative call time (Table 6).

Differential error between cases and controls in reporting of mobile phone use could substantially affect our results; such information bias could arise from several sources. First, a brain tumour, particularly in the frontal or temporal lobes, may adversely affect cognition and memory.[35] Secondly, cases may be more motivated to recall and report a publicized potential risk factor for their disease.

To investigate the accuracy of self-reported phone use, two validation sub-studies were conducted in some of the INTERPHONE centres. Amongst healthy volunteers using software-modified phones (recording number and times of calls), phone use in the past year was reported with substantial random error; with over- and under-estimation both frequent.[36] Errors were larger for duration of calls than for number of calls, and phone use was under-estimated by light users and over-estimated by heavy users. In another sub-study, records of mobile phone use up to 6 years previously were obtained for some participants in three INTERPHONE centres, allowing us to compare the interview responses with the records.[37] Overall, there was little evidence that recall quality differed between cases and controls, but there was some indication of greater over-reporting by cases than by controls for the period 3–5 years before interview. These sub-studies provide no information regarding differential reporting error for periods more distant than 5 years before interview.

Some subjects reported very high daily average call times and this was more common among cases than controls. Thirty-eight cases and 22 controls reported >5 h use/day and 10 cases and no controls reported ≥12 h/day. There is reasonable doubt about the credibility of such reports. Excluding all subjects who reported >5 h use/day reduced the ORs in the highest decile of cumulative time from 1.40 to 1.27 (95% CI 0.92–1.74). In contrast, truncating the average call time to 5 h/day had little effect on the OR. It is not clear which of these two approaches (if either) is more appropriate. However, the key question is whether these cases with unreasonably high values reflect a general tendency for cases to overestimate more than controls, which could contribute to the apparent excess risk in the highest decile. As noted earlier, there is evidence that cases tended to overestimate their past exposure more than controls did.[37]

Non-differential error (random variability or uncertainty in the exposure estimates) may also affect the findings. With dichotomous exposure indicators such bias is towards the null, but for polytomous variables the effect is difficult to predict.[38–40]

Location of tumours and laterality of use of phones

Absorption of RF energy from mobile phones is highly localized.[29] Thus, an association of phone use with tumours occurring near the location of the phone would constitute stronger evidence for aetiology than an association with more distant tumours.

Ipsilateral ORs were almost always greater than contralateral ORs. There was no consistent pattern with regard to level of exposure, although a trend towards a stronger effect of ipsilateral use relative to contralateral use with increasing exposure was observed for cumulative number of calls. Results of case–case analyses (using Inskip's method[18]) also suggested higher risks of gliomas with ipsilateral phone use, but again no consistent trend with increasing exposure. The observation of an unlikely ipsilateral effect in low exposure categories suggests that cases might have over-reported use on the side of the tumour.

There is, though, evidence of lack of such reporting bias from a sub-study. In three centres (Australia, Canada and Japan), participants (172 glioma and 160 meningioma cases and 340 controls who were regular users) were asked at the end of their interview to put a mobile phone to their ear as if answering a call. The concordance between the reported side of use of the phone and the side where it was held was lower for cases (72% glioma cases, 66% meningioma) than controls (95%). The greater degree of concordance among controls suggests differential reporting quality. Among cases, however, there was as much discrepancy in the contralateral direction (52 instances) as in the ipsilateral direction (48 instances). Thus, it is possible that the ipsilateral effect is a true effect, is due to reporting bias or is a mixture of both.

Few studies have related field strength to anatomic structures, but a recent investigation of 110 phone models found that exposure is generally highest in the temporal lobe.[29] While laterality analyses may be biased by the respondent's knowledge of the side of the tumour, results for tumours in different lobes are probably less susceptible to reporting bias. ORs for glioma in the highest exposure categories were higher for tumours in the temporal lobe than in other lobes, but the CIs around the lobe-specific estimates for each measure were wide.

Coherence and consistency

The strongest evidence of an increased risk of glioma was found for cumulative call time, which is a function of the number and duration of calls. Conceptually, cumulative call time might be the most relevant measure of exposure. However, in validation studies, the number of calls was recalled more accurately than the duration of calls.[36,37] For the cumulative number of calls, the ORs, while highest in the highest deciles, were consistently below one. In the absence of a known biological mechanism, it is hard to know whether more weight should be put on results from the more accurate or the conceptually preferred exposure measure.

The apparently increased risk of glioma for cumulative call time was restricted to the top decile, ≥1640 h. There was no upward trend across the first nine deciles of cumulative call time. In contrast with the excess risk seen on the scale of cumulative call time, risk did not appear to be increased by length of time since first exposure or by duration of exposure. The pattern of point estimates of ORs in the high call time categories in three

strata of time since exposure started—3.8 in the most recent and 1.3 in the more distant ones (Table 3)—is not what one would expect if there were a causal association; although the CI in the newest users was wide and encompassed the point estimates for heavy use in the two longer use groups. By analogy with known carcinogens, the lack of a consistently increasing risk with dose, duration of exposure and time since first exposure weigh against cause and effect. Nevertheless, given the uncertainty surrounding possible effects of RF on the brain, no strong case can be made for the plausibility or implausibility of any observed exposure response pattern.

Comparison of meningioma and glioma results

While the ORs for meningioma were lower than that for glioma in high exposure subgroups, there were some similar patterns. First, the OR for all regular users compared with never regular users was very similar. Secondly, there was no trend in relation to cumulative call time except for an elevated OR in the highest decile. Thirdly, the increase in the last decile was more pronounced for cumulative call time than number of calls. Fourthly, the highest OR for cumulative call time was seen among subjects who had recently started regular use. Fifthly, the ORs were greater for ipsilateral than contralateral use and the ratios of ipsilateral ORs divided by their corresponding contralateral ORs were of a similar magnitude. However, while there was evidence of a higher risk of gliomas in the temporal lobe than elsewhere with several different exposure metrics, there was no such evidence for meningioma. Although ORs for meningioma were generally lower than that for glioma, the otherwise similar patterns of associations of mobile phone use with meningioma and glioma could indicate shared aetiology or shared bias.

Interpretation of these findings

We have no certain explanation for the overall reduced risk of brain cancer among mobile phone users in this study, although selection bias is almost certainly a contributor. There is some evidence that very high users experienced excess risk of glioma, but that evidence is inconclusive because of possible bias. Further light may be shed on dose–response relations by work now being undertaken with the INTERPHONE data using precise coordinate localization of tumours within the brain in relation to estimates of absorbed RF energy.

The possibility of raised risk in heavy users of mobile phones is an important issue because of their ever-increasing use. Moreover, few subjects in our study had used mobile phones for >12 years; therefore, our results are uninformative with respect to lag periods longer than this.

Consistency with previous research

Our results are consistent with most of the research published to date. A large Danish cohort study of mobile telephone subscribers,[8,9] with an average follow-up time of 8.5 years, found no increased risk of brain tumours in subscribers of ≥10 years. The first case–control studies conducted included cases diagnosed in the mid-to-late 1990s and therefore could only address possible risks among short-term mobile phone users.[10,12,18,23] In addition, the highest cumulative call times in these studies were much less than in ours. Generally, these studies reported ‘negative’ results. In contrast, increased risks of malignant brain tumours at higher levels of accumulated use of analogue and digital

mobile phones and cordless desktop phones were reported from a sequence of three case–control studies from the same authors with cases in the last diagnosed as late as 2003.[13–15] However, the methods of these studies have been questioned.[41]

Some of the INTERPHONE centres have published their results for brain tumours[11,16,17,19,22,24,25] and two pooled analyses from Northern European centres have also been published.[20,21] Most cases in these reports are included in the present analyses and constitute 69% of gliomas and 57% of meningiomas. The centre-specific analyses are consistent with our all-centre results.

Much biological research has been done in recent years on possible biological effects of RF fields. This work covers *in vitro* and *in vivo* exposure, alone and in combination with other physical or chemical agents, and has found no evidence that RF fields are carcinogenic in laboratory rodents or cause DNA damage in cells in culture.[42] Possible effects of RF fields on other biological endpoints are still being explored.

The possible effects of long-term heavy use of mobile phones on risk of brain tumours require further investigation, given increasing mobile phone use, its extension to children and its penetration worldwide. The problems presented by selection and information bias in this and probably other studies suggest that new studies should, in general, only be done if they can substantially reduce or eliminate selection bias, obtain detailed and high-quality exposure information over the full period of use and offer sufficient statistical power to detect comparatively small effects in people with heavy or long continued exposure. Monitoring of age- and gender-specific incidence rates may also be valuable, particularly if informed by good longitudinal data on mobile phone use by age and sex, and having regard to features such as brain tumour location that may allow more specific inferences about possible mobile phone use effects.

Conclusion

This is the largest study of the risk of brain tumours in relation to mobile phone use conducted to date and it included substantial numbers of subjects who had used mobile phones for ≥10 years. Overall, no increase in risk of either glioma or meningioma was observed in association with use of mobile phones. There were suggestions of an increased risk of glioma, and much less so meningioma, at the highest exposure levels, for ipsilateral exposures and, for glioma, for tumours in the temporal lobe. However, biases and errors limit the strength of the conclusions we can draw from these analyses and prevent a causal interpretation.

Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences, INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION (ICNRP), 2009

A Review of the Scientific Evidence on Dosimetry, Biological Effects, Epidemiological Observations, and Health Consequences Concerning Exposure to High Frequency Electromagnetic Fields.

http://www.icnirp.net/40.htm#

Summary of Review of Experimental Studies of RF Biological Effects

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Overall, it is concluded that:

- The mechanisms by which RF exposure heats biological tissue are well understood and the most marked and consistent effect of RF exposure is that of heating, resulting in a number of heat-related physiological and pathological responses in human subjects and laboratory animals. Heating also remains a potential confounder in *in vitro* studies and may account for some of the positive effects reported.
- Recent concern has been more with exposure to the lower level RF radiation characteristic of mobile phone use. Whilst it is in principle impossible to disprove the possible existence of non-thermal interactions, the plausibility of various non-thermal mechanisms that have been proposed is very low.
- Concerning cancer-related effects, the recent *in vitro* and animal genotoxicity and carcinogenicity studies are rather consistent overall and indicate that such effects are unlikely at SAR levels up to 4 W kg-1. With regard to *in vitro* studies of RF effects on non-genotoxic end-points such as cell signaling and gene/protein expression, the results are more equivocal, but the magnitudes of the reported RF radiation induced changes are very small and of limited functional consequence. The results of studies on cell proliferation and differentiation, apoptosis and cell transformation are mostly negative.
- There is some evidence of small changes in brain physiology, notably on spontaneous EEG, and somewhat more variable evidence of changes in sleep EEG and regional cerebral blood flow but these may be of limited functional consequence; no changes were seen in cognitive function. With regard to more general physiological end-points, the evidence suggests that there are no consistent effects of non-thermal RF exposures on cardiovascular physiology, circulating hormone levels or on auditory or vestibular function, except for the auditory perception of pulsed RF such as that characteristic of radar.
- The evidence from double-blind provocation studies suggests that subjective symptoms, such as headaches, that have been identified by some individuals as associated with RF exposure, whilst real enough to the individuals concerned, are not causally related to EMF exposure.
- The experimental data do not suggest so far that children are more susceptible than adults to RF radiation, but few relevant studies have been conducted.
- Studies of the effects of RF modalities such as high peak power pulses have been somewhat diverse and sporadic; no effects have been seen other than those associated with heating and with acoustic perception.

Summary of Review of Health Effects of RF Exposure

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III.A.8. GENERAL CONCLUSIONS AND RECOMMENDATIONS
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.

A key concern across all studies is the quality of assessment of RF exposure, including the question of whether such exposure was present at all. Communication sources have increased greatly in recent years, and there is continuing change in the frequencies used and the variety of applications. Despite the rapid growth of new technologies using RF, little is known about population exposure from these and other RF sources and even less about the relative importance of different sources. Certain studies that are currently under way have made serious attempts to improve exposure assessment, based on attempts to learn more about determinants of RF exposure levels. A key element in improving future studies would be the use of a meter that monitors individual exposure. In the absence of information on what biological mechanism is relevant, if any, it is unclear what aspect of exposure needs to be captured in epidemiological studies. Ideally, the dose needs to be assessed not just as external field intensity, but also as cumulative exposure, as well as SAR, for specific anatomical sites.

The need for better exposure assessment is particularly strong in relation to transmitter studies, because the relation between distance and exposure is very weak. There is no point in conducting such studies unless it has been established that exposure levels vary substantially within the study area, and measurements of these RF levels are available. In the future, methods need to be developed to infer exposure based on some combination of knowledge regarding the sources of exposure, the levels of exposure, and location of people in relation to those sources, ideally informed by selective measurements.

Although the likelihood is low that fields emanating from base stations would create a health hazard, because of their weakness, this possibility is nevertheless a concern for many people. To date no acceptable study on any outcome has been published on this. On the one hand, results from valid studies would be of value in relation to a social concern; on the other hand, it would be difficult to design and conduct a valid study, and there is no scientific point in conducting an invalid one.

Another general concern in mobile phone studies is that the lag periods that have been examined to date are necessarily short. The implication is that if a longer lag period is required for a health effect to occur, the effect could not be detected in these studies. Only in the few countries where mobile phones were introduced very early has it been possible to look at ten years of usage or more. Much longer lag periods have been examined for occupational RF exposures, however. The published studies include some large occupational cohorts of good design and quality, except that there has been poor assessment of the degree of RF exposure, which render the results difficult to interpret.

The majority of research has focused on brain tumors and to some extent on leukemia. However, because the RF research questions are not driven by a specific biophysical hypothesis but rather by a general concern that there are unknown or misunderstood effects of RF fields, studies on other health effects may be equally justified. Examples are eye diseases, neurodegenerative diseases, and cognitive function. Given the increase of new mobile phone technologies, it is essential to follow various possible health effects from the very beginning, particularly since such effects may be detected only after a long duration, due to the prolonged latency period of many chronic diseases. Thus, research is needed to address long-term exposure, as well as diseases other than those included in the ongoing case-control studies.

Another gap in the research is children. No study population to date has included children, with the exception of studies of people living near radio and TV antennas. Children are increasingly heavy users of mobile phones, they might be particularly susceptible to harmful effects (although there is no evidence of this), and they are likely to accumulate many years of exposure during their lives..

Electromagnetic Fields and Public Health: Mobile Phones, WORLD HEALTH ORGANIZATION, May 2010

http://www.who.int/mediacentre/factsheets/fs193/en/index.html

KEY FACTS

Mobile phone use is ubiquitous with an estimated 4.6 billion subscriptions globally.
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.
There is an increased risk of road traffic injuries when drivers use mobile phones (either handheld or "hands-free") while driving.

Mobile or cellular phones are now an integral part of modern telecommunications. In many countries, over half the population use mobile phones and the market is growing rapidly. At the end of 2009, there were an estimated 4.6 billion subscriptions globally. In some parts of the world, mobile phones are the most reliable or the only phones available. Given the large number of mobile phone users, it is important to investigate, understand and monitor any potential public health impact.
Mobile phones communicate by transmitting radio waves through a network of fixed antennas called base stations. Radiofrequency waves are electromagnetic fields, and unlike ionizing radiation such as X-rays or gamma rays, cannot break chemical bonds nor cause ionization in the human body.

EXPOSURE LEVELS

Mobile phones are low-powered radiofrequency transmitters, operating at frequencies between 450 and 2700 MHz with peak powers in the range of 0.1 to 2 watts. The handset

only transmits power when it is turned on. The power (and hence the radiofrequency exposure to a user) falls off rapidly with increasing distance from the handset. A person using a mobile phone 30–40 cm away from their body – for example when text messaging, accessing the Internet, or using a “hands free” device – will therefore have a much lower exposure to radiofrequency fields than someone holding the handset against their head.

In addition to using "hands-free" devices, which keep mobile phones away from the head and body during phone calls, exposure is also reduced by limiting the number and length of calls. Using the phone in areas of good reception also decreases exposure as it allows the phone to transmit at reduced power. The use of commercial devices for reducing radiofrequency field exposure has not been shown to be effective.

Mobile phones are often prohibited in hospitals and on airplanes, as the radiofrequency signals may interfere with certain electro-medical devices and navigation systems.

Related link

Interphone study on mobile phone use and brain cancer risk

The International Electromagnetic Fields Project

Electromagnetic fields and public health: base stations and wireless technologies

Electromagnetic fields and public health: electromagnetic hypersensitivity

WHO research agenda for electromagnetic fields

ARE THERE ANY HEALTH EFFECTS?

A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established for mobile phone use.

Short-term effects

Tissue heating is the principal mechanism of interaction between radiofrequency energy and the human body. At the frequencies used by mobile phones, most of the energy is absorbed by the skin and other superficial tissues, resulting in negligible temperature rise in the brain or any other organs of the body.

A number of studies have investigated the effects of radiofrequency fields on brain electrical activity, cognitive function, sleep, heart rate and blood pressure in volunteers. To date, research does not suggest any consistent evidence of adverse health effects from exposure to radiofrequency fields at levels below those that cause tissue heating. Further, research has not been able to provide support for a causal relationship between exposure to electromagnetic fields and self-reported symptoms, or “electromagnetic hypersensitivity”.

In contrast, research has clearly shown an increased risk of road traffic injuries when drivers use mobile phones (either handheld or "hands-free") while driving. In several countries, motorists are prohibited or strongly discouraged from using mobile phones while driving.

Long-term effects

Epidemiological research examining potential long-term risks from radiofrequency exposure has mostly looked for an association between brain tumours and mobile phone use. However, because many cancers are not detectable until many years after the interactions that led to the tumour, and since mobile phones were not widely used until the early 1990s, epidemiological studies at present can only assess those cancers that become evident within shorter time periods. However, results of animal studies consistently show no increased cancer risk for long-term exposure to radiofrequency fields.

Several large multinational epidemiological studies have been completed or are ongoing, including case-control studies and prospective cohort studies examining a number of health endpoints in adults. To date, results of epidemiological studies provide no consistent evidence of a causal relationship between radiofrequency exposure and any adverse health effect. Yet, these studies have too many limitations to completely rule out an association.

A retrospective case-control study on adults, INTERPHONE, coordinated by the International Agency for Research on Cancer (IARC), was designed to determine whether there are links between use of mobile phones and head and neck cancers in adults. The international pooled analysis of data gathered from 13 participating countries found no increased risk of glioma or meningioma with mobile phone use of more than 10 years. There are some indications of an increased risk of glioma for those who reported the highest 10% of cumulative hours of cell phone use, although there was no consistent trend of increasing risk with greater duration of use. Researchers concluded that biases and errors limit the strength of these conclusions and prevent a causal interpretation. While an increased risk of brain tumors is not established from INTERPHONE data, the increasing use of mobile phones and the lack of data for mobile phone use over time periods longer than 15 years warrant further research of mobile phone use and brain cancer risk. In particular, with the recent popularity of mobile phone use among younger people, and therefore a potentially longer lifetime of exposure, WHO has promoted further research on this group. Several studies investigating potential health effects in children and adolescents are underway.

EXPOSURE LIMIT GUIDELINES

Radiofrequency exposure limits for mobile phone users are given in terms of Specific Absorption Rate (SAR) – the rate of radiofrequency energy absorption per unit mass of the body. Currently, two international bodies [1] [2] have developed exposure guidelines for workers and for the general public, except patients undergoing medical diagnosis or treatment. These guidelines are based on a detailed assessment of the available scientific evidence.

WHO'S RESPONSE

In response to public and governmental concern, WHO established the International Electromagnetic Fields (EMF) Project in 1996 to assess the scientific evidence of possible adverse health effects from electromagnetic fields. WHO will conduct a formal health risk assessment of radiofrequency fields exposure by 2012. Meanwhile, the

International Agency for Research on Cancer (IARC), a WHO specialized agency, is expected to review the carcinogenic potential of mobile phones in 2011.
WHO also identifies and promotes research priorities for radiofrequency fields and health to fill gaps in knowledge through its Research Agendas.
WHO develops public information materials and promotes dialogue among scientists, governments, industry and the public to raise the level of understanding about potential adverse health risks of mobile phones.

[1] International Commission on Non-Ionizing Radiation Protection – ICNIRP. Statement on the "Guidelines for limiting exposure to time-varying electric, magnetic and electromagetic fields (up to 300 GHz)", 2009.
[2] Institute of Electrical and Electronics Engineers IEEE Std C95.1 – 2005. *IEEE standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz*.

Electromagnetic Fields and Public Health, Electromagnetic Hypersensitivity, WORLD HEALTH ORGANIZATION, 2005

http://www.who.int/mediacentre/factsheets/fs296/en/index.html
Electromagnetic hypersensitivity
As societies industrialize and the technological revolution continues, there has been an unprecedented increase in the number and diversity of electromagnetic field (EMF) sources. These sources include video display units (VDUs) associated with computers, mobile phones and their base stations. While these devices have made our life richer, safer and easier, they have been accompanied by concerns about possible health risks due to their EMF emissions.
For some time a number of individuals have reported a variety of health problems that they relate to exposure to EMF. While some individuals report mild symptoms and react by avoiding the fields as best they can, others are so severely affected that they cease work and change their entire lifestyle. This reputed sensitivity to EMF has been generally termed “electromagnetic hypersensitivity” or EHS.
This fact sheet describes what is known about the condition and provides information for helping people with such symptoms. Information provided is based on a WHO Workshop on Electrical Hypersensitivity (Prague, Czech Republic, 2004), an international conference on EMF and non-specific health symptoms (COST244bis, 1998), a European Commission report (Bergqvist and Vogel, 1997) and recent reviews of the literature.
What is EHS?
EHS is characterized by a variety of non-specific symptoms, which afflicted individuals attribute to exposure to EMF. The symptoms most commonly experienced include dermatological symptoms (redness, tingling, and burning sensations) as well as neurasthenic and vegetative symptoms (fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitation, and digestive disturbances). The collection of symptoms is not part of any recognized syndrome.

EHS resembles multiple chemical sensitivities (MCS), another disorder associated with low-level environmental exposures to chemicals. Both EHS and MCS are characterized by a range of non-specific symptoms that lack apparent toxicological or physiological basis or independent verification. A more general term for sensitivity to environmental factors is Idiopathic Environmental Intolerance (IEI), which originated from a workshop convened by the International Program on Chemical Safety (IPCS) of the WHO in 1996 in Berlin. IEI is a descriptor without any implication of chemical etiology, immunological sensitivity or EMF susceptibility. IEI incorporates a number of disorders sharing similar non-specific medically unexplained symptoms that adversely affect people. However since the term EHS is in common usage it will continue to be used here.

Prevalence

There is a very wide range of estimates of the prevalence of EHS in the general population. A survey of occupational medical centres estimated the prevalence of EHS to be a few individuals per million in the population. However, a survey of self-help groups yielded much higher estimates. Approximately 10% of reported cases of EHS were considered severe.

There is also considerable geographical variability in prevalence of EHS and in the reported symptoms. The reported incidence of EHS has been higher in Sweden, Germany, and Denmark, than in the United Kingdom, Austria, and France. VDU-related symptoms were more prevalent in Scandinavian countries, and they were more commonly related to skin disorders than elsewhere in Europe. Symptoms similar to those reported by EHS individuals are common in the general population.

Studies on EHS individuals

A number of studies have been conducted where EHS individuals were exposed to EMF similar to those that they attributed to the cause of their symptoms. The aim was to elicit symptoms under controlled laboratory conditions.

The majority of studies indicate that EHS individuals cannot detect EMF exposure any more accurately than non-EHS individuals. Well controlled and conducted double-blind studies have shown that symptoms were not correlated with EMF exposure.

It has been suggested that symptoms experienced by some EHS individuals might arise from environmental factors unrelated to EMF. Examples may include “flicker” from fluorescent lights, glare and other visual problems with VDUs, and poor ergonomic design of computer workstations. Other factors that may play a role include poor indoor air quality or stress in the workplace or living environment.

There are also some indications that these symptoms may be due to pre-existing psychiatric conditions as well as stress reactions as a result of worrying about EMF health effects, rather than the EMF exposure itself.

Conclusions

EHS is characterized by a variety of non-specific symptoms that differ from individual to individual. The symptoms are certainly real and can vary widely in their severity. Whatever its cause, EHS can be a disabling problem for the affected individual. EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure. Further, EHS is not a medical diagnosis, nor is it clear that it represents a single medical problem.

Physicians: Treatment of affected individuals should focus on the health symptoms and the clinical picture, and not on the person's perceived need for reducing or eliminating EMF in the workplace or home. This requires:
a medical evaluation to identify and treat any specific conditions that may be responsible for the symptoms,
a psychological evaluation to identify alternative psychiatric/psychological conditions that may be responsible for the symptoms,
an assessment of the workplace and home for factors that might contribute to the presented symptoms. These could include indoor air pollution, excessive noise, poor lighting (flickering light) or ergonomic factors. A reduction of stress and other improvements in the work situation might be appropriate.
For EHS individuals with long lasting symptoms and severe handicaps, therapy should be directed principally at reducing symptoms and functional handicaps. This should be done in close co-operation with a qualified medical specialist (to address the medical and psychological aspects of the symptoms) and a hygienist (to identify and, if necessary, control factors in the environment that are known to have adverse health effects of relevance to the patient).
Treatment should aim to establish an effective physician-patient relationship, help develop strategies for coping with the situation and encourage patients to return to work and lead a normal social life.
EHS individuals: Apart from treatment by professionals, self help groups can be a valuable resource for the EHS individual.
Governments: Governments should provide appropriately targeted and balanced information about potential health hazards of EMF to EHS individuals, health-care professionals and employers. The information should include a clear statement that no scientific basis currently exists for a connection between EHS and exposure to EMF.
Researchers: Some studies suggest that certain physiological responses of EHS individuals tend to be outside the normal range. In particular, hyper reactivity in the central nervous system and imbalance in the autonomic nervous system need to be followed up in clinical investigations and the results for the individuals taken as input for possible treatment.
What WHO is doing
WHO, through its International EMF Project, is identifying research needs and co-ordinating a world-wide program of EMF studies to allow a better understanding of any health risk associated with EMF exposure. Particular emphasis is placed on possible health consequences of low-level EMF. Information about the EMF Project and EMF effects is provided in a series of fact sheets in several languages www.who.int/emf/.
FURTHER READING
WHO workshop on electromagnetic hypersensitivity (2004), October 25 -27, Prague, Czech Republic, www.who.int/peh-emf/meetings/hypersensitivity_prague2004/en/index.html
COST244bis (1998) Proceedings from Cost 244bis International Workshop on Electromagnetic Fields and Non-Specific Health Symptoms. Sept 19-20, 1998, Graz, Austria
Bergqvist U and Vogel E (1997) Possible health implications of subjective symptoms and electromagnetic field. A report prepared by a European group of experts for the European

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Electromagnetic Fields and Public Health: Base Stations and Wireless Technologies, WORLD HEALTH ORGANIZATION, 2006

http://www.who.int/mediacentre/factsheets/fs304/en/index.html
Mobile telephony is now commonplace around the world. This wireless technology relies upon an extensive network of fixed antennas, or base stations, relaying information with radiofrequency (RF) signals. Over 1.4 million base stations exist worldwide and the number is increasing significantly with the introduction of third generation technology. Other wireless networks that allow high-speed internet access and services, such as wireless local area networks (WLANs), are also increasingly common in homes, offices, and many public areas (airports, schools, residential and urban areas). As the number of base stations and local wireless networks increases, so does the RF exposure of the population. Recent surveys have shown that the RF exposures from base stations range from 0.002% to 2% of the levels of international exposure guidelines, depending on a variety of factors such as the proximity to the antenna and the surrounding environment. This is lower or comparable to RF exposures from radio or television broadcast transmitters.

There has been concern about possible health consequences from exposure to the RF fields produced by wireless technologies. This fact sheet reviews the scientific evidence on the health effects from continuous low-level human exposure to base stations and other local wireless networks.

Health concerns
A common concern about base station and local wireless network antennas relates to the possible long-term health effects that whole-body exposure to the RF signals may have. To date, the only health effect from RF fields identified in scientific reviews has been related to an increase in body temperature (> 1 °C) from exposure at very high field intensity found only in certain industrial facilities, such as RF heaters. The levels of RF exposure from base stations and wireless networks are so low that the temperature increases are insignificant and do not affect human health.

The strength of RF fields is greatest at its source, and diminishes quickly with distance. Access near base station antennas is restricted where RF signals may exceed international exposure limits. Recent surveys have indicated that RF exposures from base stations and wireless technologies in publicly accessible areas (including schools and hospitals) are normally thousands of times below international standards.
In fact, due to their lower frequency, at similar RF exposure levels, the body absorbs up to five times more of the signal from FM radio and television than from base stations. This is because the frequencies used in FM radio (around 100 MHz) and in TV broadcasting (around 300 to 400 MHz) are lower than those employed in mobile telephony (900 MHz and 1800 MHz) and because a person's height makes the body an efficient receiving antenna. Further, radio and television broadcast stations have been in operation for the past 50 or more years without any adverse health consequence being established.

While most radio technologies have used analog signals, modern wireless telecommunications are using digital transmissions. Detailed reviews conducted so far have not revealed any hazard specific to different RF modulations.

Cancer: Media or anecdotal reports of cancer clusters around mobile phone base stations have heightened public concern. It should be noted that geographically, cancers are unevenly distributed among any population. Given the widespread presence of base stations in the environment, it is expected that possible cancer clusters will occur near base stations merely by chance. Moreover, the reported cancers in these clusters are often a collection of different types of cancer with no common characteristics and hence unlikely to have a common cause.
Scientific evidence on the distribution of cancer in the population can be obtained through carefully planned and executed epidemiological studies. Over the past 15 years, studies examining a potential relationship between RF transmitters and cancer have been published. These studies have not provided evidence that RF exposure from the transmitters increases the risk of cancer. Likewise, long-term animal studies have not established an increased risk of cancer from exposure to RF fields, even at levels that are much higher than produced by base stations and wireless networks.

Other effects: Few studies have investigated general health effects in individuals exposed to RF fields from base stations. This is because of the difficulty in distinguishing possible health effects from the very low signals emitted by base stations from other higher strength RF signals in the environment. Most studies have focused on the RF exposures of mobile phone users. Human and animal studies examining brain wave patterns, cognition and behaviour after exposure to RF fields, such as those generated by mobile phones, have not identified adverse effects. RF exposures used in these studies were about 1000 times higher than those associated with general public exposure from base stations or wireless networks. No consistent evidence of altered sleep or cardiovascular function has been reported.

Some individuals have reported that they experience non-specific symptoms upon exposure to RF fields emitted from base stations and other EMF devices. As recognized

in a recent WHO fact sheet "Electromagnetic Hypersensitivity", EMF has not been shown to cause such symptoms. Nonetheless, it is important to recognize the plight of people suffering from these symptoms.

From all evidence accumulated so far, no adverse short- or long-term health effects have been shown to occur from the RF signals produced by base stations. Since wireless networks produce generally lower RF signals than base stations, no adverse health effects are expected from exposure to them.

Protection standards
International exposure guidelines have been developed to provide protection against established effects from RF fields by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998) and the Institute of Electrical and Electronic Engineers (IEEE, 2005).

National authorities should adopt international standards to protect their citizens against adverse levels of RF fields. They should restrict access to areas where exposure limits may be exceeded.

Public perception of risk
Some people perceive risks from RF exposure as likely and even possibly severe. Several reasons for public fear include media announcements of new and unconfirmed scientific studies, leading to a feeling of uncertainty and a perception that there may be unknown or undiscovered hazards. Other factors are aesthetic concerns and a feeling of a lack of control or input to the process of determining the location of new base stations.

Experience shows that education programmes as well as effective communications and involvement of the public and other stakeholders at appropriate stages of the decision process before installing RF sources can enhance public confidence and acceptability.

Conclusions
Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects.

WHO Initiatives
WHO, through the International EMF Project, has established a programme to monitor the EMF scientific literature, to evaluate the health effects from exposure to EMF in the range from 0 to 300 GHz, to provide advice about possible EMF hazards and to identify suitable mitigation measures. Following extensive international reviews, the International EMF Project has promoted research to fill gaps in knowledge. In response national governments and research institutes have funded over $250 million on EMF research over the past 10 years.

While no health effects are expected from exposure to RF fields from base stations and wireless networks, research is still being promoted by WHO to determine whether there are any health consequences from the higher RF exposures from mobile phones.
The International Agency for Research on Cancer (IARC), a WHO specialized agency, is expected to conduct a review of cancer risk from RF fields in 2006-2007 and the International EMF Project will then undertake an overall health risk assessment for RF fields in 2007-2008.

Further Reading
ICNIRP (1998) www.icnirp.org/documents/emfgdl.pdf
IEEE (2006) IEEE C95.1-2005 "IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz"
Related links
- Base stations & wireless networks: Exposures & health consequences
- Fact sheet: Electromagnetic fields and public health: Electromagnetic Hypersensitivity
- WHO handbook on "Establishing a Dialogue on Risks from Electromagnetic Fields"
- 2006 WHO Research Agenda for Radio Frequency Fields [pdf 100kb]
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Electromagnetic Fields and Public Health: Exposure to Extremely Low Frequency Fields, WORLD HEALTH ORGANIZATION, 2007

http://www.who.int/mediacentre/factsheets/fs322/en/index.html

The use of electricity has become an integral part of everyday life. Whenever electricity flows, both electric and magnetic fields exist close to the lines that carry electricity, and close to appliances. Since the late 1970s, questions have been raised whether exposure to these extremely low frequency (ELF) electric and magnetic fields (EMF) produces adverse health consequences. Since then, much research has been done, successfully resolving important issues and narrowing the focus of future research.

In 1996, the World Health Organization (WHO) established the International Electromagnetic Fields Project to investigate potential health risks associated with technologies emitting EMF. A WHO Task Group recently concluded a review of the health implications of ELF fields (WHO, 2007).

This Fact Sheet is based on the findings of that Task Group and updates recent reviews on the health effects of ELF EMF published in 2002 by the International Agency for Research on Cancer (IARC), established under the auspices of WHO, and by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2003.
ELF field sources and residential exposures

Electric and magnetic fields exist wherever electric current flows - in power lines and cables, residential wiring and electrical appliances. **Electric** fields arise from electric charges, are measured in volts per metre (V/m) and are shielded by common materials, such as wood and metal. **Magnetic** fields arise from the motion of electric charges (i.e. a current), are expressed in tesla (T), or more commonly in millitesla (mT) or microtesla (μT). In some countries another unit called the gauss, (G), is commonly used (10,000 G = 1 T). These fields are not shielded by most common materials, and pass easily through them. Both types of fields are strongest close to the source and diminish with distance. Most electric power operates at a frequency of 50 or 60 cycles per second, or hertz (Hz). Close to certain appliances, the magnetic field values can be of the order of a few hundred microtesla. Underneath power lines, magnetic fields can be about 20 μT and electric fields can be several thousand volts per metre. However, average residential power-frequency magnetic fields in homes are much lower - about 0.07 μT in Europe and 0.11 μT in North America. Mean values of the electric field in the home are up to several tens of volts per metre.

Task group evaluation

In October 2005, WHO convened a Task Group of scientific experts to assess any risks to health that might exist from exposure to ELF electric and magnetic fields in the frequency range >0 to 100,000 Hz (100 kHz). While IARC examined the evidence regarding cancer in 2002, this Task Group reviewed evidence for a number of health effects, and updated the evidence regarding cancer. The conclusions and recommendations of the Task Group are presented in a WHO Environmental Health Criteria (EHC) monograph (WHO, 2007).

Following a standard health risk assessment process, the Task Group concluded that there are no substantive health issues related to ELF electric fields at levels generally encountered by members of the public. Thus the remainder of this fact sheet addresses predominantly the effects of exposure to ELF magnetic fields.

Short-term effects

There are established biological effects from acute exposure at high levels (well above 100 μT) that are explained by recognized biophysical mechanisms. External ELF magnetic fields induce electric fields and currents in the body which, at very high field strengths, cause nerve and muscle stimulation and changes in nerve cell excitability in the central nervous system.

Potential long-term effects

Much of the scientific research examining long-term risks from ELF magnetic field exposure has focused on childhood leukaemia. In 2002, IARC published a monograph classifying ELF magnetic fields as "possibly carcinogenic to humans". This classification is used to denote an agent for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence for carcinogenicity in experimental animals (other examples include coffee and welding fumes). This classification was based on pooled analyses of epidemiological studies demonstrating a consistent pattern of a two-

fold increase in childhood leukaemia associated with average exposure to residential power-frequency magnetic field above 0.3 to 0.4 μT. The Task Group concluded that additional studies since then do not alter the status of this classification.

However, the epidemiological evidence is weakened by methodological problems, such as potential selection bias. In addition, there are no accepted biophysical mechanisms that would suggest that low-level exposures are involved in cancer development. Thus, if there were any effects from exposures to these low-level fields, it would have to be through a biological mechanism that is as yet unknown. Additionally, animal studies have been largely negative. Thus, on balance, the evidence related to childhood leukaemia is not strong enough to be considered causal.

Childhood leukaemia is a comparatively rare disease with a total annual number of new cases estimated to be 49,000 worldwide in 2000. Average magnetic field exposures above 0.3 μT in homes are rare: it is estimated that only between 1% and 4% of children live in such conditions. If the association between magnetic fields and childhood leukaemia is causal, the number of cases worldwide that might be attributable to magnetic field exposure is estimated to range from 100 to 2400 cases per year, based on values for the year 2000, representing 0.2 to 4.95% of the total incidence for that year. Thus, if ELF magnetic fields actually do increase the risk of the disease, when considered in a global context, the impact on public health of ELF EMF exposure would be limited.

A number of other adverse health effects have been studied for possible association with ELF magnetic field exposure. These include other childhood cancers, cancers in adults, depression, suicide, cardiovascular disorders, reproductive dysfunction, developmental disorders, immunological modifications, neurobehavioural effects and neurodegenerative disease. The WHO Task Group concluded that scientific evidence supporting an association between ELF magnetic field exposure and all of these health effects is much weaker than for childhood leukaemia. In some instances (i.e. for cardiovascular disease or breast cancer) the evidence suggests that these fields do not cause them.

International exposure guidelines

Health effects related to short-term, high-level exposure have been established and form the basis of two international exposure limit guidelines (ICNIRP, 1998; IEEE, 2002). At present, these bodies consider the scientific evidence related to possible health effects from long-term, low-level exposure to ELF fields insufficient to justify lowering these quantitative exposure limits.

WHO's guidance

For high-level short-term exposures to EMF, adverse health effects have been scientifically established (ICNIRP, 2003). International exposure guidelines designed to protect workers and the public from these effects should be adopted by policy makers. EMF protection programs should include exposure measurements from sources where exposures might be expected to exceed limit values.

Regarding long-term effects, given the weakness of the evidence for a link between exposure to ELF magnetic fields and childhood leukaemia, the benefits of exposure reduction on health are unclear. In view of this situation, the following recommendations are given:
Government and industry should monitor science and promote research programmes to further reduce the uncertainty of the scientific evidence on the health effects of ELF field exposure. Through the ELF risk assessment process, gaps in knowledge have been identified and these form the basis of a new research agenda.

Member States are encouraged to establish effective and open communication programmes with all stakeholders to enable informed decision-making. These may include improving coordination and consultation among industry, local government, and citizens in the planning process for ELF EMF-emitting facilities.

When constructing new facilities and designing new equipment, including appliances, low-cost ways of reducing exposures may be explored. Appropriate exposure reduction measures will vary from one country to another. However, policies based on the adoption of arbitrary low exposure limits are not warranted.

Further reading
WHO - World Health Organization. Extremely low frequency fields. Environmental Health Criteria, Vol. 238. Geneva, World Health Organization, 2007.
IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Non-ionizing radiation, Part 1: Static and extremely low-frequency (ELF) electric and magnetic fields. Lyon, IARC, 2002 (Monographs on the Evaluation of Carcinogenic Risks to Humans, 80).
ICNIRP - International Commission on Non-Ionizing Radiation Protection. Exposure to static and low frequency electromagnetic fields, biological effects and health consequences (0-100 kHz). Bernhardt JH et al., eds. Oberschleissheim, International Commission on Non-ionizing Radiation Protection, 2003 (ICNIRP 13/2003).
ICNIRP – International Commission on Non-Ionizing Radiation Protection (1998). Guidelines for limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz). Health Physics 74(4), 494-522.
IEEE Standards Coordinating Committee 28. IEEE standard for safety levels with respect to human exposure to electromagnetic fields, 0-3 kHz. New York, NY, IEEE - The Institute of Electrical and Electronics Engineers, 2002 (IEEE Std C95.6-2002).
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Non-Ionizing Radiation, HEALTH PROTECTION AGENCY OF THE UNITED KINGDOM, August 2010

Health Advice on Mobile Phones

http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields/MobilePhones/info_HealthAdvice/

Mobile phones operate by using radio waves, a form of non-ionising radiation. There is a large body of scientific evidence on the effects of exposure to radio waves because they have been widely used for decades. For example, radio, TV and radar signals are radio waves.

There are thousands of published scientific papers covering research about the effects of various types of radio waves on cells, tissues, animals and people. The scientific consensus is that, apart from the increased risk of a road accident due to mobile phone use when driving, there is no clear evidence of adverse health effects from the use of mobile phones or from phone masts. However there is now widespread use of this relatively new technology and more research is needed in case there are long term effects.

Some of the published research has produced contradictory results, particularly biology experiments using cell cultures. An important role of radiological protection specialists at the Health Protection Agency is to review the scientific evidence impartially and provide clear advice. The Agency also has an Advisory Group of experts who study the scientific evidence and provide independent advice (AGNIR, independent Advisory Group on Non-Ionising Radiation).

Basic Advice

In 2000, an independent expert group in the UK first reviewed the evidence about the health effects of mobile phones. Its report "Mobile Phones and Health" (Independent Expert Group on Mobile Phones; IEGMP) has become known as the Stewart Report after its chairman Sir William Stewart. This expert group concluded that there was no clear scientific evidence of harm to health from exposure to mobile phone signals.

However, the expert group was concerned about the widespread adoption of a new technology involving exposure from radio waves to people's heads, including those of children, at levels that are significant fractions of international guidelines. This, and some uncertainties in biological evidence, led the expert group to advise some precaution, particularly in the use of mobile phones by children.

This advice was accepted by the Department of Health and leaflets and other information were provided for the public in 2000 and 2004. The basic advice from the Stewart Report continues to be the advice of the Health Protection Agency. The benefits of mobile telecommunications are widely recognised but, given the uncertainties in the science, some precaution is warranted particularly regarding the use of handsets held against the head. This is especially relevant to the use of handsets by children and the Agency recommends that excessive use by children should be discouraged.

Regarding the siting of telephone masts, this is a planning matter and therefore Government decides the law and any permitted development rights. However the Health Protection Agency notes that measurements in the UK and elsewhere, show that exposure levels to the signals from phone masts are much less than those from using mobile phone handsets, typically by factors of 100, 1000 and even 10,000, including when people are quite close to a mast.

Since 2000, expert reviews of the evidence have been carried out in many other countries and they have come to very similar conclusions about the lack of clear scientific evidence for any adverse health effects. For more details, see the sections below on the Stewart Report and other expert reviews of the scientific evidence.

Advice on Exposure Guidelines

The Health Protection Agency published advice on limiting exposure to electromagnetic fields in 2004 and recommended the adoption in the UK of the established international guidelines from the International Commission on Non-Ionizing Radiation Protection (ICNIRP, see below). This advice was supported by a comprehensive scientific review covering the broad base of the scientific evidence.

The scientific evidence included published studies of human and animal health, the effects on biological cell cultures and the physics of the interaction of radio waves with matter (epidemiological studies, animal studies, experimental biology and dosimetry). The ICNIRP guidelines are based on a critical in-depth evaluation of the established scientific literature. The guidelines represent the international scientific consensus about this evidence and ensure the avoidance of known biological effects.

The Health Protection Agency review also gave recommendations for the research needed to fill the gaps in scientific knowledge and to improve the rigour of the guidelines.

The Health Protection Agency is committed to monitoring the results of further research related to the effects of radio waves on health and to revising its advice when appropriate.

ICNIRP Guidelines

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) is an independent international scientific organisation formally recognised by the World Health Organization. ICNIRP reviews the science relating to exposure to electromagnetic fields and produces guidelines for limiting people's exposure. ICNIRP has a website from which a copy of its guidelines and other background information may be downloaded.

ICNIRP published a comprehensive set of guidelines in 1998 restricting exposures to electromagnetic fields, including radio waves. The Commission reconfirmed the basic restrictions in the frequency range 100 kHz-300 GHz (which includes the mobile phone frequency range) in 2009.

The ICNIRP guidelines contain basic restrictions on exposure that are set at levels which avoid the known adverse health effects of exposure. At the mobile phone frequencies, compliance with the ICNIRP guidelines will avoid heating by absorption of radio frequency signals. This is because the evidence from scientific studies of animals, cells and people shows clearly that biological effects occur at levels where heating occurs. The ICNIRP guidelines are therefore used as an input to the development of standards in very many countries, including those of the European Union.

The basic restrictions are specified in terms of fundamental dose quantities that occur inside the body; consequently, they are not easy to measure in living people. Reference levels are needed which are expressed in terms of quantities measurable outside the body such as electric field strength and power density.

Mobile phone handsets expose those parts of the body that are closest to the phone when the phone is in use, and most often this is the head. Therefore, for mobile phones, the most important restriction in the guidelines is the one on the localised Specific Energy Absorption Rate (SAR), a measure of the energy absorbed in the head.

Base station antennas tend to be very much further away from the body than a mobile phone and in this situation the reference level in terms of power density is usually meaningful as an indicator of SAR averaged over the whole body.

The Independent Expert Group on Mobile Phones (Stewart Report)

The Independent Expert Group on Mobile Phones (IEGMP) published its report of May 2000. It has become known subsequently as the Stewart Report.

The Stewart Report supported the conclusion of ICNIRP that heating remains the best basis for setting exposure limits. The report also supported the approach of ICNIRP to have separate exposure guidelines for workers and for members of the public. The public guidelines are more restrictive because within the general public there may be people with illnesses or other characteristics that render them more susceptible to the heating effects of radio waves.

The Stewart Report concluded that the balance of evidence was that exposures to radio frequency waves below ICNIRP guidelines did not cause adverse health effects to the general population. However there were uncertainties in the science and further research needed to be carried out. Given the uncertainties and the widespread use of mobile phone technology, the Stewart Report recommended a precautionary approach. This included a recommendation that excessive use of mobile phones by children should be discouraged.

Other Expert Reviews of the Scientific Evidence

Since 2000 there have been a number of reviews of the evidence carried out by scientific expert groups in the UK and in other countries, and most have come to conclusions very similar to those in the Stewart Report. A selection is given here

The Zmirou Report was published in France in 2001 and the Health Council of the Netherlands published its first report on the topic in 2002. Both reports came to conclusions about the scientific evidence that were similar to those in the Stewart Report. In December 2003, the Swedish Radiation Protection Authority published its first review and concluded that there was no significant change in the scientific evidence and the conclusions of the Stewart Report were still valid. Following these initial reports, both the Health Council of the Netherlands and the Swedish Radiation Protection Authority have published annual reviews of the evidence. The general conclusions about the evidence have not changed. These annual reports can be found on the website links given above.

In December 2003 the HPA's independent Advisory Group on Non-Ionising Radiation (AGNIR) published a follow up review of the scientific evidence since the Stewart Report. AGNIR concluded that the research published since the Stewart Report did not change the balance of evidence, but stressed the continued need for research.

In 2004, the ICNIRP Standing Committee on Epidemiology published a detailed review of epidemiological studies of health effects from exposure to radio waves (A Ahlbom, A Green, L Kheifets, D Savitz and A Swerdlow. Epidemiology of Health Effects of Radiofrequency Exposure. *Environmental Health Perspectives* 2004; **112**(17): 1741-1754). This was a review of many studies carried out over several decades, looking at cancer, fertility, heart problems and cataracts in people who worked with radio waves. It also looked at studies of public exposure from radio and TV transmissions, focusing on leukaemia and studies of mobile phone users, but also looking at brain tumours and other cancers and symptoms. The reviewers concluded that "Results of these studies to date give no consistent or convincing evidence of a causal relation between RF exposure and any adverse health effect." However the authors did not rule out the possibility of an association because of the rapid introduction of mobile phones and their widespread use. Also, "A key concern across all studies is the quality of assessment of RF exposure" and there is "…almost no data is available on the consequences of childhood exposure".

In 2007, the UK Mobile Telecommunications and Health Research (MTHR) programme published a report summarising the results of the work it had funded since 2001. It concluded that none of the research had provided evidence of biological effects or health effects below guideline levels. Nevertheless there is still a need for good research and it could not rule out the possibility of long-term effects. The MTHR research programme was set up in response to a recommendation from the Stewart Report and is jointly funded by Government and industry. Its independence is safeguarded by a committee of experts who review the research proposals and monitor each project. Scientists receiving funds from MTHR are encouraged to publish their results in peer reviewed science journals.

In 2008 the US National Cancer Institute published a detailed factsheet on mobile phone use and cancer. The NCI concluded that although research has not demonstrated a consistent link between mobile phone use and cancer, scientists still caution that further surveillance is needed before conclusions can be drawn.

The European Commission set up a Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) in 2004 and this committee has published reports on the Possible Effects of Electromagnetic Fields on Human Health in 2007 and 2009. In the 2009 report (http://ec.europa.eu/health/ph_risk/committees/04_scenihr/docs/scenihr_o_022.pdf) the Committee concluded "….from three independent lines of evidence (epidemiological, animal and in vitro studies) that exposure to RF fields is unlikely to lead to an increase in cancer in humans. However, as the widespread duration of exposure of humans to RF fields from mobile phones is shorter than the induction time of some cancers, further studies are required to identify whether considerably longer-term (well beyond ten years) human exposure to such phones might pose some cancer risk."

In 2009 the French Agency for Environmental and Occupational Health Safety (Afsset) published an opinion from an expert group on biological and health effects from radiofrequency waves.
After reviewing the biological, epidemiological and health evidence, this expert group concluded "that the majority of the studies carried out do not show effects for exposures at non-thermal powers" and "that available work does not currently allow the mechanism of a non-thermal effect nor a cumulative mechanism of action of radiofrequencies to be identified". Nevertheless, the expert group recognised the continuing uncertainties in the scientific evidence and Afsset issued precautionary advice aimed at minimising radiofrequency exposures to people, and to children in particular.

In 2009, members of the ICNIRP Standing Committee on Biology published a review of the effects of radiofrequency fields on the human nervous system (E van Rongen, R Croft, J Juutilainen, I Lagroye, R Saunders, R de Seze, T Tenforde, L Vershaeve, B Veyret and Z Xu. Effects of radiofrequency electromagnetic fields on the human nervous system. *J Toxicol and Env. Health* 2009 Part B; **12**: 572-597). They concluded that "There is some evidence of an effect of exposure to a Global System for Mobile Telecommunication (GSM)-type signal on the spontaneous electroencephalogram (EEG). They noted however, that the effect may be of little functional significance since, "No consistent significant effects on cognitive performance in adults have been observed. If anything, any effect is small and exposure seems to improve performance." With regard to subjective symptoms such as headaches and migraine, the authors noted that these had been "attributed to various radiofrequency sources both at home and at work. However, in provocation studies a causal relation between EMF exposure and symptoms has never been demonstrated. There are clear indications, however, that psychological factors such as the conscious expectation of effect may play an important role in this condition.

In 2009, members of the ICNIRP Standing Committee on Epidemiology published an update of their 2004 review mentioned above (A Ahlbom, M Feychting, A Green, L Kheifets, D Savitz and A Swerdlow. Epidemiologic evidence on mobile phones and Tumor Risk: A Review. *Epidemiology* 2009; **20**(5): 639-652) They noted that the number of papers on this topic had grown since 2004, but methodological problems remain. These are primarily the selective non-response of participants, and the inaccuracy and bias in their recall of phone use. Most studies had shown small increased or decreased

risk amongst users, but a subset of studies showed an elevated risk. The subset of elevated results comes from a particular research group and there is no obvious explanation of why they obtain such different results from other studies. Overall, the ICNIRP Standing Committee conclude that the available data do not suggest a causal association between mobile phone use and fast growing tumours in the brain such as malignant glioma. The similar absence of an association for slow growing tumours (such as meningioma and acoustic neuroma) is far less conclusive, because the period of observation is simply too short.

The INTERPHONE Study

The results of this important study were published in May 2010. The authors 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"

This multi-national study was set up in 2000, following a successful feasibility study during 1998/99. It involves research in 13 countries to see whether mobile phone use is associated with an increased risk of head and neck tumours (including brain and salivary gland tumours).

The study was undertaken as a collaborative effort between a number of partner institutions, co-ordinated by the International Agency for Research on Cancer (IARC), part of the World Health Organization (WHO). The participating countries were Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden and the UK.

Most individual studies in the various countries were published between 2004 and 2008. The pooled INTERPHONE study has combined the results from individual countries into one study involving nearly 6,500 cases and over 7,500 controls. This pooled study (see link below) contained more detailed data and analysis than in the studies from individual countries.
http://www.oxfordjournals.org/our_journals/ije/press_releases/freepdf/dyq079.pdf

The first step was to identify people with head and neck tumours (cases) and a similar number of people without such tumours (controls). The researchers then asked the individuals about their usage of mobile phones (both cases and controls) so they could be classified into groups reflecting heavy, light or non users. All the participants were asked to recall the side of the head that the mobile phone was normally, or most frequently, used. This information was obtained via an in-person, computer-assisted interview.

In view of the way the information was gathered, there are many considerations that have to be taken into account when interpreting the results of the Interphone Study. These are discussed at length in the published paper and some examples are given below.

The results from the individual INTERPHONE studies in different countries and the pooled study appear to show a protective effect, correlating the use of mobile phones with a reduced risk of head and neck tumours. These unexpected findings could be due to selection bias. In most countries the participation rate was fairly high for cases, but lower among potential controls. If mobile phone use differed between those controls who took part in the studies and those potential controls who did not take part, then this would lead to biased findings. Such a situation could arise if people with a relatively high level of education and socio-economic status were more willing than others to participate in this research and tended to use mobile phones more often than other members of the population. As a consequence, over-estimation of exposure among controls due to selective participation might result in an apparent protective effect of mobile phone use.

In contrast, results from individual countries also show that people with cancers in the head and neck tend to associate the use of mobile phones with the side of the head or neck where the tumour has appeared. This is a relatively strong association for some tumours (glioma and acoustic neuromas) after more than 10 years' usage. These findings might be due, at least in part, to bias in recalling the side of the head on which the mobile phone was generally used. The cases might have tended to over-report use on same side of head as that where the tumour arose, because some of them may have thought that mobile phone use caused their tumour. Conversely, they may have tended to under-report use on the other side of the head from where the tumour did not arise. In contrast, the controls are unlikely to have systematically over-reported use on one side of the head. Therefore, the overall interpretation of these results should bear in mind both selection and recall biases.
In order to estimate how strong an influence this recall bias and other biases in the INTERPHONE study could be, various validation studies have been carried out. These studies showed that mobile phone use was being under-estimated by light users and over-estimated by heavy users, and the over-estimation of use was greater for the more remote time periods. The possibility of a selection bias caused by light users refusing to participate as controls in the study was also identified as a possible contributor to the apparent protective effect of mobile phone use.

There is also some uncertainty in the classification of tumours as right sided or left sided, and precisely where they are in the head. Measurements and modelling show that the exposure to radio waves from mobile phones is very localised and decreases rapidly with depth. More data on the precise location of tumours and their proximity to the mobile phone usage area is needed, rather than a simple classification on the left or right side of the head.

Comments on the pooled INTERPHONE study (2010)

Following its publication in May 2010, the INTERPHONE pooled study has attracted attention and comment. Here we show extracts from comments made by an independent advisory group and also comments from the international commission responsible for advising on exposure restrictions.

Advisory Group on Non-ionising Radiation (AGNIR)

The Advisory Group made the following comments shortly after the publication of the INTERPHONE study

"The INTERPHONE study was well designed and carefully conducted, and has contributed importantly to our understanding of possible health risks from use of mobile phones. As with all epidemiological studies, and particularly case-control investigations that rely on recall of complex past exposures from memory, there are uncertainties in interpretation. Nevertheless, within the limits of those uncertainties, which are discussed at some length in the report, the study provides no clear, or even strongly suggestive, evidence of a hazard. Moreover, it indicates that if there is any hazard of brain cancer or meningioma from use of mobile phones then the risk during the initial 10-15 years of use must be small.

"This conclusion is consistent with the findings of most other epidemiological studies that have examined the relation of brain tumours to use of mobile phones, and also with the absence of demonstrable effects on cancer incidence when laboratory animals have been exposed to radiofrequency radiation experimentally.

"Because mobile phones have only been in widespread use for less than 20 years, the INTERPHONE study could not address the possibility of longer term risks to health. Given the enormous scale on which the technology has been adopted, there is therefore a need for continuing epidemiological surveillance to ensure that any adverse effects are detected at the earliest possible stage. The recently launched COSMOS study, which is being funded in the UK as part of the Mobile Telecommunications and Health Research (MTHR) programme, will contribute importantly to meeting this need."

See the full statement from AGNIR

International Commission on Non-Ionizing Radiation Protection (ICNIRP)

ICNIRP has published a note on the INTERPHONE study, commenting that it is by far the largest study on mobile phones and health to date.

The Commission concludes, "Overall, the study did not find an increase in the risks of glioma or meningioma in relation to mobile phone use."

However, it notes, "No raised risk of brain tumours was found among people who reported the largest number of calls but an apparent raised risk was observed in people in the highest of ten categories of reported cumulative hours of mobile phone use. This category included a number of people who were recorded with highly improbable hours of use, presumably reflecting erroneous reports, and there was no general dose response gradient of increasing risk with increasing amount of use."

It also comments, "There are serious methodological limitations inherent in studies of this type, which depend on study participants trying to remember and report their entire lifetime use of mobile phones. Such recall is problematic particularly for brain tumour patients. ICNIRP agrees with the Interphone authors that the biases and errors in the study preclude a causal interpretation of the results."

The full note from ICNIRP can be found at
http://www.icnirp.org/documents/ICNIRPnote.pdf

Last reviewed: 17 August 2010

WI-FI and Health, HEALTH PROTECTION AGENCY OF THE UNITED KINGDOM, October, 2009

http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields/WiFi/

General position

There is no consistent evidence to date that Wi-Fi and WLANs adversely affect the health of the general population. The signals are very low power, typically 0.1 watt (100 milliwatts) in both the computer and the router (access point) and the results so far show exposures are well within internationally accepted (ICNIRP) guidelines. Based on current knowledge and experience, radio frequency (RF) exposures from Wi-Fi are likely to be lower than those from mobile phones. Also, the frequencies used in Wi-Fi are broadly the same as those from traditional RF applications.

On the basis of the studies so far carried out in house, the HPA sees no reason why Wi-Fi should not continue to be used in schools. However with any new technology it is a sensible precautionary approach, as happened with mobile phones, to keep the situation under ongoing review so that parents and others can have as much reassurance as possible. That is why Sir William Stewart, formerly the chairman of the HPA, stated that it would be timely to carry out further studies as this new technology is rolled out. The HPA continues to discuss this with relevant parties.

Basics

Wi-Fi is a particular type of wireless local area network (WLAN) - ie it is not necessary to plug a computer into a phone network via a cable. There are many types of WLAN but all of them allow two or more computers to form a network using radio frequency (RF) signals. They allow users to access and share data, applications, internet access or other

network resources in the same way as wired (cable) systems. For more information, view the Wireless Local Area Networks (WLANs) page.

ICNIRP is the International Commission on Non-Ionizing Radiation Protection. See the ICNIRP website at http://www.icnirp.org.

Key points

- There is no consistent evidence to date that exposure to RF signals from Wi-Fi and WLANs adversely affect the health of the general population.
- The signals from Wi-Fi are very low power, typically 0.1 watt (100 milliwatts) in both the computer and the mast (or router) and resulting exposures should be well within internationally-accepted guidelines.
- The frequencies used are broadly the same as those from other RF applications such as FM radio, TV and mobile phones.
- Based on current knowledge, RF exposures from Wi-Fi are likely to be lower than those from mobile phones.
- On the basis of current scientific information, exposures from Wi-Fi equipment satisfy international guidelines. There is no consistent evidence of health effects from RF exposures below guideline levels and no reason why schools and others should not use Wi-Fi equipment.

Exposure to electromagnetic fields from wireless computer networks (Wi-Fi) - update on project progress

Following the announcement by the Board of HPA on 12 October 2007, a systematic programme of research into WLANs and their use started at the HPA Radiation Protection Division. At the start of the project, comprehensive Wi-Fi test facilities were set up at the HPA Chilton site and a review of technical standards and wireless equipment used in UK schools was carried out.

Due to the popularity of laptops in classrooms and the likelihood that the majority of Wi-Fi exposure would come from these devices because they are generally nearer to children than the access points, it was decided that the experimental measurements would begin with laptops transmitting in the 2.4 GHz frequency band. A total of 15 laptops were chosen from among the most popular models used in the education sector in the UK.

The objective of the laboratory measurements was to establish the radiation pattern (ie the angular distribution of electric field strength around each laptop) during transmission and identify the angles at which the field was a maximum. The electric field strength at these angles was then measured as a function of distance.

The results have so far shown that, for a given position, the field strength fluctuated between 2 (and sometimes 3) distinct levels because of the existence of several transmitting antennas within each laptop. Overall, similar radiation pattern measurements for all 15 laptops have been observed with a minimum in the direction from the front of

the laptop (towards the torso of the user). Generally, two angular maxima were observed that were symmetrically opposed across a vertical plane bisecting the screen and keyboard. All 15 laptops tested had electric field strength values indicating they had output powers during transmission in the range 6-20 mW. Taking into account the directional properties, the Equivalent Isotropically Radiated Power (EIRP) calculated for all laptops was in the range 17-57 mW and well below the 100 mW (EIRP) limit set for Europe.

A more detailed description of the project and some early results are presented here  Wi-Fi in schools (PDF, 276 KB). Furthermore, these results have been presented at the Bioelectromagnetics Society (BEMS) and the European BioElectromagnetics Association (EBEA) BioEM2009 conference (June 2009), see paper 9-2 at http://bioem2009.org/session-9/.

These results are consistent with the HPA position that exposures to the radio waves from Wi-Fi equipment are not expected to exceed internationally-accepted guidelines and that they are less than from mobile phones. Further results will be published on the HPA website after they have been finalised.

Further work

The remainder of the laboratory measurements includes the assessment of the electric field strength around access points operating at 2.4 GHz. Measurements will also be carried out on a selection of laptops and access points operating in the 5 GHz band.

Further work will then involve the modelling of Wi-Fi equipment and its internal RF structures (antennas) in order to assess the localised specific energy absorption rates (SARs) in users, including children. In addition, measurements of radiated powers and transmit time proportions in schools are planned.

The experimental results, together with information from other studies on radio signals and health, will then be used as the basis for a wider health risk review.

Last reviewed: 26 October 2009

Electric and Magnetic Fields at Power Frequencies, HEALTH CANADA, April 2010

http://www.phac-aspc.gc.ca/publicat/cdic-mcc/29-1-supp/ar_05-eng.php

- The current evidence relating to averaged magnetic field exposures greater than 0.4 μT and leukemia in children suggests, but does not prove, a causal relationship.

- Studies of workers occupationally exposed to high levels of electric and magnetic fields also suggests an association between high level ELF EMF exposure and an increased risk of cancer, specifically acute non-lymphocytic leukemia.
- There is inadequate evidence that residential exposures to electric or magnetic fields are associated with increased cancer risks for adults.

Electromagnetic Hypersensitivity, IEEE, 2002

COMAR is a Technical Committee of the Engineering in Medicine and Biology Society (EMBS) of the Institute of Electrical and Electronics Engineers (IEEE). It reports to the EMBS President and Administrative Committee.
COMAR's primary area of interest is biological effects of non-ionizing electromagnetic radiation. It examines and interprets the biological effects and presents its findings in an authoritative manner, usually in Technical Information Statements (TIS's) or Position Papers. These papers are subject to an extensive review process within the Committee and represent the consensus of the Committee

http://ewh.ieee.org/soc/embs/comar/Hypersensitivity.htm

Electromagnetic Hypersensitivity
Certain individuals experience a variety of health symptoms, which they attribute to exposure to electric or magnetic fields from sources such as power lines, household appliances, visual display units (VDUs), light sources, mobile telephones and mobile phone base stations. Some individuals are so severely afflicted that they cease work and change their entire lifestyle, or take exceptional measures such as sleeping under aluminium blankets.

This perceived sensitivity to electromagnetic fields has the general name "electromagnetic hypersensitivity" or EHS. The fields that electromagnetically hypersensitive individuals consider to be the cause of their symptoms vary considerably, but they are invariably far below recommended exposure limits, and very far below field levels that are known to produce adverse effects in unaffected humans.

This Technical Information Statement describes what is known about EHS and summarizes recommendations from medical groups for helping people with EHS.

Prevalence of Symptoms Associated with EHS

The most comprehensive survey of EHS was reported by Bergqvist and colleagues in 1997. This study identified a list of symptoms reported by electromagnetically hypersensitive individuals. In decreasing order of frequency the symptoms are:

- Nervous system symptoms (e.g. fatigue, stress, sleep disturbances)
- Skin symptoms (e.g. facial prickling, burning sensations, rashes)

- Various body symptoms (e.g. pain and ache in muscles)
- Eye symptoms (e.g. burning sensations).
- Various less common symptoms, including ear, nose, and throat symptoms, digestive disorders.

The severity of the symptoms varied greatly. In some cases they were sufficiently severe to prevent the EHS individual from carrying out normal life activities.

The Bergqvist committee obtained a range of estimates of the number of electromagnetically hypersensitive individuals in the general population. Its survey of Swedish centers for occupational medicine suggested that a few individuals per million in the population are electromagnetically hypersensitive. By contrast, the committee's survey of self-help groups for electromagnetically hypersensitive individuals led to a much higher estimate, of up to a few tenths of a percent the population that experiences some form of EHS. The first estimate may be too low, since it would include only individuals who are treated in occupational health clinics. The second estimate is almost certainly too high, since it was based on individuals who were self-selected for EHS.

Both the prevalence of EHS, and the reported symptoms, vary considerably with geographic location. EHS has a higher prevalence in Sweden, Germany, and Denmark than in the United Kingdom, Austria, and France. EHS individuals in Nordic countries are more likely to report symptoms from use of visual display units, and their symptoms are more commonly related to skin disorders, than elsewhere in Europe (Bergqvist,1997).

Provocation Studies

In provocation studies, investigators expose electromagnetically hypersensitive individuals to electric or magnetic fields similar to those that they considered to be the cause of their symptoms, in an attempt to elicit the EHS symptoms under controlled laboratory conditions. Such studies are valuable in probing for links between the symptoms and exposure to fields.

So far, at least 9 provocation studies have been reported on electromagnetically hypersensitive individuals (for a review of work through the mid-1990s see Bergqvist 1997). The studies have been overwhelmingly unsuccessful in being able to link EHS symptoms in these subjects to exposures to electric or magnetic fields.

For example, Flodin et al (2000) exposed 15 electromagnetically hypersensitive individuals and normal controls to electric and magnetic fields in their homes or workplaces. The electromagnetically hypersensitive individuals were no better than control subjects in identifying their exposure to electric or magnetic fields during the experiment.

Some users of mobile telephones have reported headaches and other health symptoms connected with the use of the phones (Chia et al 2000). Hietanen and colleagues (2002) tested 20 subjects who considered themselves to be sensitive to fields from mobile

telephones. During real or sham (simulated) exposures to radiofrequency (RF) energy from mobile telephone handsets, the subjects reported a variety of symptoms. However, the authors report, "the number of reported symptoms was higher during sham exposure than during real exposure conditions," and "none of the test subjects could distinguish real RF exposure from sham exposure".

One early study, by Rea and colleagues (1991) did elicit responses from electromagnetically hypersensitive individuals by exposing them to magnetic fields at levels comparable to those found in many ordinary environments. In that study, electromagnetically hypersensitive individuals were exposed to magnetic fields over a range of frequencies (from 0.1 Hz to 5 MHz), from a coil positioned 0.3 meters from their feet. However, other investigators criticised that study because of the possibility that the coils produced audible cues, and other technical problems (Bergqvist 1993). It is well known that such cues can easily confound studies that seek to establish the sensitivity of individuals to weak electric and magnetic fields (eg. Tucker et al (1978)).

Taken as a whole, the provocation studies strongly suggest that EHS symptoms are not related to actual exposures to electric or magnetic fields, and that electromagnetically hypersensitive individuals are no better than non-hypersensitive individuals in detecting the presence of fields.

Resemblance to Other Disorders

The symptoms reported by electromagnetically hypersensitive individuals, such as headache, fatigue, and stress, are common and nonspecific, i.e. they may have many causes.

In some cases, the symptoms experienced by electromagnetically hypersensitive individuals may result from environmental factors other than electromagnetic fields. These might include "flicker" of fluorescent lights, glare and other visual problems with VDUs, and effects resulting from poor ergonomic design of workstations. Other factors might include poor indoor air quality or emotional stress in the workplace or living environment. Sensations of warmth when using a mobile telephone might be caused by heat generated in the electrical circuits within the handsets, or from lack of air circulation around the ear when the handset is held against it.

There is also clear evidence that psychological factors are important in some cases. For example, some of the subjects in the study by Tucker (1978) reported headaches during placebo experiments in which the fields had never been turned on.

EHS bears close resemblance to idiopathic environmental intolerances (IEI), otherwise known as multiple chemical sensitivities (MCS). In MCS, individuals report a variety of symptoms which they attribute to exposure to chemicals in the environment (Bornschein et al, 2001). In both EHS and MCS the symptoms are nonspecific (might have a variety of causes), the exposure levels to chemicals or electromagnetic fields are invariably far below those that are expected to produce adverse effects, and provocation studies are

typically unable to link the symptoms with exposure. Both syndromes remain poorly understood.

Finally, EHS has apparent similarities to "microwave illness", which has been reported in the Russian and Eastern European medical literature at various times since at least the 1970s. This syndrome is characterized by nonspecific symptoms such as headache and malaise in workers with presumed exposure to electromagnetic fields. However, the syndrome is not recognized by Western physicians. Moreover, the Russian data consist largely of case reports (and not well-controlled epidemiology studies, which would be more informative) with little if any attempt to determine the fields to which the workers were actually exposed. Consequently, the nature of the electromagnetic field exposure that produced the symptoms is not established (Gluszcz 1979). Other physicians have complained about the vagueness of the diagnostic criteria for the illness (eg. Djordjevic 1983).

Helping electromagnetically hypersensitive individuals

Whatever its cause, EHS is a real, and sometimes disabling, problem for the affected individual. The Bergqvist committee offered recommendations for helping electromagnetically hypersensitive individuals, which are summarized below.

The Bergqvist committee recommended that the starting point for all treatment should be the health symptoms of the individual, and not his or her perceived need for electrical "sanitation" of the workplace or home. Electromagnetic field surveys in normal workplace and residential environments are extremely unlikely to uncover the presence of fields that can be related to the symptoms of the EHS individual.

In helping electromagnetically hypersensitive individuals, it is important to try to identify and treat any relevant health, environmental, or occupational hygiene problems that might be present, without assuming that they are caused by exposure to electric or magnetic fields.

This requires, for severely affected individuals:

- Medical evaluation of the EHS individual to identify and treat any specific medical conditions that may be responsible for the symptoms.
- Evaluation of the workplace or home for factors that might contribute to the presented symptoms. These might include indoor air pollution, excessive noise, poor lighting, or ergonomic factors. In the workplace this evaluation would normally be conducted by an industrial hygienist.

Apart from identifying any treatable causes of the patient’s symptoms, physicians need to initiate communication with the EHS individual and help develop strategies for coping with the situation.

For electromagnetically hypersensitive individuals with long lasting symptoms and severe handicaps, therapy should be directed principally at reducing symptoms and functional handicaps. As recommended by the Bergqvist committee, this should be done in close co-operation between

- Physicians (for handling the medical aspects of the symptoms)
- A hygienist (for identifying and if necessary controlling factors in the environment that are known to have adverse health effects of relevance to the \ A psychotherapist, where appropriate.

The Bergqvist committee also stressed the importance of providing electromagnetically hypersensitive individuals, health-care professionals, and employers with information about health and safety hazards of electromagnetic fields, and their possible relation to EHS. The committee stressed that this information should be balanced and appropriate for different target groups, including the general population and various professional groups. The committee also stressed that the information should include a clear statement that no scientific basis currently exists for a connection between EHS and exposure to electromagnetic fields.

Given the similarity of EHS to multiple chemical sensitivities, medical advice for handling MCS patients might also be helpful. For example, Magill and Suruda (1998) recommend that treatment should aim to establish an effective physician-patient relationship, and encourage patients to return to work and to a normal social life.

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Abstract

Idiopathic Environmental Intolerance attributed to electromagnetic fields (IEI-EMF; formerly 'electromagetic hypersensitivity') is a medically unexplained illness in which subjective symptoms are reported following exposure to electrical devices. In an earlier systematic review, we reported data from 31 blind provocation studies which had exposed IEI-EMF volunteers to active or sham electromagnetic fields and assessed whether volunteers could detect these fields or whether they reported worse symptoms when exposed to them. In this article, we report an update to that review. An extensive literature search identified 15 new experiments. Including studies reported in our earlier review, 46 blind or double-blind provocation studies in all, involving 1175 IEI-EMF volunteers, have tested whether exposure to electromagnetic fields is responsible for triggering symptoms in IEI-EMF. No robust evidence could be found to support this theory. However, the studies included in the review did support the role of the nocebo effect in triggering acute symptoms in IEI-EMF sufferers. Despite the conviction of IEI-EMF sufferers that their symptoms are triggered by exposure to electromagnetic fields, repeated experiments have been unable to replicate this phenomenon under controlled conditions. A narrow focus by clinicians or policy makers on bioelectromagnetic mechanisms is therefore, unlikely to help IEI-EMF patients in the long-term.

Electromagnetic Field Hypersensitivity, UNIVERSITY OF OTTAWA, MCLAUGHLIN CENTRE FOR POPULATION HEALTH RISK ASSESSMENT

http://www.rfcom.ca/faq/answers.shtml#q13

13. Are some individuals hypersensitive to electromagnetic fields?

Some individuals report health symptoms that they relate to exposure to EMF. These effects have been termed electromagnetic hypersensitivity (EHS). On occasion these effects can have profound effects on the individuals' way of life. They complain of a variety of non-specific symptoms, which vary from person to person, and include general complaints like tiredness and dizziness, as well as skin, digestive, and other symptoms. There are more reports of EHS in Scandinavian countries than elsewhere. Provocation studies almost all have shown that individuals with EHS cannot detect EMF exposure any more accurately than non-EHS individuals. A WHO workshop on EHS in Prague in 1994 concluded that: "The symptoms are certainly real and can vary widely in their severity. Whatever its cause, EHS can be a disabling problem for the affected individual. EHS has no clear diagnostic criteria and there is no scientific basis to link EHS symptoms to EMF exposure".

For more information on the subject, see WHO's web site at www.who.int/peh-emf/en/ and search for "Electrical hypersensitivity".

The web site of the Committee on Man and Radiation of the Institute of Electric and Electronic Engineers also has a useful report on electromagnetic hypersensitivity. This can be accessed at http://ewh.ieee.org/soc/embs/comar/ or through "Links".

For more on this subject, see "Research-Clinical-Other".

Wireless Technology and Health Outcomes: Evidence and Review, ONTARIO AGENCY FOR HEALTH PROTECTION AND PROMOTION, September, 2010

http://www.oahpp.ca/about/whatsnew/201009_2.html

Conclusions

Research on potential health effects from exposure to RF energy is an active field of investigation. Not surprisingly there is inconsistency and in some cases conflict between the results of individual studies.

Given this inconsistency, it is possible to select the results of individual research studies in support of a variety of opinions; which may range from no risk of health effects on the one hand, to a clear need to reduce current exposure limits on the other.
For this reason, up-to-date reviews of literature which follow a weight of evidence approach are far more useful for informing debate and sound policymaking than reliance on individual studies.

The Royal Society of Canada performed a highly credible review in 1999. Updates to this review have been published; the most recent in 2009. While the most recent review continues to call for additional research to follow up on new findings, after a decade of additional research, there is still no conclusive evidence of adverse effects on health at exposure levels below current Canadian guidelines.

While far from conclusive, there is emerging evidence that long-term frequent use of cellphones may be associated with an increased risk of tumours on the side of the head where the cellphone is used. This is an active area of research and additional studies may confirm or refute this association.

The degree of 'precaution' that should be incorporated into exposure limits for the public is always a subject for debate. There is general agreement that the exposure limits in Health Canada's Safety Code 6 are protective against effects produced through tissue heating. Consistent evidence on the level at which this occurs is available and exposure limits can be set on the basis of this well-established effect and use of safety factors selected by the standard setting organization.

Recently published research demonstrates that Wi-Fi exposure are not only well within recommended limits, but are only a small fraction (less than 1%) of what is received during typical use of cellphones3.

For this reason much of the research on possible effects of RF energy has been focused, and will likely continue to focus, on exposures from cellphones rather than the lower exposures associated with RF uses such as Wi-Fi. RF exposures to the public, including school children, from Wi-Fi are far lower than occur with cellphone use and to date there is no plausible evidence that would indicate current public exposures to Wi-Fi are causing adverse effects on health.

Given the experience with other sources of non-ionizing radiation (e.g. power lines) that have been in use much longer than cellphones or Wi-Fi, it is unlikely that all controversies related to potential RF effects will be resolved even after decades of additional research.

Recent Research on EMF and Health Risks, SWEDISH STATE RADIATION PROTECTION AUTHORITY, 2009

Swedish State Radiation Protection Authority: Recent Research on EMF and Health Risks

Executive summary
A large number of cell studies are done on both genotoxic and non-genotoxic outcomes, such as apoptosis and gene expression. There are no new positive findings from cellular studies that have been well established in terms of experimental quality and replication. Potential heating of the samples is still seen as a major source of artefacts. Moreover, these few positive results are not related to each other and/or are not relevant for health risk assessment.

There are animal studies on brain structure and brain function as well as on genotoxicity and cancer. Also reproductive effects are looked at. However, animal studies have not identified any clear effects on any of a number of different biological endpoints following exposure to RF radiation typical of mobile phone use, generally at levels too low to induce significant heating.

Many human laboratory studies reviewed here are provocation studies with rather short exposures. Most use methods that are too crude, or look at phenomena that are too small, or non-existent, for the research to be informative. However, EEG alpha- and betafrequencies seem to be sensitive to modulation by some pulse-modulation frequencies of the microwave- or GSM-signal. This curious effect does not have any behavioural counterpart, since similar types of EMF have been applied in various behavioural studies with negative results. This needs to be pursued. Surprisingly few studies have been done on children. In light of all official recommendations in different countries with special emphasis on children's use of mobile phones, this is rather peculiar.

Several epidemiological studies on mobile phone use and cancer have been presented since the previous report, including national studies from the Interphone group as well as other studies. There are also studies on reproductive outcomes. A few recent studies on

people living near transmitters have also appeared. None of this changes any of the Groups previous conclusions. For conclusions, see the section on conclusions based on currently available data. However, one can draw some methodological conclusions at this point. One is that the problems in case control studies are too large for more such studies to be warranted at present. Another one is that cross- sectional research on symptoms, or other end points for that matter, also have too big inherent methodological problems to be warranted.

Conclusions on RF fields based on research available to date

Cancer and mobile phones

Overall the studies published to date do not demonstrate an increased risk of cancer related to mobile phone use within approximately ten years of use for any tumour of the brain or any other head tumour. Despite the methodological shortcomings and the limited data on long latency and long-term use, the available evidence does not suggest a causal association between mobile phone use and fast-growing tumours such as malignant glioma in adults (at least for tumours with short induction periods). For slow-growing tumours such as meningioma and acoustic neuroma, as well as for glioma among longterm users, the absence of association reported thus far is less conclusive because the observation period has been too short. This is consistent with results from animal and cellular research, which does not indicate that exposure of the type that is generated by mobile telephony, might be implicated in the origin or development of cancer. Long-term animal data on balance do not indicate any carcinogenic effect.

However, there are currently no data on mobile telephone use and cancer risk in children. For tumours other than intracranial, few epidemiological studies have been completed, but reasons to suspect an association with mobile telephony are even weaker than for tumours of the head.

Cancer and transmitters

The majority of studies on cancer among people who are exposed to RF from radio- or TV- transmitters or from mobile phone base stations have relied on too crude proxies for exposure to provide meaningful results. Indeed, only two studies, both on childhood leukaemia, have used models to assess individual exposure and both of those provide evidence against an association. One cannot conclusively exclude the possibility of an increased cancer risk in people exposed to RF from transmitters based on these results. However, these results in combination with the negative animal data and very low exposure from transmitters make it highly unlikely that living in the vicinity of a transmitter implicates an increased risk of cancer.

"Electromagnetic hypersensitivity, EHS"

While the symptoms experienced by patients with perceived electromagnetic hypersensitivity are very real and some subjects suffer severely, there is no evidence that RF exposure is a causal factor. In a number of experimental provocation studies, persons who consider themselves electrically hypersensitive and healthy volunteers have been exposed to either sham or real RF fields, but symptoms have not been more prevalent during RF exposure than during sham in any of the experimental groups. Several studies

have indicated a nocebo effect, i.e. an adverse effect caused by an expectation that something is harmful. Associations have been found between self-reported exposure and the outcomes, whereas no associations were seen with measured RF exposure.

President's Cancer Panel, NATIONAL INSTITUTES OF HEALTH, 2009

http://deainfo.nci.nih.gov/advisory/pcp/pcp.htm
This is a panel of three – an oncologist, an immunologist, and a tumor virologist. Early in 2009 the panel held a session on nuclear fallout, electromagnetic fields, and radiation exposure. A number of people presented, including Devra Davis, the author of a book on radiofrequency and health effects as well as David O. Carpenter, who has also written on the topic and recommends against using cell phones unless a landline is unavailable.

We do not see a "global call for the 'precautionary principle'" as is iterated in the Complaint filed with PUC.

Page iv
"Sharp controversy exists in the scientific community as to possible adverse health effects from exposure to low frequency electromagnetic energy. The use of cell phones and other wireless technology is of great concern, particularly since these devices are being used regularly by ever larger and younger segments of the population. At this time, there is no evidence to support a link between cell phone use and cancer. However, the research on cancer and other disease risk among long-term and heavy users of contemporary wireless devices is extremely limited. Similarly, current and potential harms from extremely low frequency radiation are unclear and require further study."

Page 60
"Mechanisms by which ELF EMR may be harmful have been proposed, but are not supported by peer-reviewed research. For example, it has been suggested that these exposures can cause cells to produce stress proteins (i.e., indicating that the cell recognizes the energy as harmful).290 The scant peer-reviewed literature on ELF EMR health effects highlights an important area in which research is needed to elucidate if, and how, ELF EMR raises risks for specific cancers in defined populations and at defined exposure levels."'
"Findings of a lack of association between ELF EMR from power lines or other sources and cancer are consistent among numerous international organizations, including WHO,296,297 IARC,298 the EU Scientific Committee on Emerging and Newly Identified Health Risks,299 and the International Commission for Non-ionizing Radiation Protection.288 All emphasize the need for further research in this area. U.S. environmental organizations such as the National Institute of Environmental Health Sciences (NIEHS),300 the Occupational Safety & Health Administration (OSHA),301 and the American Industrial Hygiene Association302 generally conclude that the link between ELF EMR and cancer is controversial or weak."

Press Release on Wireless Networks, SWEDISH RADIATION SAFETY AUTHORITY, November 2009

The Nordic radiation Safety authorities see no need to reduce public exposure generated by mobile base stations and wireless networks, November 16, 2009
http://www.stralsakerhetsmyndigheten.se/In-English/About-the-Swedish-Radiation-Safety-Authority1/News/Press-release-The-Nordic-radiation-Safety-authorities-see-no-need-to-reduce-public-exposure-generated-by-mobile-base-stations-and-wireless-networks/

AUSTRALIAN RADIATION PROTECTION AND NUCLEAR SAFETY AGENCY

http://www.arpansa.gov.au/eme/index.cfm

Cell Phones and Cancer Risks, NATIONAL CANCER INSTITUTE (NCI), NATIONAL INSTITUTES OF HEALTH (NIH), May, 2010

http://www.cancer.gov/cancertopics/factsheet/Risk/cellphones

Key Points from NCI on Cell Phones and Cancer

- Cell phones emit radiofrequency (RF) energy, which is another name for radio waves.
- Research suggests that the amount of RF energy produced by cell phones is too low to cause significant tissue heating or an increase in body temperature.
- Concerns have been raised that RF energy from cell phones may pose a cancer risk to users.
- Researchers are studying tumors of the brain and central nervous system and other sites of the head and neck because cell phones are typically held next to the head when used.
- Research studies have not shown a consistent link between cell phone use and cancer. A large international study (Interphone) published in 2010 found that, overall, cell phone users have no increased risk for two of the most common types of brain tumor—glioma and meningioma. For the small proportion of study participants who reported spending the most total time on cell phone calls there was some increased risk of glioma, but the researchers considered this finding inconclusive.

Cell Phones and Brain Cancer, NATIONAL CANCER INSTITUTE (NCI), NATIONAL INSTITUTES OF HEALTH (NIH), November, 2010

http://www.ncbi.nlm.nih.gov/pubmed/20639214
The use of cellular telephones has grown explosively during the past two decades, and there are now more than 279 million wireless subscribers in the United States. If cellular phone use causes brain cancer, as some suggest, the potential public health implications could be considerable. One might expect the effects of such a prevalent exposure to be reflected in general population incidence rates, unless the induction period is very long or confined to very long-term users. To address this issue, we examined temporal trends in brain cancer incidence rates in the United States, using data collected by the Surveillance, Epidemiology, and End Results (SEER) Program. Log-linear models were used to estimate the annual percent change in rates among whites. With the exception of the 20-29-year age group, the trends for 1992-2006 were downward or flat. Among those aged 20-29 years, there was a statistically significant increasing trend between 1992 and 2006 among females but not among males. The recent trend in 20-29-year-old women was driven by a rising incidence of frontal lobe cancers. No increases were apparent for temporal or parietal lobe cancers, or cancers of the cerebellum, which involve the parts of the brain that would be more highly exposed to radiofrequency radiation from cellular phones. Frontal lobe cancer rates also rose among 20-29-year-old males, but the increase began earlier than among females and before cell phone use was highly prevalent.
Overall, these incidence data do not provide support to the view that cellular phone use causes brain cancer.

POTENTIAL SOURCES OF CONSULTING EXPERTS

ICNIRP
http://www.icnirp.net/what.htm

What is ICNIRP?
ICNIRP is the International Commission on Non-Ionizing Radiation Protection. It is a body of independent scientific experts consisting of a main Commission of 14 members, 4 Scientific Standing Committees covering Epidemiology, Biology, Dosimetry and Optical Radiation and a number of consulting experts. This expertise is brought to bear on addressing the important issues of possible adverse effects on human health of exposure to non-ionising radiation.

ICNIRP Commission Members:
http://www.icnirp.net/commission.htm
ICNIRP Consulting Experts:
http://www.icnirp.net/cm.htm

RF-COM at the UNIVERSITY OF OTTAWA
http://www.rfcom.ca/about/index.shtml

RFcom is an internet-based information resource about health effects of wireless technologies.

The project is based at the McLaughlin Centre for Population Health Risk Assessment, Institute for Population Health, University of Ottawa.
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The contents of the site are the sole responsibility of the Project Team. Neither the public or private sector liaison members of the Project Team nor the funders are involved in decisions taken by the Project Team about information to be posted on the site.

RFcom is managed by a Science Panel that reviews and reports on the most recent research studies about wireless technology and health from around the world. All studies referenced on this website must meet the following criteria:the source must be credible and accountable material must be peer-reviewed-research and data that has been accepted and validated in the Canadian and international communities all studies must have been carried out by an independent third-party person or organization

The use of wireless phones is now an established part of many societies today, with billions of users around the world. This technology has greatly improved our ability to communicate at home or at work in our local and global communities. People use mobile telephones not only for work, but also for the convenience and safety of their families.

The rapid growth in the use of wireless phones has been accompanied by public concerns about the safety of this new technology. Although numerous scientific reviews have concluded that there is no evidence of a health risk from wireless phones or other wireless communication devices, the concerns continue to be reflected in media reports.
This web site attempts to answer the following questions about wireless phones:
How do they work?
How are safety standards established for them?
What have scientific authorities to say about their safety?
What has research found about their biological effects?
What research is planned in the future?