Mobile telephones, sometimes called cellular telephones or handys, are fast becoming an integral part of modern telecommunications. In some parts of the world, they are the most reliable or only telephones available. In others, cellular phones are very popular because they allow people to maintain continuous communication without hampering freedom of movement—a quality widely appreciated both at work and leisure.

A recent review of the effects of exposure to radiofrequency (RF) fields conducted by WHO and the release of an important review on mobile phones and health by an expert committee in the UK form the basis for updating this fact sheet.

Prevalence of Use

In many countries a significant fraction of the population is already using mobile telephones, and the market is still growing rapidly. Scandinavian countries have the world's highest number of mobile telephone subscriptions in relation to population, with more than 60% adults in Finland and close to 50% in Norway and Sweden using mobile telephones. As of mid-2000, 32% of the US population uses mobile telephones. The cellular telephone industry predicts that there will be as many as 1.6 billion mobile phone subscribers worldwide in the year 2005.

The rapid increase in the number of mobile telephone users has necessitated the installation of many base stations, which are distributed through a service area that communicate with users' handsets. For example, as of early 2000 there were about 20,000 base stations in operation the United Kingdom, and as many as 100,000 in the United States.

Concerns for health

Many citizens and some scientists have expressed concerns about possible adverse health effects of cellular technology, either from RF fields emitted by the mobile telephones themselves or their base stations. Given the huge numbers of users of mobile telephones, and the large and rapidly increasing numbers of base stations, even small adverse effects on health could have major public health implications. This fact sheet addresses these concerns.

Several important considerations must be kept in mind when evaluating possible health effects of RF fields. One is the frequency of operation. Current mobile telephone systems operate at frequencies between 800 and 1800 MHz. It is important not to confuse such RF fields with ionizing radiation, such as X-rays, gamma rays, or short-wave ultraviolet radiation. Unlike ionizing radiation, RF fields cannot cause
ionization or radioactivity in the body. Because of this, RF fields are called non-ionizing radiation (NIR).

A second consideration is the level and duration of exposure. Potential adverse effects of RF energy depend on the amount of exposure. Levels of RF exposure to an individual are limited by national and international exposure guidelines, which are designed to avoid all known hazards with large safety factors.

Mobile telephone handsets and base stations present quite different exposure situations. The RF exposure to a user of a mobile telephone, is far higher than to a person living near a cellular base station. However, apart from infrequent signals used to maintain links with nearby base stations, the handset is transmitting RF energy only while a call is being made, whereas cellular base stations are continuously transmitting signals.

**Exposure Levels**

**RF fields from handsets:** Mobile telephone handsets are low-powered RF transmitters, which transmit a maximum power in the range of 0.2 to 0.6 watts. This contrasts with other kinds of hand held transmitters, such as “walkie talkies” which may transmit tens of watts or more. The head of the user receives the highest localized RF exposure. However, the exposure levels fall off very rapidly with distance from the handset. For example, the RF exposure to a person 30 cm from a transmitting handset is a factor of 100 times below that typically received by the handset user.

**RF fields near base stations:** Base stations transmit a maximum power level from a few watts to 100 watts or more, depending on the size of the region or “cell” that they are designed to service. Base station antennas are typically about 20-30 cm in breadth and a metre in length, mounted in arrays on towers, building rooftops, or other structures at a height from 15 to 50 m above ground. These antennas emit beams of RF energy that are typically very narrow in the vertical direction but quite broad in the horizontal direction. Because of the narrow vertical spread of the beam, the RF field intensity at the ground directly below the antenna is low. It increases slightly as one moves away from the base station to reach a maximum at a distance of 50-100 meters from the base station, and then decreases as one moves further away from the antenna.

Close to the antennas, typically within 2-5 metres from them, the field strengths can exceed exposure limits. For this reason, some antennas mounted on rooftops have fences to keep people away from places where the RF fields exceed exposure limits. Since antennas direct their power outward, and do not radiate significant amounts of energy from their back surfaces or tops and bottoms, the levels of RF energy inside a building from antennas mounted on the rooftop or sides of the building are normally very low.

Both measurements and calculations show that RF signal levels in areas of public access from cellular base stations are invariably far below international guidelines, typically by a factor of 100 or more.
It should be noted that many other sources of RF energy also exist in the community. Paging and various communications transmitters such as used by fire, police and emergency services, operate at similar power levels as cellular base stations, and often at a similar frequency. Some television station antennas also operate at similar frequencies (500-800 MHz) but transmit at far higher power levels. In typical urban areas, the strongest RF signals in the environment are normally associated with television broadcast facilities.

**Health Effects**

RF fields penetrate exposed tissues to depths that depend on the frequency; about a centimetre or less at the frequencies used by mobile telephones. RF energy is absorbed in the body it produce heat, but the body's normal thermoregulatory processes carry this heat away.

Possible health effects of RF fields at similar frequencies as those used by mobile telephones have been researched for decades. Numerous biological effects of this energy have been reported, many of which are obviously related to heating. A variety of other biological effects have been reported in animals and cells from RF fields, some at levels below present exposure guidelines. However, most of these have no clear relevance to health hazards.

Based on available evidence, international committees have developed technical standards that are designed to avoid excessive heating of tissue and all other identified health hazards from RF absorption. Cellular base stations and handsets comply with these guidelines.

Most RF studies have examined the results of acute (short term) exposure to RF fields at levels far higher than those normally associated with wireless communications. However, with the advent of such devices as walkie-talkies and mobile telephones, it has become apparent that there were very few studies addressing the question of localized exposures to RF fields to the head and neck.

WHO has identified research needs to make better health risk assessment and promoted the research to funding agencies. Because of this and other initiatives, many studies have been undertaken to address these issues, most of which are still underway. While no clear health hazards have emerged from this research, scientists have reported effects of using cell phones in human subjects. The reported effects include changes in brain activity, reaction times, and sleep patterns. These effects are small and have no apparent health significance, and the effects themselves have not been independently confirmed by other investigators. Many more studies are in progress on these end-points.

Current scientific evidence indicates that exposure to RF fields, such as those emitted by mobile phones and their base stations, is unlikely to induce or promote cancers.

- Several cancer studies in which animals were exposed to RF energy similar to that emitted by mobile phones, found no evidence that RF energy causes or promotes brain cancer. By contrast, one recent study found that RF fields, increased the rate
at which mice developed lymphoma, a form of cancer that affects the immune system. The health implications of this finding are unclear, in part because the animal model (a strain of mice that had been genetically modified to develop lymphoma) may have no relevance to humans. Several studies are underway to confirm this finding and determine any relevance of these results to cancer in human beings.

- Three epidemiological (population health) studies have been reported in the past few years on users of mobile phones. These have found no evidence of increase in risk of cancer or any other disease with use of mobile phones. One of these studies reported a borderline-significant association between the side of the head in which a tumour was located in brain cancer patients and the side on which the patient used a cellular telephone, but a technical problem (reporting bias) may have contributed to the finding.

These studies are limited, however, by the long time (years to decades) it takes cancer to develop, and by their inability to detect small increases in risk should any occur. Therefore, presently available evidence does not indicate a health problem, but at the same time it is not sufficient to rule out small increases in risk, or risks that might become apparent only after years of use of mobile telephones.

Apart from possible health effects, research has clearly demonstrated an increased risk of traffic accidents while the driver is using a mobile telephone, either a conventional handset or a "hands-free" model. There is also a small risk of electrical interference to medical devices such as pacemakers, implantable defibrillators, and some kinds of hearing aids if a mobile telephone is used in close proximity to the device.

**What WHO is Doing**

In response to public concerns about possible health effects of exposure to EMF, WHO established in 1996 the International EMF Project to assess the existing scientific evidence of possible health effects of electromagnetic fields (EMF), including RF fields emitted by mobile phones and their base stations, and to recommend new research.

WHO's International EMF Project has identified specific scientific studies needed to address the problem of localized exposure. One important study being undertaken by the International Agency for Research on Cancer (IARC) -- a specialised cancer research organization of WHO -- is investigating the relationship between mobile telephone use and head and neck cancers.

In addition, WHO has established a formal mechanism for reviewing the research results once they are published.

**What should be done while research is ongoing?**

One of the objectives of the International EMF Project is to help national authorities weigh the benefits of mobile telecommunications technology against the detriment of any, even subtle, adverse health effects, and decide what additional protective
measures may be needed. It will take about 3-4 years for the required research to be completed, evaluated and published. In the meantime, WHO recommends:

• **Strict adherence to the existing international and national health-based standards**: Such standards, based on current knowledge, are developed to protect everyone in the population: mobile telephone users, those who work near or live around base stations, as well as people who do not use mobile telephones. If additional precautionary measures to reduce human exposure to RF fields are introduced, they should not undermine the science base of the standards by incorporation of arbitrary additional safety factors. Precautionary measures can be introduced as a separate policy that encourages, through voluntary means, the reduction of RF fields by equipment manufacturers, service providers and the public. Details of such measures are given in a separate fact sheet.

• **Precautionary measures**: Presently available scientific evidence does not indicate the need for any special precautions for use of mobile telephones on health grounds. Further, there is no evidence to suggest that children are more likely to will be affected by RF exposure.
  
  • If individuals are concerned that there may be health effects from exposure to mobile telephones, they might choose to limit their own or children's RF exposure by using “hands-free” devices to keep mobile telephones away from the head.
  
  • Use of devices or shields on mobile telephones to absorb RF energy cannot be justified on health grounds, and the effectiveness of many devices marketed for purposes of reducing RF exposure to the user is unproven.

• **EMF Interference**: Mobile telephones, as well as other electronic devices in common use, can cause electromagnetic interference in electrical equipment. Therefore, caution should be exercised when using mobile telephones around sensitive electromedical equipment used in hospital intensive care units. Mobile telephones can, in some instances, cause interference to aircraft navigation systems, and to certain medical devices, such as cardiac pacemakers and hearing aids. Individuals using these medical devices should contact their doctor to determine their susceptibility to these effects.

• **Driving safety.** There is a well established increase in risk of traffic accident while the driver is using a mobile telephone, either a conventional handset or one fitted with a “hands free” device. Motorists should be strongly discouraged from using mobile telephones while driving.

• **Simple protective measures**: Fences or barriers or other protective measures are needed for some base stations (principally, those located on building rooftops) to preclude unauthorized access to areas where exposure limits may be exceeded.

• **Consultations with local authorities and the public in siting base stations**: Obviously the mobile telephone base station site must offer good signal coverage and be accessible for maintenance. While RF field levels around base stations are not considered a health risk, siting decisions should take into account aesthetics
and public sensibilities. For example, siting base stations near kindergartens, schools and playgrounds may need special consideration. Open communication and discussion between the mobile telephone operator and the public during the planning stages for a new antenna can help create public understanding and greater acceptance of a new facility.

- **Accurate information, appropriately targeted:** An effective system of health information and communications among scientists, governments, the industry and the public is needed to raise the level of general understanding about mobile telephone technology and reduce any mistrust and fears, both real and perceived. **This information should be accurate, but at the same time be appropriate in its level of discussion and understandable to the intended audience.**

For further information, please contact Health Communications and Public Relations, WHO, Geneva, Switzerland (4122) 791 2532/2599, fax (4122) 791 4858, email: inf@who.int. All WHO Press Releases, Fact Sheets and Features can be obtained on Internet on the WHO home page http://www.who.int. Further information can be obtained from the International EMF Project home page at: http://www.who.int/emf/.