



Life Safety in a World of Electromagnetic Radiation Pollution

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ABSTRACT *The use of cell phone for long-duration is a matter of great concern due to adverse health effects. The radio frequency impact on human being is not completely investigated. Comprehensive research efforts are yet indeed in progress. The strongest health risks are from exposure to electric and magnetic fields generated due to the use of cell phones. Fewer data are available in support of fields used by telecommunication technology. However, extensive research activities are ongoing and much more data will be available in the near future. At present scenario there is a situation of scientific uncertainty and considerable public concern creates dilemmas for decision makers.*

1. Introduction

Nowadays, there is a great concern on the health effects of a mobile phone system being billions of people around the world use mobile phones every day. Base stations or telecommunication towers are continuously being erected. Owing to this, scientists worldwide are concerned about the potential health risks link with the use of this device. Moreover, radiofrequency impact on human is not completely understood by people. The term radiation often conjures fear and scare [1].

The mobile phone system is referred to as cellular due to the limitation of available radiofrequencies; it is divided up into cells. In the GSM (digital global system) system, cells consist of base station antennae emitting at specified frequencies and a group or network of users whose mobile phones communicate at those specified frequencies. In the CDMA (code division multiple access) system, all cells use the same radiofrequency spectrum and interference is prevented by transmitting a code which repeats at constant time intervals. Normally, base station antennae must be elevated and located clear of physical obstruction to ensure wide coverage and reduce the incidence of dead spots. These dead spots represent areas where there is no signal due to obstruction from tall buildings etc. Such dead regions are covered by microcells whose antennae have much lower power outputs of around 1 watt, but are densely concentrated in urban areas. As technology progresses and data demands have increased on the mobile networks, the numbers of towers has increased tremendously, but no effort is being made between companies to share such towers.

The rest of this paper is organized as follows. In Section 2, various electromagnetic radiations are described. Section 3 deals with the mobile phone technology. The working mechanism of cell phone and its adverse effects are discussed in Sections 4 and 5 respectively. Finally, the concluding remarks are given in Section 5.

2. Electromagnetic radiation (EMR)

Radiation is a form of energy which is electromagnetic in nature. It consists of waves of electric and magnetic energy moving together through space at the speed of light. We live in a radiation world and are exposed to both natural and man-made radiation. Every second of our life, we are exposed to all forms of radiation such as ultraviolet light from the sun and radio waves from radio and television broadcasts. When we go for a chest x-ray examination, we are exposed to X-rays. There are two types of radiation: ionizing and non-ionizing radiations. Ionizing radiation contains enough energy to cause ionization. Ionization has ability to break bonds between molecules. Its interaction with matter can change chemical reactions in the body that leads to damage in biological

tissues including effects on DNA (deoxyribonucleic acid)-the genetic material. Non-ionizing radiation does not have sufficient energy to cause ionization in living matter. It causes some heating effect, but usually not enough to cause any kind of long-term damage to tissue. Radiofrequency energy, visible light and microwave radiations are considered non-ionizing. For the same strength, ionizing radiations capable of causing health effects than non-ionizing radiation due to the ionization process [1, 2, 38].

Radiation behaves in the same manner as light. It travels in a straight line and when it collides with an object, it can be either transmitted, or reflected, or absorbed. It readily reduces its energy as it moves away from its source where radiation is produced. This means that a person will receive less exposure if one can stay indoors compared to staying outside or keep a distance compared to standing close to the source. The term electromagnetic field (EMF) is generally used to cover fields in the frequency range below 300 GHz. Radiofrequency (RF) signal is a wave that spreads out from its source such as the antenna. It is often referred to as an electromagnetic wave that is made up of linked electric and magnetic components. The radiofrequency part of the electromagnetic spectrum includes electromagnetic waves produced by television and radio transmitters including base stations and microwaves [1-8].

3. Mobile phone technology

A mobile/cellular phone is a low-power, single-channel, two-way radio. It contains both a transmitter and a receiver. It emits RF radiation into microwave range to transmit information to the base station. It also acts like a receiver of information, in a similar manner as a transistor radio. The radiation emitted by the antenna is insufficient to cause any significant heating of tissues in the ear or head, although a rise in skin temperature may occur as a result of placing the mobile phone too close against the ear or head [2].

Antennas, which produce RF radiation, are mounted on either transmission towers or roof-mounted structures. These structures need to be of a certain height in order to have a wider coverage. When we communicate on a mobile phone, we are connected to a nearby base station. From that base station our phone call goes into the regular fixed-line phone system. As the mobile phones and their base stations are two-way radios, they produce RF radiation to communicate and therefore expose the people near them [2].

The first generation "1G" mobile phones and their networks were first used in analogue form with 450 MHz bandwidth. Thereafter, analogue 900 MHz system and was closed by 2000. The digital global system for mobile communication

(GSM) started in 1991, representing the second generation of mobile phone systems "2G". The latest system currently in mass use is based on adaptations of CDMA and TDMA (code and time division multiple access, respectively; 800-1900 MHz; "3G"). The telecom regulatory of India defines broadband as speed greater than 256 kbps. This definition is however, inadequate and outdated. The recent US FCC national broadband defines broadband as 100Mbps downlink and 50 Mbps uplink. The latest 4G technologies are chasing speed as high as 1Gbps. The radio waves emitted by modern GSM handsets can have a peak power of up to 2W, while other digital mobile technologies such as CDMA and TDMA have power outputs under 1W, levels generally regarded as being safe by most international governing authorities [2, 38].

Cordless phones

As reported by interphone study group, Germany, radio-frequency electromagnetic fields emitted from base stations of digital enhanced cordless telecommunications (DECT) system, causes the risk of glioma and meningioma. One important source of low-level continuous exposures to radio-frequency electromagnetic fields (RF EMFs) is base stations of cordless phones that are located indoors, the DECT standard, operating at about 1900 MHz [2].

Walkie-talkies

These devices emit at relatively very high power outputs 3-4W compared to mobile and cordless phones, even though their frequency bands may be lower. They are considered to be the worst offenders of all the mainstream hand-held wireless two-way communication devices in terms of electromagnetic radiation exposure. Children use them without any knowledge of the potential dangers link with such devices [5].

Inverse Square Law

The intensity of electromagnetic radiation varies with the distance from the source according to the inverse square law. This means that the radiation's intensity is inversely proportional to the square of the distance between the source and the exposed object. So, according to this principle more away the headless is the exposure of the electromagnetic radiation.

Potential effects on body tissues

The potential effects of mobile phone-associated electromagnetic radiation on tissues include thermal and non-thermal. Thermal effects are due to tissues being heated by rotations of molecules induced by the electromagnetic field. In the case of a cell phone, the head/ear surfaces close to the phone may be induced to heat. This heating has been thought to cause molecules within cells called heat-shock proteins to become activated and repeated activation of such proteins by microwaves/electromagnetic radiation can lead to cellular events culminating in cancerous transformation of the cell. Non-thermal effects are due to low-frequency long-term pulsing of the carrier signal [2].

Specific absorption rate (SAR)

The SAR measures the rate at which radiation is absorbed by the human body. The Federal Communication Commission (FCC; USA) has set a SAR of 1.6 W/kg for the head. The SAR is 0.08 W/kg averaged over the body as defined by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. The averaging volume head versus whole body must be specified in order to make meaningful interpretations of stated SAR values between emitters and between receivers. A SAR of 4 W/kg is associated with a 1 degree temperature rise in humans. Although current mobile phones operate with power outputs that fall within acceptable government-set limits, local thermal or heating effects on the head may still be quite apparent to users after prolonged usage. In mobile telephony, SAR depends on several factors, including the antenna type and position, the distance between the phone and the head, and the power

output of the phone which through adaptive power control, can change during the conversation [2].

Adaptive power control

The level of electromagnetic radiation a user's head may be exposed to during mobile phone conversation may vary, with the variable power output of the phone. The operator's network controls adjusts the output power of each connected mobile phone to the lowest level compatible to a good signal quality. This is obtained by scaling the power from the maximum 1 or 2 W at 1800 MHz and 900 MHz, respectively. Such adaptive power control takes place continuously, with the selected power level depending on several factors, including the distance from the base station, the presence of physical obstacles such as tall buildings, whether the phone is used indoors or outdoors, and handovers between linked base stations. During handovers, the output power of the phone is generally set to the highest level [2].

Magnetic flux density

The term magnetic flux is used to describe the field that results when a magnetic field is present in any material. The unit of magnetic flux is the Weber (Wb). The unit of magnetic flux density is the Tesla (T), being Wb/m² [1, 2].

Magnetic power flux density

The rate of flow of electromagnetic energy per unit area is used to measure the amount of radiation at a given point from a transmitting antenna. This quantity is expressed in units of W/m² or mW/cm². The maximum exposure level for members of the public exposed to electromagnetic radiation at 900MHz is 0.45 W/m². This figure can be compared with the amount of heat radiated by the human body at room temperature of about 2W/m² [1, 2].

4. Working mechanism of cell phone

The extremely low frequency (ELF) fields have a long wavelength, such as frequency 50 Hz corresponds to a wavelength of 3500 km, which is almost equal to the earth's radius. As a result, such fields easily pass through the body without deposition of any energy. The established mechanism of interaction between such fields and the human body is induction of electric currents. The RF fields have wavelengths in the order of a few centimeters or less, depending on the actual frequency. Depending on the field strength, some energy is deposited in the body, mainly within one or two centimeters of its surface. The only known consequence of this is heating [10, 29].

5. Adverse health effects

Exposure to electromagnetic radiation

Exposure to the radiation emitted from mobile phones varies according to several factors, including: (i) the power output of the phone at any given time; (ii) the type of phone and the type and location of its antenna; (iii) the distance between the head and the telephone; (iv) a young child user's versus an adult user's head; (v) urban versus rural location during usage; (vi) the pattern of usage, i.e., the length and number of calls [1, 2, 38].

Effects of weak long-term ELF exposure

Given the small amount of energy that is deposited in connection with exposure to ELF fields, any health effects due to weak long-term exposure would have to be produced by a to-date unknown biophysical mechanism. It is suggested that childhood cancer mortality is associated with the existence of power lines near the children's homes, and particularly with such power lines that are indicative of high magnetic field exposure [9, 11]. In parallel with the childhood cancer research, possible associations between other implicated diseases and ELF fields have been explored. Most of this research was directed towards other forms of cancer: brain tumors, leukaemia in adults, and male and female breast cancer are the forms that have attracted the greatest interest [29]. Apart from the cancer field, cardiovascular disease is another area

that has attracted most of the interest. This is based on physiological experiments which noted that ELF magnetic fields appeared to affect heart rate variability [16-17, 29].

Effects of weak long-term RF exposure

The situation for RF fields is very different from that for ELF. Whereas early research has looked at people with occupational RF exposure studies that specifically address mobile telephony are few and recent. Till now more than a dozen epidemiological studies on mobile phone users have been published—with predominantly negative and positive findings [14, 29].

There are basically two types of studies on mobile phone users, which differ with respect to how exposure information is obtained. One group of studies uses records from the network operators. The operators can provide data on number of years of contract, frequency of calls, duration of calls and also, under certain circumstances, more detailed data about individual subscriptions and calls. The studies that have used these data so far have limited themselves to basic data [15-20, 29]. The other group of studies asks subjects in case-control studies about their phone use. More detailed data can in principle be obtained by using this approach. However, recall bias is always a concern in such studies. These case-control studies may also be affected by selection bias. In particular, the studies by Hardell and co-workers have been criticized for the possibility of both selection bias and recall bias. Later methodological studies have compared operator data and questionnaire data and showed that subjects systematically over-estimate the amount of phone use, which speaks in favor of using a combined approach [21-27, 29].

RF exposure from base stations has now been attention, but this is initiated by the public rather than by research interests. Scientists normally observe that the exposure levels from base stations are exceeded by about a thousand times by exposure levels from the phones themselves. Thus, from the scientific view it makes more sense to study exposure from phones. Yet, it is true that base stations give rise to whole body exposure for 24 hours a day, for those who stay in the neighborhood. This research area is still in a premature state and the results of the published studies are of limited interest. This experimental research is currently very intense and results are to be expected in the near future [28, 29].

Other adverse effects

Shortly, cell phones use microwave radiation to communicate. Electromagnetic waves alter electric activity of the brain and cause disturbance in sleep cause difficulty in concentration, fatigue, and headache and increase reaction time in a time-

dependent manner. They increase the resting blood pressure and reduce the production of melatonin. They are also implicated in DNA strand breaks [35-36]. In addition, the use of cell phones has also been related to Alzheimer's disease and cancer [30-36].

Furthermore, studies have linked cell phone use with brain cancer, mouth cancer and leukemia [37]. Hardell et al found that people who used cell phones are two and a half times more likely to have a temporal brain tumor on the side of the head where they held their phone. Studies that claim a relationship between cell phones and diseases like cancer and Alzheimer's should not be brushed up. Cancer incidences have exploded over the last few decades, and a large part of the increase in occurrences cannot be explained.

6. Conclusions

Electromagnetic fields are link with several factors with public health concern. The fields are invisible and they represent new technology; power line, base station and other sources of exposure are uncontrollable by the exposed individual. The current scientific situation is in uncertainty and it is often pointed out that the existence of risks cannot be ignored. The evidence for the presence of health risks from RF fields is of course very weak, but cannot be neglected.

This presents decision makers are with several dilemmas. Even if the risks from ELF field exposure were taken for granted, it would not follow automatically what actions should be taken. The dilemma is that very few people are exposed at high levels of disease and evidence is very rare. So the decision maker would have to balance the public health benefits and the costs and technical and practical consequences of various schemes that could be considered in order to reduce exposure to the population.

For RF fields, the public health consequences would probably be large if a risk is to be detected. However, the evidence for a risk is at present very weak. Shortly, more research is always needed to understand the full extent of the health implications of microwave radiation. However, there has been enough research to prove the link between cell phone use and negative health effects. The specific absorption rate (SAR) used for declaration of a mobile phone safety, equal to 2 W/kg averaged over ten grams of brain tissue, in the opinion of the RNCNIRP (Russian national committee of non-ionizing radiation protection), cannot be viewed as sufficiently scientifically grounded in this case, and is not guarantee protection of childhood and juvenile health.

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