

Health Impacts of Radiofrequency Exposure From Mobile Phones and Their Transmitter Base Stations.

*C.U. EZE, A.O. OKARO

Department of Medical Radiography & Radiological Sciences, Faculty of Health Sciences & Technology, College of Medicine, University of Nigeria, Enugu Campus, Enugu State, Nigeria.

*Author for correspondence

ABSTRACT

The widespread use of mobile phones and indiscriminate siting of transmitter base stations near residential buildings in our environment may have serious health impacts. This report attempts to investigate the possible health risks associated with radiofrequency (RF) exposure from mobile phones and their transmitter base stations. A literature review by internet browsing, Medline and manual search was carried out. There are epidemiological evidences showing that low intensity pulsed radiation from mobile phones and base station antennae have serious health impacts. However, there are few independent replications of some of these effects at present. There is also poor information about mechanisms of radiation interactions, dosimetry issues and dose response effects. The global system of mobile communication (GSM) has public health implications. Exposures should be kept as low as reasonably achievable (ALARA).

Key words: Mobile phones, Transmitter base stations, RF radiation, Radiobiology.

Mobile phones are low powered devices that transmit and receive radiofrequency (RF) electromagnetic signals from their base stations. They work on the principle of radio communication by microwave emission and reception from the antennae. A RF wave used in radio communication is called a carrier wave. It is transmitted either in analogue or in digital form. The transmission of global system of mobile communication (GSM) is in digital form (Elwood 1999).

There are two sources of RF exposure from the mobile phone systems: the base station antennae and the antenna of the mobile phone itself. Exposure from the antenna is continuous but of low intensity and it irradiates the whole body of persons in the nearby community. Exposure from the mobile phone or handset is mainly to the head of the user and is more intense but only for intermittent periods (Cox 2003).

The widespread use of mobile phone technology world wide implies increased level of exposure of the population to RF radiation. This raises the question of whether there are any implications on human health. Notably, telecommunication technologies were introduced without adequate information about their nature and without prior discussion within the scientific community about the possible consequences on health. The aim of this paper is, therefore, to review the possible biological effects associated

with exposure to RF fields of mobile phones and their transmitter base stations.

MECHANISMS OF OPERATION OF GSM

A mobile phone sends to, and receives information by radio communication from the base station. The phone systems depend on RF communication between the handsets and fixed base station. Fixed base station refers to the transmitting station, mast and antenna. Each base station covers a specific area as great as 10^3m^2 in rural areas or as small as 200500m^2 in towns where demand is greatest. The base station closest to a handset receiving a call will transmit the RF signal. If the user moves, this signal may be transferred to a nearer base station in order to maintain an optimum user signal at the lowest possible power output.

The antenna of a handset radiates in all directions but a base station antenna produces a beam that is much more directional. In addition, the stations have subsidiary beams called side-lobes into which a small fraction of the emitted power is channeled. A handset that is in operation has a low-frequency magnetic field associated with surges of electric current from the battery that are necessary to implement "time division multiple access" (TDMA). The TDMA is the system currently used to increase the number of users who can simultaneously communicate with a base station. Each user of the GSM system needs a frequency channel of bandwidth 200 kHz. Networks occupy

about 174 channels within the 35 MHz bandwidth of the 900 MHz band and 374 channels within the 75 MHz bandwidth of the 1800 MHz band that are available (Owen 2000).

MECHANISMS OF RF INTERACTIONS WITH BIOSYSTEMS

Absorption of RF radiation by matter causes molecules to vibrate which in turn causes heating effects. Notably, absorption of RF radiation from a mobile phone at distances within the wavelength of a RF transmitter occurs at a region known as near field. Since some mobile phone radiations have wave length of 30cm at 900 MHz, the user's head will be within the near field region.

RF radiation interacts with matter by causing molecules to oscillate with the electric field. This interaction is most effective for molecules which are polar such as water. The water molecules lose their rotational energy via friction with other molecules and cause an increase in temperature. RF radiation absorbed by the body occurs primarily as a result of the interaction with water.

The amount of heat produced in a living organism depends primarily on the intensity of the RF radiation once it has penetrated the system. It also depends on certain electrical properties of the biosystem and on the efficiency of the body's thermoregulation mechanism. Amongst the most thermally vulnerable areas of the body are the eyes and testes because of their low blood supply.

The existence of non-thermal biological responses to RF radiation is now generally accepted. Athermal effects are due to production of water hydrolysis, free radicals, peroxides and superoxides. They are non-linear because it depends on the state of the person when exposed to RF radiation.

DOSIMETRY OF RF RADIATION

The rate at which the energy of RF radiation is absorbed by a particular mass of tissue is called the specific absorption rate (SAR) and is measured in Watts per kilogram (W/Kg) (Gabriel et al 1987). It varies from point to point in the body because the electric field changes with position and the conductivity is different for

different types of tissues. The typical value of electric field needed to produce an SAR of 1 W/kg is about 30V/m. The SAR produced by a particular value of electric field is somewhat larger in children than in adults because their tissue normally contains a larger number of ions and so has a higher conductivity (Gabriel et al 1987). The Federal Communications Commission in the USA regulates output of hand-held mobile phones and other communication devices to levels where the specific absorption rate (SAR) does not exceed 1.6 W/kg for any 1gm of tissue when averaged over 30 minutes (Gabriel et al 1987).

BIOEFFECTS

Mobile phone usage has aroused a lot of controversy about its potential risk to health. To understand the effects this might have on the biological tissue, the intensity of the field needs to be determined within the various parts of the body that are exposed.

Effects of RF From Base Stations: The RF from a base station is a narrow beam reaching the ground 50 - 200m away from the tower which is typically 10 - 30m tall. The electric fields strength is about 50 - 100 times smaller than from a phone but at the top of the tower the signal is much stronger (Hammerius et al 2000). Studies on the possible effects of microwave exposure from base stations revealed leukaemia in children, brain tumours, lung cancer and micronucleus induction in adults (Altpeter et al 1995, Albelin 1999, Maskarinec et al 1994, Hocking et al 1996, Dolk et al 1997, Selvin et al 1992, Robinette et al 1980, Garay-vrhovac et al 1990, Johnson-Liakouris 1998). Although microwave radiation is non-ionizing, it is able to effect subtle conformational changes in molecular architecture thereby altering biochemical processes e.g. increased leakage of calcium from brain tissue. (Johnson-Liakouris 1998). Since calcium triggers release of neurotransmitter, any disturbance of its chemical balance would upset the integrity of the nervous and immune systems. It also causes increased level of ornithine decarboxylase, a rate limiting enzyme which plays an important role in deoxyribonucleic acid (DNA) replication. A more disturbing report is that it alters human mood and behaviour, ranging from depression/docility to rage

(Frey 1975) and it may induce sounds intracranially (Goldsmith 1997). Of particular concern is the way in which this radiation affects brain functions, especially its electric properties, electrochemistry and blood brain barrier (BBB) and because it degrades the immune system depending on the intensity and frequency of the RF Radiation. The duration of rapid eye movement (REM) sleep is shortened by exposure to RF radiation while nocturnal secretion of melatonin is partly inhibited, both of which lead to sleep and concentration problems. There is also an elevated risk of cancer especially in women and it could provoke epileptic seizures in children. (Persson 1997).

Effects From Mobile Phones: The close proximity of mobile phone to the head leads to relatively high specific absorption rates (SAR) (Taki et al 1996, Van Leeuwen et al 1999, Hurt et al 2000) and causes direct perturbations in the central nervous system (CNS). (Hermann et al 1997, Mckinlay 1997, Valberg 1997, Jutilainen et al 1998, Rothman 2000, Santini et al 2000). Exposure to RF fields of mobile phones has also been implicated in low birth weight, preterm delivery and still birth fetuses. (Grajewski et al 1997, Pastore et al 1997). Exposures also activate a variety of cellular signal transduction pathways (Leszczynski et al 2002) and cause electromagnetic interference with pacemakers. (Hayes et al 1997). Other effects include headache, epilepsy, sleep disruption, and neuroepithelial tumours. It also impairs short term memory, causes brain tumour, tiredness, depression and induces thermal effects which affects the body thermoregulation (Rothman 2000). The most susceptible tissue/organs are the eyes and the testis, causing cataract formation and reduced sperm counts respectively. (Hyland 2000) The hypothalamus is most susceptible to damage by RF radiation exposure (Rothman 2000).

EPIDEMIOLOGICAL EVIDENCE OF RISKS IN MAN

The results of most epidemiological surveys in humans are alarming and include the studies conducted by the scientists. Borbely et al (1989) exposed healthy male volunteers to 900

MHz RF fields either altering 15 minutes on/15 minutes off intervals or for 30 minutes once immediately preceding sleep. Both cases showed an increase in EEG powers in non REM sleep. Further investigation on this study corroborated the findings. (Wagner et al 2000). Reaction times after exposure was shown to affect the cognitive functions in man especially when doing tasks that require attention and manipulation of information in the working memory (Freude et al 2000).

A survey on the interactions of RF radiation with neurological tissues showed that there is a risk of developing brain tumours through the use of mobile phones. These tumours occur mainly in the temporal and occipital regions. (Moulder et al 1999). High intensities of RF radiation from mobile phone were found by Irnich et al (1996) to interfere with pacemakers.

A survey on how the base stations affect exposed residents was carried out by measuring the RF in and around bedrooms etc. Results showed that nausea, headaches, depression, discomfort, mood problems, difficulty in concentration, and memory loss were direct effects from RF radiation from base stations (Navarro et al 2002).

Salford et al (2003) at the Lund University Hospital in Sweden published a recent article showing how the use of GSM phones led to brain damage. They found a reduction in the brain reserve capacity leading to increased risk of developing early Alzheimer's disease in those who might have gotten it in their life time and increased risk of developing it in those who might never have had it. This also holds true for dementia. Leszczynski et al (2002) found that even weak microwave intensities could weaken human brain cells. A recent study suggested that acute low level exposure increased the permeability of the BBB and caused lasting neuronal damage (Lonn et al 2004).

The effects of RF radiation from mobile phone on the CNS were investigated by Hossmann and Hermann (Hossman et al 2003). The study showed that exposure to mobile phone radiation could lead to increased activity in hundreds of protein in the cells. The results also revealed that one hour exposure to mobile phone radiation caused cultured cells to shrink, a reaction seen only in damaged cells. They suggested that this could lead to headaches, mood swings, lethargy, depression,

suicide, anger, rage and violence.

There is evidence that at the frequencies used in mobile phone technology, children will absorb more energy per kilogram of body weight from an external electromagnetic source than adults (D' Andrea et al 2003, Youbicier-simo et al 1999, Scientific Advisory System 1999), hence they are at higher risks.

A 20 year study of servicemen in Poland established the strongest link between mobile phones and cancer (Szmigielski 1996). The study revealed a high cancer death rate among soldiers exposed to microwave radiation at levels comparable to that emitted by mobile phones when in use. This is believed to be the first significant study which shows a link between humans, microwave radiation and cancer.

EXPOSURE GUIDELINES

One approach that is often adopted in risk management is to define exposure limits or guidelines below which the recognized adverse effect would not be expected to occur. In the United Kingdom (UK), national guidelines on exposure to RF radiation were drawn up by the National Radiological Protection Board (NRPB) (National Radiological Protection Board 1993). Having reviewed all relevant epidemiological studies, NRPB concluded that the results were inconclusive and could not provide an adequate starting point from which to derive exposure guidelines (National Radiological Protection Board 1993). While some research works had suggested that adverse health effects might occur from exposures lower than those needed to produce significant heating, the evidence for these were not considered sufficiently robust to form basis for the derivation of exposure guidelines.

The NRPB exposure guidelines incorporate basic restrictions on the specific energy absorption rate, for mobile phones, the relevant restrictions are for frequencies between 10 MHz and 10 GHz. The SAR is averaged over an exposure time and a specified mass of tissue depending on the tissue region. Averaging times are specified because of the time taken for the temperature of tissue to equilibrate when they are exposed to the RF radiation. The SAR for hand-held mobile phones should not exceed 1.6 W/Kg for any 1 gm of tissue when averaged over 30

minutes.

RECOMMENDATIONS

1. Widespread use of mobile phones by children especially for non-essential calls should be minimized.
2. When a mobile phone is in use it should be held away from the body as much as possible, not pressed against the head.
3. Exposure generally should be as low as reasonably achievable (ALARA) by keeping incoming mobile phone calls as brief as possible.
4. As much as possible, use pagers on the mobile phone message bank service.
5. Transmitter base stations should not be sited close to residential buildings especially tall buildings.

CONCLUSION

There are health impacts of RF exposures from mobile phones and their transmitter base stations. The extent of the effects is still being studied as there are few independent replications. In general, there is some doubt about the validity of some claimed effects of RF exposure at the cellular levels as there is a poor record of reproducibility of findings. The results do not appear to form part of any patterns in terms of exposure or biological response. Mechanisms of RF interactions in biosystems include: thermal due to friction of polar molecules rotating under the influence of dipole and athermal due to production of water hydrolysis, free radicals, peroxides and superoxides.

Recent studies showed low intensities of RF to have beneficial effects while high intensities have detrimental health effects. High intensities have hazardous effects on health due to thermal and athermal processes of RF interactions in biosystems. It is, therefore, essential to keep exposures as low as reasonably achievable.

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