Health effects of Mobile Phone

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Abstract

The increased use of mobile phone by the public is accompanied by a wave of contradictory reports about the possible health effects, which result from exposure to electromagnetic fields (EMF) by the phone’s user and neighbors of stations. Given the immense numbers of users of mobile phones, even small adverse effects on health could have major public health implications. This article reviews the present knowledge concerning the biological and medical effects of exposure to cellular phone. However, this knowledge still contains certain gaps which should be filled. Health conditions which have reported to the use of mobile phones mainly include some types of cancer, changes of brain activity and effect on hearing. The numerous epidemiological studies relative to the occurrence of cancer by exposure to electromagnetic fields are conflicting. The absence of associations reported thus far is less conclusive because the current observation period is still too short. Currently data are completely lacking on the potential carcinogenic effect of exposures in childhood and adolescence. This review summarizes the current state of evidence concerning whether the radiofrequency fields (RF) energy used for wireless communication might be hazardous. Relevant studies were identified by searching Medline.

Introduction

The public focus on cancer as a health concern of RF exposure may be a spillover from anxiety about the carcinogenic effects of ionizing radiation, rather than being due to any direct biological theories or findings relating to RF exposure. (Rothman, 2000)

The nocebo hypothesis states that expectations of sickness cause sickness in the expectant individual. Maintaining anxiety by fostering doubts in gullible populations about the quality of the environment they live in may cause serious mental illness. Anxiety caused by health scares is an increasing public health problem, which should be addressed in its own right. (Bonneux, 2007)

Change is the only constant in the world, or better said, advancement and evolution is imperative to any field of science and technology. Computing and communication science has seen drastic change in the past decade or two. (Chauhan, 2002) These systems then end up in landfills and are not regular municipal waste. They contain many hazardous substances like heavy metals, non-biodegradable materials and persistent, bioaccumulative toxins. Various end-of-life options need to consider for such substances. The inherent property of pervasiveness is mobility and use of unwired devices. The communication among such devices has to be through the air instead of wire. The only media presently used for this wireless communication is the part of electromagnetic spectrum (the radio frequency). Constant exposure to this frequency is a cause of concern among some researchers. Though there is no study, which has consistently shown the health hazard from RFR (radio frequency range), but this does not prove the non-existence of the hazard. This paper is an attempt to make the reader aware of threat to human life and environment, caused by mobile devices and wireless communication and suggest some solutions to the same. (Chauhan, 2002)

Mobile phones also called cellular phones are an integral part of modern telecommunications. In many countries, over half the population already uses mobile phones and market is still growing rapidly (WHO, 2000). Since their introduction in a few countries in the 1980s, mobile phones have gone from being expensive items that were mainly used by the business elite, to being communication tools used by the general population. (Samkange-Zeeb and Blettner, 2009)

When considering just the sheer numbers of published studies, the number of the no-effect studies is larger than the number of the studies that show an effect. This is commonly referred as the “weight of the evidence” that is pointing out to the no effect- result, as the prevailing one. This argument is often used as evidence indicating that there are no health effects below the present safety standard limits. We need to determine what kind of important health-related studies have not yet been done and, therefore, what important health-related evidence we are missing. Only when considering both, the available and the missing evidence, we can more reliably judge the reliability of the current safety standards. (Leszczynski & Xu, 2010)

In view of the current limited state of knowledge concerning the possible adverse health effects of RF
exposure, and of the increasingly widespread use of portable telephones in many countries, research – in particular epidemiological studies – must be carried out to determine whether radiotelephones could cause adverse health effects. (Cardis and Kilkenny, 2001) Our main aim in this paper is to give a broad outline of the environmental and health concerns that have arisen from mobile phone use, and to summarize what is known about these adverse effects. We will focus not only on effects that have been investigated extensively, such as brain cancer, but also on some outcomes that are currently discussed as being of potential concern (e.g., hearing and behavioral problems), which have not yet been studied in population-based studies.

Uses of mobile phone:

Cell phone usage include: help people feel safe, financial benefits, manage time efficiently, and keep in touch with friends and family members. People have various feelings and attitudes towards cell phone usage (Aoki & Downes 2003). Self reported mobile phone use may not fully represent pattern of actual use and this has implication for calculating exposures from questionnaire data (Parslow, et al., 2003). For many parents, they offer an important means of keeping in touch with their children as they travel to and from school, sporting activities or meeting with friends. (Samkange-Zeeb and Blettner, 2009)

Through the global wireless network, participants scattered across a city or the world can easily coordinate activities and upload data to servers that can process it and integrate it with other data, such as GIS map layers and weather reports, that a variety of organizations publish on the web. Most modern phones, and certainly phones of the future, can record images, motion, and other signals, automatically associating them with location and time. New data-modeling techniques can infer a lot about individuals and the places they inhabit. (Goldman et al., 2009)

Telehealth technology could encourage better doctor-patient interaction regarding patient symptoms and quality of life monitoring, a study carried out aiming to develop a new system for transmitting patients self-reported outcomes using mobile phones or the internet and to test whether patients can and will use the system via a mobile phone, the results show that more than half of patients used mobile phone (Bielli et al., 2004).

A study was conducted to develop a health education program to reduce body weight via mobile phones message, a tendency for reduced body weight was found in 46% of participants (Kubota et al., 2004). A program targeting college students that integrates web and cell phone technologies to deliver a smoking-cessation intervention, the results provide support for using wireless text messages to deliver potentially effective smoking-cessation behavioral interventions to college students (Obermayer et al., 2004).

In the year 2000, there were an estimated 500 million mobile phone users worldwide. Today, there are about 3.3 billion users. (Samkange-Zeeb and Blettner, 2009)

According to the International Telecommunications Union, the number of cell-phone subscriptions has reached 5 billion (mid 2010), with more than half of all users believed to be children and young adults. (Levis et al., 2011)

Egyptian mobile phone use will exceed 100% by the end of 2012, claims a new report from Business Monitor International, as subscriptions climb to outnumber the country’s actual population. The high growth in mobile use will be driven by the appearance of new operators in the market which will serve rural areas, says the report. It also forecasts 15% of mobile subscribers will be using 3G by the year 2015. (Ahram on line, 2011)

The latest report by the Ministry of Communications and Information Technology has revealed that the number of cell phone users in Egypt is more than 92 million, with a prevalence rate of 113%, and an annual increase of 27.8%. The same report, published on the ministry's website, detected a drop in the number of fixed-line telephone users, now 8.5 million, with a prevalence rate of 11%, and an annual drop of 12%. (Egypt Independent, 2012)

Problems, challenges and limitation of epidemiological studies:

When evaluating the possible health effects of mobile phone radiation, as with any other environmental factor, no matter naturally occurring or man-made, are needed several types of scientific evidence such as (i) the possible mechanism how the effect is induced in living organism, (ii) in vitro laboratory studies that confirm the existence of a biophysical and biochemical mechanism of the effect, (iii) animal studies, (iv) human volunteer studies, and (v) epidemiological evidence of the effect on human population. Each type of the evidence is of different significance and value for the estimation and proof of human health effect. The most important is epidemiological evidence, followed by the human volunteer studies and animal experiments. (Leszczynski & Xu, 2010)

For diseases other than cancer, few studies are
available and the evidence is inconclusive. In the light of an absence of any credible biological hypotheses and convincing experimental results on how low level RF could cause disease, epidemiologic research is particularly important. It is also the most relevant branch of science for risk identification and assessment because it directly investigates the putative exposure-disease relationship in humans under real-life circumstances. (Schüz et al., 2011) In vitro evidence does not directly inform about the possible health impact but it provides information about the possible mechanism of the effect on cellular level. (Leszczynski & Xu, 2010)

The epidemiological evidence on the association between a risk factor and cancer is then summarized according to discrete categories (sufficient, limited, inadequate, no evidence). The distinctions among categories are chiefly based on (a) reproducibility of the evidence; (b) validity (absence of bias and confounding); (c) role of chance. (WHO, 2000)

Methodological considerations revealed that three important conditions for epidemiologic studies to detect an increased risk are not met: a) no evidence-based exposure metric is available; b) the observed duration of mobile phone use is generally still too low; c) no evidence-based selection of end points among the grossly different types of neoplasias is possible because of lack of etiologic hypotheses. Concerning risk estimates, selection bias, misclassification bias, and effects of the disease on mobile phone use could have reduced estimates, and recall bias may have led to spuriously increased risks. The overall evidence speaks in favor of an increased risk, but its magnitude cannot be assessed at present because of insufficient information on long-term use. (Kundi, 2009)

Epidemiologic studies are based on diagnosed tumors, whose identification depends not just on the induction period (period between exposure and initiation of disease) but also on their latency (ie, how long they are present before being detected). Latency is likely to be short for fast-growing malignancies, but could be decades for less aggressive tumors such as acoustic neuromas and benign meningiomas. (Ahlbom et al., 2009) There seems to be a major discrepancy not only in the results of the executed case-control epidemiological studies but also in deciding which of the studies are methodologically of better, more reliable, quality. We have performed sufficiently many epidemiological case-control studies but their results are of insufficient quality to reliably draw any health-risk-related estimates. (Leszczynski & Xu, 2010)

There is a call for changing methodological approach applies also to other areas of EMF research because when looking at the EMF publications one gets impression that this research is “stuck” on replication and re-replication of the studies using the same, often outdated, methods that in the end do not give resolution to the problem. (Leszczynski & Xu, 2010). Analytical epidemiology intends to estimate the risk as a function of exposure to an agent by application of one of three classical study types: cross-sectional, case–control, and cohort study designs. (Kundi, 2009)

In epidemiological studies, exposure assessment is a challenge and random exposure misclassification is likely to have occurred in these studies. The corresponding bias probably diluted any exposure–response association, if one existed. (Röösli, 2010) In several studies, there were indications that nonparticipation was related to exposure status, with mobile phone users more willing to participate than nonusers. Selection bias introduced by nonparticipation was estimated to cause a downward bias of around 10% in odds ratios for regular mobile phone use. Exposure definitions and methods of categorization (ever/never use of mobile phones; definition of regular, heavy, and long-term use; and the exposure cut points) were inconsistent across studies, making direct comparison difficult. (Ahlbom et al., 2009) The Interphone protocol defined regular use as at least one outgoing or incoming call per week for at least 6 months, with ever-regular use starting 1 year before the reference date. Hardell and colleagues defined the unexposed subjects as those who have not used a mobile or cordless phone for ≥ 1 year before diagnosis (or reference date in controls). (Kundi, 2009) It was concluded that the actual use of mobile phones was underestimated in light users and overestimated in heavy users. (Hardell et al., 2008)

For all study designs, it has to be assumed that exposure to the agent can be assessed with a certain sensitivity and specificity. In the case of mobile phone use, the appropriate exposure metric is unknown. Absorption of electromagnetic energy in the body of the user depends on technical features of the phone and the network, as well as on anatomical features and habits of use. It is obvious that given a certain indicator of mobile phone use, such as years of regular use, cumulative number of calls, cumulative hours of use, or cumulative absorption of electromagnetic energy in a certain area of the body. (Kundi, 2009)

Cross-sectional studies are by design limited in their ability to elucidate causal relationships. For self-reported outcomes, information bias could create
spurious exposure–outcome associations if study participants are aware of their exposure status, which is to be expected if exposure is assessed on the basis of distance to a visible transmitter. Selection bias is also of concern, since people who believe that they can feel exposure may be more likely to participate in a study. Cross-sectional studies may reveal effects of prolonged mobile phone base station exposure if the applied measures do in fact represent the exposure level over a longer time period. (Röösli, 2010)

Data collection or selection of study participants was obviously related to exposure and outcome and therefore biased. (Röösli, 2010) Method of data acquisition could be important in several respects: a) interviews not blinded to case status may introduce a bias from the expectations of the interviewer; b) the interaction between interviewee and interviewer as such can lead to bias (Rosenthal effects); c) answering a questionnaire at home is less demanding (especially considering the conditions after surgery) than personal interviews; d) at home it is possible to check telephone bills or to inspect contracts with network providers to verify data. Exposure assessment in patients could be particularly biased if conducted by interviews compared with the questionnaire method (Kundi, 2009), the interviewer was aware whether they were a case (patient) or a control, thereby potentially introducing observational bias. (Hardell et al., 2008) Bias often represents underreporting of mobile phone use, because it is more likely that a patient forgot using a mobile phone once years ago. For these reasons, the questionnaire method seems to be superior to the interview technique. However, there are also advantages of the computer-assisted personal interview (CAPI) method: data can be immediately checked for errors and discrepancies, and the interviewer can explain points that are not clear and may help in recalling inquired items (Kundi, 2009).

An interview creates a stressful situation for a patient with a recent brain tumor diagnosis and operation. These patients, especially under pressure, often have difficulties remembering past exposures and inevitably have problems with concentration and may have problems with other cognitive shortcomings. According to Hardell experience a better option would have been to start with a mailed questionnaire that could be answered by the patient during the period of well-being. If necessary this can be complemented by a telephone interview. This procedure has the additional advantage that it can be accomplished without disclosure during the data collection, whether a person is a case or a control. (Hardell et al., 2008)

**Method:**
To identify studies on environmental and health effects of mobile phone use in PubMed/Medline, we searched the database using various combinations of the terms mobile phones, electromagnetic fields (EMFs), RF, microwave, health effects, environmental effects, subjective symptoms, epidemiology, cancer, hearing impairment and childhood exposure. Original reports of research surveys, experimental studies and review articles were selected. We also used the search engine ‘Google’ to look for data on the global prevalence, trends and uses of mobile phones, citing some newspaper articles and reports identified during the search. Non-English language articles with abstracts written in English were also considered.

**Impacts of mobile phone:**
We became so engrossed in making this technology unobtrusive that we ignored the long-term negative effects that this technology is causing on our society. The threat posed by introduction of such devices can be classified as:

i) Environmental impacts:
   a) Physical waste
   b) Energy consumption

ii) Health impacts.

**Environmental impacts of mobile phone:**
WEEE (waste from electrical and electronic equipments) is the popular informal name for electrical and electronic equipment at the end of their useful life. E-Waste is dangerous as certain components therein contain hazardous materials that pose a threat to public health and the environment. Among WEEE are Information technology and telecommunications equipment and consumer equipment such as televisions, stereo equipment, electric tooth brushes, transistor radios, lighting equipment (fluorescent lamps). Others are electrical and electronic tools (handheld drills, saws, screwdrivers), toys (Play station, Game boy, etc.), large household appliances (refrigerators/freezers, washing machines, dishwashers), small household appliances (toasters, coffee makers, irons, hairdryers), medical equipment systems (with the exception of all implanted and infected products), monitoring and control instruments and automatic dispensers. (Shivoga, 2010)

It poses threat to humans and other flora and fauna in two ways – direct (environmental) and indirect (health) hazards. Disposal of these devices, which are soon becoming obsolete due to introduction of new generation, are a severe threat to environment due the dangerous trash that they produce: plastics that do not
biodegrade, heavy metals that are carcinogenic, gasses from production and incineration that are toxic, and landfills that threaten generations to come. This is the physical waste that cannot be classified under the regular municipal waste and needs different end-of-life disposition options. Apart from this physical waste, another significant environmental concern is the transfer of hazardous waste from developed to developing countries. The Amendment has not yet entered into force, but several countries have already implemented the ban, including the European Union and China. However, illegal trading is pervasive and those who benefit from the waste trade continue to strongly oppose a global ban with European Union’s (EU) directives such as WEEE and restriction of Hazardous substances (ROHS) coming into effect from 2006 in Europe. E-waste recycling is increasingly receiving a major trust. (Reena1, 2011)

It is sincerely hoped, however, that the future generation of mobile phones will not be considered hazardous waste. This will be a reality not because we have turned away from Basel’s text, obligations and definitions, but because the mobile phones of the future will cease to contain harmful substances such as beryllium, arsenic, lead, brominated flame retardants, and will cease to threaten the environment and health of future generations. However, such “greening of design” is not as likely to occur promptly if we continue to allow the real costs of pollution to be transferred to weaker economies and populations desperate for even toxic jobs. (Baselaction network, 2004)

There have been a large number of occupational studies over several decades, particularly on cancer, cardiovascular disease, adverse reproductive outcome and cataract, in relation to RF exposure. Results of studies on mobile telephone users, particularly on brain tumors and less often on other cancers and on symptoms to date give no consistent evidence of causal relation between RF exposure and any adverse health effect. (Ahlbom et al., 2004) Occupational RF exposures are more varied in dose, type of signal, and anatomical localization than exposures from cellular telephones. (Rothman, 2000)

Epidemiologic, cellular and animal studies have been carried out, but none of them have reached definitive conclusions. Although some biological effects on cell culture have been observed, their link with human cancer development is far from established. Most of the animal studies show negative results. (Colonna, 2005).

Adaptive power control (a technology to adapt the transmission power to what is required given actual conditions, such as distance between the phone and base station) may reduce the emitted power by as much as a 1000-fold. With adaptive power control, exposure is generally higher at greater distance from the base station (eg, in rural areas) (Lonn, et al., 2004), when the user is moving (eg, in a car), and in places where there is intensive use with frequent handovers. To compensate for the shielding effect of building materials, power levels of phones are, on average, higher when a phone is used indoors than outdoors. The importance of the various usage
circumstances may vary with geographic location and over time. In addition to system characteristics, the radiofrequency exposure also depends on the characteristics of the phone itself, including the type and location of the antenna (e.g., pull-out rod or built-in) and the tilt of the phone relative to the head. (Ahlbom et al., 2009)

The specific energy absorption rate (SAR) is a measure commonly used to calculate the RF energy absorbed by the body during mobile phone use. Mobile phones typically operate at frequencies of 450–900MHz (analog systems), 1800–1900 MHz (digital systems) and 1900–2200MHz Universal Mobile Telecommunications System (UMTS). The highest brain SAR values measured in a laboratory using real mobile phones were reported to be in the range of 0.9–1.76 W/kg for analog phones, and 0.44 W/kg for digital Global System for Mobile Communications (GSM) phones—values that fall below the International Commission for Non-Ionising Radiation Protection (ICNIRP) recommendation of 2.0 W/kg. (Samkange-Zeeb and Blettner, 2009) Mobile phone technology has changed considerably since its inception, with the earlier analog phones being replaced gradually by digital ones. The former technology operates at a higher power than the latter, emitting more electromagnetic radiation. (ICNIRP, 2004) A considerable number of long-term mobile phone users (duration of use X 10 years) have used both analog and digital phones, and have thus been exposed to the power settings of both technologies. (Samkange-Zeeb and Blettner, 2009)

Base stations:

Base stations are low-powered radio antennae that communicate with user handsets. Given the immense number of users of mobile phones, even small adverse effects on health could have major public health implications. Several important considerations must be kept in mind when evaluating possible health effects of radio frequency (RF) fields. One is frequency of operations, current mobile phone systems operate at frequencies between 800-1800 mega-hertz (MHz) such RF field should not be confused with ionizing radiation such as X-ray or gamma rays. Unlike ionizing radiation, RF fields cannot cause ionization or radioactivity in the body. RF exposure to a user of mobile phone is far higher than to person living near a cellular base station. However, apart from infrequent signals used to maintain links with nearby base stations, the handset transmits RF energy only while a call is being made, whereas base stations are continuously transmitting signals (WHO, 2000).

To safeguard human health and the environment, the following solutions and recommendations were made: Sharing of infrastructure such as Base Transmission Stations (BTS) and fibreoptic cable network so as to reduce duplication in the physical infrastructure by service providers, phone number portability and discouragement of locking of clients to networks (modems, laptops and handsets on offer) noting that ‘technology’ to go round some of these controls is already in use, albeit illegally, proper consumer education and responsibility, capacity building through curricula in schools, the media and stakeholders workshops and enforcement of policies, laws and regulations. (Nyansikera, 2010)

To date, little is known about the levels of radiofrequency exposure in the general population from sources such as mobile phones being used by oneself or other people, mobile phone base stations, and radio and television transmitters. Measurements that have been performed have usually been made as a result of public concern about base station exposures or other specific sources, and have therefore been made at locations that could be assumed to have higher fields than would be the case if measurement locations were selected randomly. Furthermore, all measurements have been stationary, and there is today no knowledge about the level of exposure that an individual will have throughout the day. Some countries have set up networks monitoring the radiofrequency exposure at certain locations, but again, the locations chosen have been driven by the existence of base stations or other RF exposure sources, and do not reflect the RF exposure in the general population. (Ahlbom et al., 2004)

In a study carried out to examine whether or not neighbors of cell towers are particularly concerned about adverse health effects of mobile phones bases stations (MPBSs), the outcome of this study indicates that the risk rating is comparable with other perceived common hazards of civilized world. It is hypothesized that offering information and participation to the concerned population will be efficient in reducing exaggerated fears (Hutter et al., 2004). The performed study showed the relationship between incidence of individual symptoms, the level of exposure and the distance between a residential area and base station. This association was observed in both groups of persons, those who linked their complaints with presence of base station and those who did not notice such a relation. Further studies, clinical and those based on questionnaires are needed to explain the background of the reported complaints (Bortkiewiez et al., 2004).

The electromagnetic field levels near wireless
transmitting stations for mobile phones are certainly modest when we consider that they never exceeded the limits established by the aforesaid Ministerial decree. On the contrary radio and television equipment creates a much greater source of exposure (L’Abbate et al., 2004)

In conclusion, a review does not indicate an association between any health outcome and radiofrequency electromagnetic field exposure from MPBSs at levels typically encountered in people’s everyday environment. The evidence of no relationship exists between MPBS exposure and acute symptom development. (Röösli, 2010) Comparison of complaints frequencies for 16 non specific health symptoms was done. The results showed significant increase in relation with age of subjects (elder subjects are more sensitive) and also that the facing location is the worst position for some symptoms studied especially for distance till 100 m from base stations. No significant difference is observed in the frequency of symptoms related to the duration of exposure (from 1 year to > 5 years) expected for irritability significantly increased after > 5 years. Other electromagnetic factors (electrical transformers, radio-television transmitters) have effects on the frequency of some symptoms reported by the subjects (Santini et al., 2003). In this study the complaints include headache, sleep disturbance, discomfort, irritability, depression, loss of memory, and dizziness. Women significantly more often than men complained of headache, nausea, loss of appetite, sleep disturbance, depression, and discomfort (Santini et al., 2002).

In a case study, there was a neurological abnormality in a patient after accidental exposure of the left side of the face to mobile phone radiation [Code Division Multiple Access (CDMA)] from a down-powered mobile phone base station antenna (Hocking & Westeman, 2001). To entangle the area of mobile phone availability one needs to find a base antenna network. This means that the base antennas are closer and closer to people. Each antenna is the source of electromagnetic fields and thus it has to be designed carefully with respect to public health (Dackiewiez & Krawczyk, 2003). Since antennae direct their power outward, and do not radiate significant amounts of energy from their back surfaces or towards the top or bottom of antenna, the levels of RF energy inside or to the sides of the building are normally very low (WHO, 2000).

Health impacts of mobile phone:

The known biological effects associated with these fields vary with the frequency and intensity of exposure. Frequency is the number of cycles per second that energy wave oscillates. Intensity varies both with the amount of power emitted (measured by watts) by the energy source and the distance of the individual from the source. Different regions of electromagnetic spectrum may affect biological systems differently. However, for much of the non-ionizing radiation spectrum, including RF, we currently have insufficient scientific information to evaluate the full range of potential health risk of human exposure (NIOSH, 1993).

The effect of RF on living organisms may be didactically divided into the following:

Thermal effects and non thermal effects

1) Thermal effects: these are the best known effects. They result from water molecule polarization as electromagnetic waves course through tissues and produce heat (temperature variation over 1°C). (Repacholi, 2001) This is the principle behind microwave ovens and medical diathermy devices. (Surdulescu & Steward, 2005)

Although from the perspective of the thermal effects paradigm, the rate of energy deposition in tissues of the mobile phone user is below levels considered harmful, there has been debate since the 1930s that tissue heating may not be the only relevant effect elicited by exposure to high-frequency EMFs; thus, there may be a relevant risk that has not been established yet because of the scarcity of exposure conditions that are comparable across a significant proportion of the population. (Kundi , 2009)

Current evidence indicates that the temperature elevation resulting from RF exposure is not carcinogenic. If hyperthermia occurs in the presence of exposure to known carcinogens, such as radiation or chemical carcinogens there is the potential for modulation of carcinogenic effects of those agents. In some circumstances, hyperthermia can actually protect against tumor formation. In other instances, hyperthermia clearly increases incidence of tumor formation (Dewhirst et al., 2003).

2) Non-thermal effects: these take place with no temperature change in biological tissues. These effects have not yet been fully clarified, and are the reason for many debates among scientists. These effects include electrical force induction and possibly an increase in heat shock protein synthesis in cells. The most significant expression of these proteins occurs in the physiological cell defense response against oxidative stress and in osmotic pressure variations, among other factors. Continuous heat shock protein synthesis, however, may be involved in oncogenesis, by inhibiting cell apoptosis. This
mechanism might explain how chronic exposure to high RF loads could cause cancer in susceptible subjects (French et al., 2000) a mechanism that is still under debate in the scientific community. However, Focke et al., (2010) reported that ELF-EMF might interfere with the DNA repair process which might cause accumulation of damaged DNA in cell. If so, such process could be considered as at least potential trigger for the development of cancer.

Lim, et al., (2005) carried out a study to determine whether exposure to mobile phone radiation causes a non thermal stress response in human leukocytes. They reported that heat caused an increase in the number of cells expressing stress proteins heat shock protein (HSP70, HSP27) and this increase dependent on time. However no statistically significant difference was detected in the number of cell expressing stress proteins after RF field exposure

Genotoxic effect:

Rats were exposed to a far field 1.6 GHz iradium wireless communication signal for two years. Bone marrow smears were examined for the extent of genotoxicity, there was no evidence for excess genotoxicity in rats that were chronically exposed to 1.6 GHz compared to sham-exposed and cage controls (Vijayaxmi et al., 2003).

No study thus far has demonstrated that exposure to RF without thermal effects produces genetic mutations or chromosomal aberrations in mammal cells, which suggests that RF cannot initiate tumors (Moulder et al., 2005). This is in contrary to the results of another study which indicate that the genotoxic effect of electromagnetic radiation is elicited via a non-thermal pathway (Mashevich et al., 2003).

It is known that although humans and animals possess many of the same genes, the functions of the same genes might differ and some of the same cancer types are regulated by different genes in animals and in humans. This causes that some of the cancers that will appear in animal will not appear in humans and vice-versa. (Leszczynski & Xu, 2010)

Effects on fertility:

Data suggest that EMR emitted by cellular phone influences human sperm motility. In addition to these acute adverse effects of EMR on sperm motility, long-term EMR exposure may lead to behavioral or structural changes of the male germ cell. These effects may be observed later in life, and they are to be investigated more seriously. (Erogul et al., 2006) In the analysis of the effect of GSM equipment on the semen it was noted that an increase in the percentage of sperm cells of abnormal morphology is associated with the duration of exposure to the waves emitted by the GSM phone. It was also confirmed that a decrease in the percentage of sperm cells in vital progressing motility in the semen is Correlated with the frequency of using mobile phones. (Wdowiak et al., 2007)

Cancer:

As the head is the part of the body that receives the most exposure to microwave radiation, several epidemiological studies have been conducted in different countries to determine a causal association between mobile phones and cancer. Most of these studies focus on brain tumor, while others focus on salivary gland cancer, intraocular melanoma and cancer of the hemopoietic and lymphatic tissue. Some of these studies found a direct correlation between mobile phone use and increase cancer risk, this risk increases with increasing latency and duration of mobile phone use (Kundi et al., 2004).

In an 18-month carcinogenicity study, transgenic mice were exposed to pulsed 900 MHz (RF) radiation at a whole-body specific absorption rate (SAR) of 0.5, 1.4 or 4.0 W/kg, the results showed no effect of RF radiation under the conditions used on the incidence of any neoplastic or non-neoplastic lesion, and thus the study does not provide evidence that RF radiation possesses carcinogenic potential. (Oberto et al., 2007)

To study the hypothesis that exposure to RF from mobile phones increases the incidence of gliomas, meningiomas and acoustic neuromas in adults. The incident cases were of patients aged 19-69 years who were diagnosed during 2001-2002 in Southern Norway. Population controls were selected and frequency-matched for age, sex, and residential area. Detailed information about mobile phone use was collected from glioma patients, meningioma patients and acoustic neuroma patients and from controls, no increasing trend was observed for gliomas or acoustic neuromas by increasing duration of regular use, the time since first regular use or cumulative use of mobile phones. The results from this study indicate that use of mobile phones is not associated with an increased risk of gliomas, meningiomas or acoustic neuromas. (Klaeboe et al., 2007)

The overall pattern of results does not support the presence of an association between mobile telephone use and glioma. There is no consistent evidence of an increased risk of meningioma among mobile phone users. (Ahlbom et al., 2009)

Christensen, et al., (2004) reported that the use of cell phone for 10 years or more did not increase the risk of acoustic neuroma over that of short-term users. Furthermore, tumors did not occur more frequently on
the side of the head on which the telephone was typically used and the size of the tumor did not correlate with the pattern of cell phone use.

Acoustic neuroma can cause unilateral deafness, which could lead to cessation of phone use (and hence spuriously reduced risks). Alternatively, the deafness could lead to the diagnosis of an otherwise unrecognized tumor and hence lead to spuriously increased risks. (Ahlbom et al., 2009) Our study group was the first to report a consistent pattern of an association between wireless phones and glioma and acoustic neuroma, whereas this was not found for meningioma. Meta-analysis of all published studies in this area using a reasonable latency period of at least 10 years confirmed this finding for use of mobile phones and ipsilateral glioma and acoustic neuroma, but no significant association was found for meningioma. (Hardell et al., 2008)

A retrospective cohort study of cancer incidence was conducted in Denmark, all users of cellular telephones during the period from 1982-through 1995. The results of this investigation, the first nationwide cancer incidence study of cellular phones users, do not support the hypothesis of an association between use of these telephones and tumors of the brain or salivary gland, leukemia or other cancer (Johansen et al., 2001) There was also no association with the type of phone used, using a phone for a long time (more than 5 or 10 years) or excessive use (more than 2000 hours); although the last two results were based on small numbers of cases and controls. The authors conclude that the results add to the evidence that using wireless phones is not associated with an increased risk for salivary gland tumours. However, the authors note that further studies are needed with more information on long-term and heavy use of wireless phones. (Soderqvist et al., 2012)

Incidence rates for malignancies which are developed in the head and neck including those sites that hypothetically receive the highest levels of radio frequency radiation during cellular telephone use, have not changed materially since the introduction of cellular telephones to New-Zealand (Cook et al., 2003). In a Swedish study, the data suggests that the use of hand-held cellular telephone does not increase risk of brain cancer (Muscat et al., 2000).

In a study carried out on rabbits, the results revealed that the standard cellular telephone can alter brain function as a consequence of absorption of energy by brain (Marino et al., 2003). Three groups of rats were exposed to mobile phone electromagnetic field of different strength; there was highly significant evidence of neural damage in the cortex, hippocampus and basal ganglia in the brain of exposed rats (Salfore et al., 2003). In another study aiming to explore the possible influence of RF on human brain function, the result showed that RF emitted by cellular phones has no abnormal effect on human EEG activity (Hietanen et al., 2000). It was reported that ten minutes exposure to the EMF emitted from mobile telephone had no effect on hearing at least at outer ear, middle ear and cochlear level (Ozturan et al., 2002). Mobile phones do not affect propagation of electrical stimuli along the auditory nerve to auditory brainstem centers (Bak et al., 2003). After very high exposures, nerves may be grossly injured. After lower exposures, which may result in dysaesthesia, ordinary nerve conduction studies find no abnormality but current perception threshold studies have found abnormalities (Hocking & Westeman, 2003).

**Children:**

Regarding children, there are currently little data on cell phone use and health effects, including the risk of cancer. (Mussa, 2011) In a study carried out in UK, it was concluded that major changes in head development occur after second year of life that might point at a difference in electromagnetic susceptibility between children and adults. The health council therefore finds no reason to recommend limiting the use of mobile phones by children (Van Rongen et al., 2004). Studies on the health-related effect of electromagnetic fields are available in particular for the low-frequency range, based on an appropriate estimation of exposure, a number of these studies reveal an association between exposure to this type of fields and the occurrence of infantile leukemia in the highest exposure category (Nowak & Radon, 2004).

In a study that carried out in Egypt, ninety women with uncomplicated pregnancies aged 18-33 years, and 30 full term healthy newborn infants were included. The pregnant mothers were exposed to EMF emitted by mobile telephones while on telephone-dialing mode for 10 minutes during pregnancy and after birth. The main out come were measurements of fetal and neonatal HR and COP. A statistical significant increase in fetal and neonatal HR, and statistical significant decrease in stroke volume and COP before and after use of mobile phone were noted. All these changes are attenuated with increase in gestational age. (Rezk et al., 2008)

**Accidents:**

Based on the epidemiological evidence available, the main public-health concern is clearly motor vehicle collisions, a behavioural effect rather than an effect of...
Electromagnetic hypersensitivity

The term "electromagnetic hypersensitivity" (EHS) if often used to denote a phenomenon where individuals experience adverse health effects while using or being in the vicinity of electric, magnetic, or electromagnetic field sources and devices, and when the individuals themselves attribute their symptoms to these sources and devices. There are no diagnostic criteria available, and symptoms experienced vary substantially between different individuals, but are generally non-specific with no objective signs present. The severity of the condition varies; the majority of cases present mild symptoms, but some cases experience severe problems with major consequences for work and every day life. (Ahlbom et al., 2004) The scientific literature on this area has been reviewed previously by Bergqvist et al. for the European Commission (Bergqvist, et al. 1997), updated in 2000 [Bergqvist, et al. 2000], and by Levallois (Levallois 2002). This report briefly summarizes the findings of the previous reviews, and evaluates additional studies available in the scientific literature.

It is difficult or even impossible to correctly estimate the prevalence of EHS, simply because there are no established diagnostic criteria, and the definition of the disease is largely based on each individual’s own beliefs and attribution of various symptoms to different sources of electromagnetic field exposure. Therefore, assessments of the prevalence will entirely depend on the methods used to identify cases, and the types of questions asked in each specific survey. The hitherto reported prevalence of EHS varies considerably throughout the world and between reports; at the time of the review for the European Commission [Bergqvist, et al. 1997] For reasons discussed above the validity of the reported prevalence in different studies can be questioned, and the prevalence in different countries cannot easily be compared. Finding out such sensitive subpopulation and defining it might be only possible by examining molecular level responses to this radiation. (Leszczynski & Xu, 2010) Reported prevalence rates of electromagnetic hypersensitivity (EHS), which refers to the attribution of symptoms to exposure of RF EMFs, ranged from 1.5 to 10% in various population-based studies, with the majority of participants complaining of sleeping disorders and headaches. (Samkange-Zeeb and Blettner, 2009)

The authors conclude that although the symptoms of EHS sufferers are certainly real and can be very debilitating, the current scientific evidence does not show a connection with EMF. (Oftedal et al., 2012) There was no significant association between short-term RF exposure from GSM mobile phones and subjective symptoms (e.g. headaches, nausea etc), well-being and physiological parameters (e.g. heart rate, blood pressure etc) in humans. (Augner et al., 2012)

The human volunteer studies have focused on mobile phone radiation effects on e.g. cognition, blood pressure, headaches, skin allergy-like symptoms, sleep disorders or direct recognition, by the exposed subject, whether mobile phone emits radiation or is switched off. These studies have one major set-back – experimental environment and used exposure and measurement hardware can psychologically affect behavior of the volunteers during the experiments and the obtained information might become subjective and unreliable. (Leszczynski & Xu, 2010) Studies conducted in Saudi Arabia, Egypt, and Poland reported associations between mobile phone use and headache, fatigue, dizziness, tension, difficulties with concentration and sleep disturbances. Regular mobile phone users reported health complaints, such as tiredness, stress, headache, anxiety, concentration difficulties and sleep disturbances more often than less frequent users. (Samkange-Zeeb and Blettner, 2009)

Interphone study:

The Interphone collaboration consisted of a series of 16 coordinated case–control studies coordinated by the International Agency for Research on Cancer in Lyon, was initiated in 1999 and conducted in 13 countries. The US studies and some of the Swedish studies were based on case ascertainment that started as early as 1994, while the Interphone studies ascertained cases from 2000 through 2004. (Ahlbom et al., 2009) 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. There was no increase in risk of acoustic neuroma with ever regular use of a mobile phone or for users who began regular use 10 years or more before the reference date. (Wild, 2011)
**COSMOS Study:**

The international cohort study on mobile phone use and health (COSMOS) is a long term project to investigate possible health effects associated with long term mobile phone use. The UK study is part of an international consortium of five European countries (UK, Denmark, Sweden, Finland, and the Netherlands) which together will characterise the mobile phone use (through operator traffic records and a self-reported questionnaire) and follow the health of at least 200,000 mobile phone users (18+ years of age) for 20 to 30 years. Health outcomes to be studied include risk of cancers, benign tumors, neurological and cerebro-vascular diseases, as well as change in occurrence of specific symptoms over time, such as headache and sleep disorders. (Schüz et al., 2011)

A large, prospective cohort study of mobile phone users with long-term follow-up has been given top priority in many EMF research agendas, because exposure information is captured prior to occurrence of disease, removing a major weakness of the previous case–control studies which are subject to possible recall bias. (Schüz et al., 2011)

Its major advantages are exposure assessment prior to the diagnosis of disease, the prospective collection of objective exposure information, long term follow-up of multiple health outcomes, and the flexibility to investigate future changes in technologies or new research questions (Schüz et al., 2011)

**Discussion**

All studies have some methodological deficiencies: (1) too short duration of mobile phone use to be helpful in risk assessment (2) exposure was not rigorously determined, and (3) there is a possibility of recall and response error in some studies (Kundi et al., 2004). The major limitation of epidemiological studies addressing the health effects of mobile phone use is related to exposure assessment. These limitations are inherent in case-control studies. Quality of evidence can be improved by conducting prospective cohort studies. (Auvinen et al., 2006). Some studies collected data from the 1990s, when most of the handsets were analog. These have been replaced by digital technology, where microwave emissions have a lower output power at higher frequencies.(Moulder et al., 2005)

If we admit that RF and microwaves may take decades to initiate tumors, monitoring people exposed to radiation will have to continue before we conclude that there is no risk for developing neoplasms. (International Commission for Non-Ionizing Radiation Protection, 2004). There is no evidence supporting the influence of mobile phone use on the occurrence of benign or malignant CNS tumors, results of studies on mobile phone handset radiation and the risk of developing acoustic neuroma have been contradictory (Balbani & Montovani, 2008)

Various papers have suggested that exposure to mobile phone microwaves has no influence on the activity of cochlear outer hair cells or of cochlear nerve electrical conduction, both in vivo and in vitro. Another point is that all of the studies on humans were carried out on normal-hearing volunteers. It is not know whether the cochlea of patients with inner ear conditions would be more sensitive to electromagnetic radiation. (Balbani & Montovani, 2008)

To date all of the existing epidemiological studies on RF exposure and symptoms are cross sectional, which makes them of limited value in an evaluation of whether low level RF exposure can cause various symptoms. In a cross-sectional study the exposure and the outcome are assessed simultaneously, without consideration of the time sequence of the events. In addition, all of the available studies on RF exposure ask the subjects themselves to assess both their exposure (e.g. distance to nearest base station or amount of mobile phone use) and the outcome (various symptoms), which lead to a considerable risk that the exposure assessment is influenced by the disease, or that only symptoms that an individual attribute to the RF exposure are reported. Another limitation is that the participation rates in most of the studies are low or not possible to assess, and there is a large potential for selection bias; people who experience symptoms that they attribute to mobile phones or base stations may be more prone to participate in a study investigating this particular question, than people with no such beliefs. Also the Stewart report [IEGMP 2000] acknowledged the limitations inherited in studies using a cross-sectional design.

In two studies on base station exposure and symptoms published; one from France [Santini, et al. 2002a] and one from Spain[Navarro, et al. 2003]. None of the studies have reported how subjects were selected for participation in the studies, and participation rates cannot be estimated. Participants have answered questions about various symptoms such as headaches, concentration difficulties, memory loss, fatigue, sleeping problems etc. They were also asked to estimate the distance to the nearest base station, with no independent validation. Not only is self reported distance to base stations a questionable exposure assessment method; it has also been shown that distance is a poor surrogate for RF exposure from
base stations [Schuz and Mann 2000]. The Spanish study also made measurements of the exposure in the homes, but did neither report how subjects were selected for measurements nor the proportion of subjects agreeing to have measurements taken in their homes. For unknown reasons they have also excluded all participants living between 150 and 250 meters from a base station, which makes correlation coefficients between distance and exposure of little value. Both the French and the Spanish study report an increased prevalence of symptoms close to base stations, but the design limitations make it impossible to assess whether these findings are a results of bias or real effects.

The first 10-years after the start of use of mobile phone, do not show any link between brain cancer and mobile phone radiation. However, even if such causal link would exist, it might be not detectable in such short-term studies because the numbers of phone users 10-20 years ago were small. (Leszczynski & Xu, 2010).

Because of the lack of studies that would provide unbiased information whether the human body responds to mobile phone radiation, it is problematic to consider that the presently available safety standards protect all users of mobile phones. (Leszczynski & Xu, 2010)

Due to ethical considerations, there are no published studies where the effects of mobile phone radiation on development or health of children have been examined. The scientific evidence comes only from the studies examining young animals and its applicability to human children might be of limited value. (Leszczynski & Xu, 2010)

Some case-control studies have asked about the habitual side of mobile phone use when the phone is hand-held, and have sought to investigate the association with ipsilateral and contralateral brain tumors. However, there is no evidence of consistency over time in a person’s preferred side of use. Retrospective self-report of preferred side of use may be subject to bias. If cases believe that mobile phone use may have caused their tumor, they might over-report mobile phone use on the same side as the tumor. In addition, analysis of data regarding laterality of phone use presents analytic problems. First, a method is needed for handling cases and controls who say they have no preferred side of use. Second, the analysis of control data regarding laterality of mobile phone is problematic because controls have no tumor to determine a reference side. (Ahlbom et al., 2009)

**Recommendation**

The current safety standards might be the best what can be done using the presently available scientific evidence and they should not be altered arbitrarily, without scientific justification. However, these standards are not yet sufficiently supported by the science and can not be considered as scientifically reliable.

This is why we should continue research in this area. The reason for continuation of research is not just science for the science’s sake. The reason is that our scientific evidence is insufficient to support the notions that there will be no health effects and that the safety standards are sufficient to protect all users. The present situation of scientific uncertainty calls for both precautionary measures and for further research, we will look at the health issues associated with mobile phone use that might be of interest for future research.

According to the weight each research activity carries in human health risk assessment: epidemiology, laboratory studies in humans, animals, cellular systems, and mechanisms. It should be recognized that, whilst epidemiological and human laboratory studies directly address endpoints related to human health, cellular and animal studies are of value in assessing causality and biological plausibility. Dosimetry is considered separately, but is important for all research. (WHO, 2006)

Animal studies are used when it is unethical or impractical to perform studies on humans and have the advantage that experimental conditions can be rigorously controlled, even for chronic exposures. (WHO, 2006). Use novel experimental techniques and methodological approaches, to get a better insight into possible biological effects of power lines and mobile phones on DNA damage. (Leszczynski & Xu, 2010). The need for in vitro laboratory studies for discovering the biochemical mechanism of the effect and they provide support for human and animal studies, but they can not be directly used to determine the probability of health risk or in providing information for setting of human health safety standard. (Leszczynski & Xu, 2010)

Human volunteer studies, using methods of proteomics, transcriptomics and other reliable biochemical analyses, are urgently needed to demonstrate whether human body (tissues, organs) responds, or not, to mobile phone radiation on molecular level. This research will provide information which molecules, proteins and genes react to mobile phone radiation. With this information in hand it will be possible to formulate new, knowledge-based,
hypotheses for further health risk related studies in humans (Leszczynski & Xu, 2010)

Recent studies suggest that RF exposure has no or very little effect on the expression of cancer-related genes (e.g., proto-oncogenes and tumor suppressor genes). However, the results of studies of the effects of RF exposure on stress protein expression, particularly Hsps, have so far been inconsistent, although mostly negative outcomes have been reported in vitro. Heating remains a potential confounder, and probably accounts for some of the positive effects reported. Nevertheless, further studies should be conducted to evaluate the influence of RF exposure on major stress signaling pathways. (Vecchia et al., 2009)

Further experimental and epidemiologic studies are needed to seek explanations for the controversies in studies on mobile phones so far. These studies should apply sound methodology for exposure assessment of mobile phone radiation and should focus on the effects of long-term use (more than 10 years). Cohort studies, in particular, should be established to investigate the long-term effects of mobile phone use on brain cancer as well as to address a broad range of health outcomes, not only brain tumours. (Mussa, 2011) In a cohort study, new endpoints brought up by other research activities can be included even during the conduct of the study, and the effects of evolving technologies (e.g., digital, 3G, and new modulation patterns) can be naturally integrated and have the advantages of avoiding the recall and selection biases common to case-control studies.

A call has been made for future studies to adopt an interdisciplinary approach involving psychology, laboratory study and epidemiological disciplines together with improved personal dosimetry to explore the subjective symptoms due to mobile use. (Samkange-Zeeb and Blettner, 2009)

Mobile phones are not only used for telephoning, but also for sending text messages, listening to music, playing games and watching videos, thereby exposing different body parts to electromagnetic waves. Although there is currently no evidence of significant exposures from these other forms of usage, an assessment of patterns of exposure, which takes into account the various ways in which mobile phones can be used, is needed. (Samkange-Zeeb and Blettner, 2009). Researchers have recommended further study of effects on the eye lens and lens epithelial cells

Little is known about possible adverse effects of mobile phone use on children, especially effects that might appear later in life. Ideally, prospective cohort studies covering different age groups as well as pregnant women and capable of incorporating the rapidly changing technology and exposures should be conducted. (Samkange-Zeeb and Blettner, 2009)

Studies of pre and postnatal exposure to low-frequency EMFs on immune function and on the induction of minor skeletal variations. Effects of prolonged intermittent exposure from the early postnatal period on subsequent cognitive function in animals.

Further studies should focus on exposure gradients rather than exposed versus non-exposed groups.

Future studies should also be planned in less industrialized countries, where hardly any investigation has been carried out to date. Further research should focus on long-term effects of mobile phones bas stations and should include children and adolescents.

Additional cross-sectional studies would be of limited value, so future studies should apply a longitudinal design.

WHO developed a Research Agenda in order to facilitate and coordinate research worldwide on the possible adverse health effects of EMF. Studies to fill important gaps in knowledge focused on health risk assessment that are needed to significantly reduce the uncertainty in the current scientific information.

• A large prospective longitudinal cohort study of mobile telephone users that includes
• Incidence as well as mortality data.
• Large-scale studies of subjects with high occupational RF exposure, including cohort studies as well as the use of the RF occupational exposure data within large scale existing case-control studies.as workers exposed to RF fields in some occupations receive high exposure levels and sometimes exceeding ICNIRP guidelines.
• Prospective cohort study of children and adolescent mobile phone users and all health outcomes other than brain cancer such as cognitive effects and effects on sleep quality. These endpoints are critical for children because of the importance of cognitive abilities and learning in early development
• Studies of RF effects on cell differentiation, e.g., during haemopoiesis in bone marrow, and on nerve cell growth using brain slices/cultured neurons. The possibility that haemoipoietic and/or neuronal tissue might show an abnormal growth response to RF exposure would be important because of lack of investigation in this area.
• Micro-dosimetry research (i.e., at the cellular or subcellular levels) that may yield new insights concerning biologically relevant targets of RF exposure.
• Risk perception of individuals, including studies on the formation of beliefs and perceptions about the relationship between RF exposure and health. To adequately communicate research results, and to contribute to an informed public debate about RF
exposure and health, more knowledge about the prevalence of perception patterns, and the concerns shaping these patterns and their diffusion, is needed

Conclusion

Currently, much remain unknown about the health effects of mobile phones, no biological data exist to give a reason for concern about the health effects of magnetic field pulses from mobile phones. Only a small number of studies done on the effects of these frequencies of radiation have investigated cancer as an end point. At present, evidence for a causal relationship between mobile phone use and cancer relies predominantly on epidemiology, in particular on the large studies. Nevertheless, an increased risk of mobile phone use and brain tumor, restricted to heavy mobile phone use, to very early life exposure, or to rare subtypes of brain tumors may be compatible with stable incidence trends at this time and thus further monitoring of brain tumor, especially during childhood, incidence rate time trends is warranted. Weak evidence in favor of a causal relationship is provided by some animal and in vitro studies, but overall, genotoxicity assays, both in vivo and in vitro, are inconclusive up to date.

References

18. Bonneux L. Electromagnetic fields: damage to health due to the nocebo effect. Ned Tijdschr
Geneesk. 2007 Apr 28;151(17):953-6. [Article in Dutch]
21. Chauhan S. Environmental and health hazards of mobile devices and wireless communication
31. Hardell L, Carlberg M, Hansson Mild K Methodological Aspects of Epidemiological Studies on the Use of Mobile Phones and their Association with Brain TumorsOpen Environmental Sciences, 2008, 2, 54-61
32. Harwell AEA, Green Public Procurement –Mobile Phones Technical Background Report for the European Commission – DG Environment by, June 2010
67. Ofstedal G et al Are some people hypersensitive to electromagnetic fields? EMF Spectrum 2012; 1:3-6
70. Ofstedal G et al Are some people hypersensitive to electromagnetic fields? EMF Spectrum 2012; 1:3-6
72. Ofstedal G et al Are some people hypersensitive to electromagnetic fields? EMF Spectrum 2012; 1:3-6


82. SHIVOGA WA E-WASTE: IMPACTS, CHALLENGES AND THE ROLE OF GOVERNMENT, SERVICE PROVIDERS AND THE CONSUMERS WORKSHOP HELD AT OLE SERENI HOTEL, NAIROBI –KENYA, 9th -10th June 2010


88. Wargo J, Taylor H, Alderman N, Wargo L, Bradley J, Addiss S, CELL PHONES, TECHNOLOGY EXPOSURES HEALTH EFFECTS, This project was developed and managed by Environment and Human Health, Inc., 2012.


90. WHO World Health Organization –Regional Office for Europe, Copenhagen EVALUATION AND USE OF EPIDEMIOLOGICAL EVIDENCE FOR ENVIRONMENTAL HEALTH RISK ASSESSMENT, 2000


Illustrations

Illustration 1

Table 1. Select Cell Phone Radiation Studies Demonstrating Potential Effects on Fertility

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Effect Noted</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeIuliis et al.</td>
<td>2009</td>
<td>&quot;RF-EMR in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately, DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and well-being of their offspring.&quot;</td>
</tr>
<tr>
<td>Salama N et al.</td>
<td>2009</td>
<td>&quot;Low intensity pulsed radiofrequency emitted by a conventional mobile phone kept in the standby position could affect the testicular function and structure in the adult rabbit.&quot;</td>
</tr>
<tr>
<td>Agarwal A et al.</td>
<td>2009</td>
<td>&quot;Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility.&quot;</td>
</tr>
<tr>
<td>Agarwal A et al.</td>
<td>2008</td>
<td>&quot;Use of cell phones decrease[s] the semen quality in men by decreasing the sperm count, motility, viability, and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality.&quot;</td>
</tr>
<tr>
<td>Yan JG et al.</td>
<td>2007</td>
<td>&quot;Rats exposed to 6 hours of daily cellular phone emissions for 18 weeks exhibited a significantly higher incidence of sperm cell death than control group rats through chisquared analysis.... [A]normal clumping of sperm cells was present in rats exposed to cellular phone emissions and as not present in control group rats. These results suggest that carrying cell phones near reproductive organs could negatively affect male fertility.&quot;</td>
</tr>
</tbody>
</table>
Illustration 2

Table 2. IARC Cancer Groups:

<table>
<thead>
<tr>
<th>IRC's</th>
<th>Number</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1:</strong> Carcinogenic to humans</td>
<td>107</td>
<td>Asbestos, arsenic, benzene, radon, solar radiation, vinyl chloride, tobacco smoke</td>
</tr>
<tr>
<td><strong>Group 2A:</strong> Probably carcinogenic to humans</td>
<td>59</td>
<td>Nitrate or nitrite, UV radiation, trichloroethylene</td>
</tr>
<tr>
<td><strong>Group 2B:</strong> Possibly carcinogenic to humans</td>
<td>266</td>
<td>Carbon tetrachloride, gasoline, diesel fuel (marine), lead, naphthalene, styrene, RF-EMFs</td>
</tr>
<tr>
<td><strong>Group 3:</strong> Unclassifiable as to carcinogenicity in humans</td>
<td>508</td>
<td>Fluorescent lighting, Hepatitis D virus, personal use of hair coloring products, malathion, melamine</td>
</tr>
<tr>
<td><strong>Group 4:</strong> Probably not carcinogenic to humans</td>
<td>1</td>
<td>Caprolactam (used in making plastics and nylon)</td>
</tr>
</tbody>
</table>
### Illustration 3

**Table 3. RF Radiation from Cell Phones and Cancer: Conclusions of Peer-Reviewed Review Studies**

<table>
<thead>
<tr>
<th>Author</th>
<th>FINDINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahlbom A et al. (2009)</td>
<td>“…the studies published to date do not demonstrate an increased risk within approximately  years of use for any tumor of the brain or any other head tumor... For slow growing tumors...the absence of association reported thus far is less conclusive because the observation period has been too short.”</td>
</tr>
<tr>
<td>Khurana VG et al. (2009)</td>
<td>“...there is adequate epidemiologic evidence to suggest a link between prolonged cell phone usage and the development of an ipsilateral brain tumor.”</td>
</tr>
<tr>
<td>Han YY et al. (2009)</td>
<td>&quot;Some studies of longer term cell phone use have found an increased risk of ipsilateral AN [acoustic neuroma].”</td>
</tr>
<tr>
<td>Kohli et al. (2009)</td>
<td>“The evaluation of current evidence provided by various studies to suggest the possible carcinogenic potential of radiofrequency radiation is inconclusive.”</td>
</tr>
<tr>
<td>Myung et al.</td>
<td>“...there is possible evidence linking mobile phone use to an increased risk of tumors from a meta-analysis of low biased case-control studies.”</td>
</tr>
<tr>
<td>Croft et al (2009)</td>
<td>“There are reports of small associations between MP-use ipsilateral to the tumour for greater than  years, for both acoustic neuroma and glioma, but the present paper argues that these are especially prone to confounding by recall bias.”</td>
</tr>
<tr>
<td>Abdus-Salam et al. (2008)</td>
<td>“...published research works over several decades including some with over ten years of follow up have not demonstrated any significant increase in cancer among mobile phone users. However, the need for caution is emphasized as it may take up to four decades for carcinogenesis to become fully apparent.”</td>
</tr>
<tr>
<td>Kundi (2008)</td>
<td>&quot;The overall evidence speaks in favor of an increased risk, but its magnitude cannot be assessed at present because of insufficient information on long-term use.”</td>
</tr>
</tbody>
</table>
Illustration 4

Table 4. Epidemiological Studies on Children and Potential Health Effects from Mobile Phone Use:

<table>
<thead>
<tr>
<th>Study</th>
<th>Date</th>
<th>Health Effect</th>
<th>Finding</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardell et al.</td>
<td>2008</td>
<td>Brain tumors</td>
<td>Those who used cell phones before age 20 had &gt;5-fold increase in glioma risk.</td>
<td>Sweden</td>
</tr>
<tr>
<td>CEFALO Study</td>
<td>2004-2008</td>
<td>Brain tumors</td>
<td>“Regular users of mobile phones were not statistically significantly more likely to have been diagnosed with brain tumors compared with non users.”</td>
<td>Denmark, Norway, Sweden, and Switzerland</td>
</tr>
<tr>
<td>Danish National Birth</td>
<td>1998-2008</td>
<td>Behavioral</td>
<td>Behavior problems</td>
<td>Denmark</td>
</tr>
<tr>
<td>Birth cohort/UC LA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOCH3E</td>
<td>2006-2010</td>
<td>Environmental</td>
<td>Pending</td>
<td>Korea</td>
</tr>
<tr>
<td>MOBI-KID Study</td>
<td>Began 2010</td>
<td>Brain tumor</td>
<td>Pending</td>
<td>Australia, Canada, Germany, Greece, Israel, Italy,</td>
</tr>
</tbody>
</table>
Illustration 5

Table 5. Comparison of the Hardell and Interphone Studies:

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>FINDING</th>
<th>CONCERNS</th>
<th>FUNDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lennart Hardell et al.</td>
<td>Increased risk for glioma and acoustic neuroma after 10 years of mobilephoneuse</td>
<td>Recall bias; no doseresponse relationship</td>
<td>Independently funded</td>
</tr>
<tr>
<td>IARC's Interphone</td>
<td>Suggestions of an increased risk of glioma at the highest exposure levels.</td>
<td>Biases and error prevent a causal interpretation.</td>
<td>Funded in part by industry with agreement to guarantee scientific independence</td>
</tr>
</tbody>
</table>
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