

Risk of Brain Tumors From Wireless Phone Use

Rash Bihari Dubey, MTech,* Madasu Hanmandlu, PhD,† and Suresh Kumar Gupta, PhD‡

Abstract: The debate regarding the health effects of low-intensity electromagnetic radiation from sources such as power lines, base stations, and cell phones has recently been reignited. Wireless communication has dramatically influenced our lifestyle; its impact on human health has not been completely assessed. Widespread concern continues in the community about the deleterious effects of radiofrequency radiations on human tissues and the subsequent potential threat of carcinogenesis. Exposure to low-frequency electromagnetic field has been linked to a variety of adverse health outcomes. This article surveys the results of early cell phone studies, where exposure duration was too short to expect tumor genesis, and 2 sets of more recent studies with longer exposure duration: the Interphone studies and the Swedish studies led by Hardell.

Key Words: brain tumors, cell phones, wireless phones, electromagnetic radiations, glioma, meningioma, acoustic neuroma

Abbreviations: RFR - radiofrequency radiations, ICNIRP - International Commission on Non-Ionizing Radiation Protection, FCC - Federal Communications Commission, WHO - World Health Organization, SAR - specific absorption rate

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Health hazards due to the extensive use of cell phones among ever growing schemes of society are a matter of concern. Effect of radiofrequency radiation (RFR) on the human giving rise to brain tumor is being extensively studied all over the world.^{1–3} Investigations suggest that the use of a mobile phone for 10 or more years can dramatically increase the risk of developing a tumor.⁴

Mobile phones use electromagnetic radiation (EMR) in the microwave range, and this may be harmful to the human health. Some national radiation advisory authorities have recommended measures to minimize the exposure of their citizens to other digital wireless systems, such as data communication networks.^{5–8} Studies by cell phone industries show^{9–11} that cell signal is absorbed deeply into the brains of children and up to 2 in into an adult skull. Figure 1 shows an estimate of the absorption of RFR into the brain based on age. Salford et al¹² document serious neuronal damage in rat brains after an exposure to a microwave radiation from a cell phone, at levels comparable with what people would experience during normal use. Damage to nerve cells was observed in several places within the brain, including the cortex, the hippocampus, and the basal ganglia. Currently, there is an international effort underway to develop and conduct long-term toxicology studies on the potential health effects associated with cellular phone RFR emissions.¹³

This article evaluates the current literature on cell phone use and acoustic neuroma (AN) risks and proposes additional studies

to unravel any possible linkage. During the recent years, there has been an increasing public concern on potential cancer risks from microwave emissions from wireless phones. The scientific evidence on the long-term mobile phone use and its association with certain tumors came mostly from the Hardell group and the Interphone study group.^{1,14,15} The results of these studies remain controversial, in part, because most studies suffer from various methodological deficiencies: reliance on small populations, short-term exposure periods, and difficulty in characterizing changing exposures throughout a lifetime in large populations. In addition, most negative studies have been substantially funded by the cell phone industry.^{16,17}

LITERATURE REVIEW AND RESEARCH MOTIVATION

According to some studies, the use of a cell phone can slightly decrease the risk of developing the brain tumors, glioma and meningioma.¹⁸ Most studies have not found any association between cell phone use and the development of head tumors.¹⁹ It is safe for persons with a pacemaker to use a cell phone (www.americanheart.org), although radiofrequency (RF) energy from cell phones can create electromagnetic interference that may disrupt the functioning of pacemakers (www.fda.gov).

Many studies have suggested an association between cell phone use and the development of glioma, a type of brain cancer. According to one metastudy, there is a consistent pattern connecting cell phone use and the increased risk of developing brain cancer.²⁰ Many studies have found that long-term cell phone use increases the risk of tumors of the head.²¹ The RF emissions from cell phones have been shown to damage genetic material in blood cells, which is a common precursor to cancer.⁹ The RFR from cell phones can damage the DNA in sperm. Cell phone storage in front pockets has been linked to poor fertility and an increased chance of miscarriage and childhood cancer.²² Long-term cell phone use can increase the likelihood of being hospitalized for migraines and vertigo by 10% to 20% (www.clevelandclinic.org).

Independent research by a number of investigations has suggested a link between brain tumors and cell phone use.^{23,24} Cell phones radiate microwaves, as do microwave ovens. Most European Parliament members have voted for a set of changes based on health concerns associated with electromagnetic fields (EMFs).²⁵ Cell phone radiation damages DNA, an undisputed cause of cancer.²⁶ Cell phone radiation has been shown to cause the blood-brain barrier to leak. The leakage of blood-brain barrier resulting from cell phone use increases the possibility of brain tumors.

A study discovered remarkable differences between the independent research and the industry-funded research in favor of industry interests. By falsifying the evidence, the latter showed that the radiation could protect against tumors. The protective effect study is illustrated in Figure 2.

CELLULAR TECHNOLOGY

Cell phone technology consists of base stations called transmission tower antennae and cell phone handheld units. The latest system currently is based on adaptations of code division

From the *ICE Department, Apeejay College of Engineering, Sohna, Gurgaon; †Electrical Engineering Department, IIT, New Delhi; and ‡Vaish College of Engineering, Rohtak, India.

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Reprints: Rash Bihari Dubey, MTech, ICE Department, Apeejay College of Engineering, Sohna, Gurgaon, India (e-mail: rbdubeyster@gmail.com).
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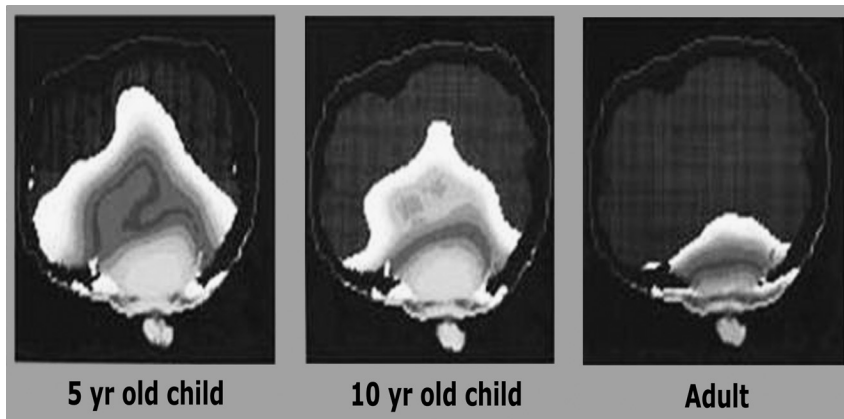


FIGURE 1. Illustration showing an estimate of the absorption of RFR into the brain based on age (courtesy from <http://www.environmentalhealthtrust.org>).

multiple access and time division multiple access (800 and 1900 MHz). Radio waves emitted by modern global system for mobile communications handsets have a peak power of 1 to 2 W, whereas other digital cellular technologies have power outputs of below 1 W, level generally regarded as being safe by international regulatory authorities. The output power of the phone is generally set to the highest level during handovers between network base stations as a user moves from one geographic area to another or when signal interference is greatest. In rural areas, base station power output is much higher because of the vast areas requiring coverage between sparsely distributed base stations, and cell phones rurally are more often at their maximum power output during use to maintain good communication.^{14,27}

Electromagnetic Radiation

An EMF is composed of an electric field generated by differences in voltage and a magnetic field generated by the

flow of current (Fig. 3). The field propagates at the speed of light in waves of a certain length that oscillate at a certain frequency. Electromagnetic radiation is often described by its frequency—the number of oscillations of the perpendicular electric and magnetic fields per second and is expressed in hertz. Cell phones operate by the bidirectional transmission of radio waves of ultrahigh frequency. The global system for mobile communications cell phones operate at a frequency of 900 or 1800 MHz. The interaction of cell phones with the base station via RFR occurs even when the phone is not in use. The frequency at which cell phones operate is in the same spectrum as that used by televisions and radios, thus identified as RFR.^{28,29} Radiofrequency radiation in this range is non-ionizing radiation. It does not carry enough energy to completely move an electron none from an atom or molecule. Instead, the energy is sufficient only for excitation, the movement of an electron to a higher energy state. Therefore, RFR emitted by cell phones does not

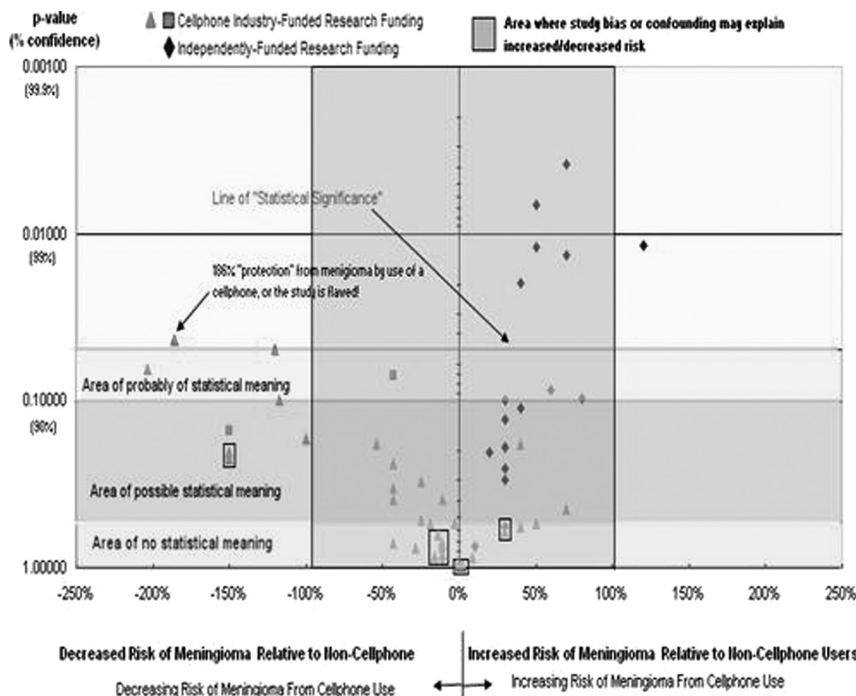


FIGURE 2. A study of industry bias in brain tumor research (courtesy from <http://www.psrast.org/mobileng/mobilstarteng.htm>).

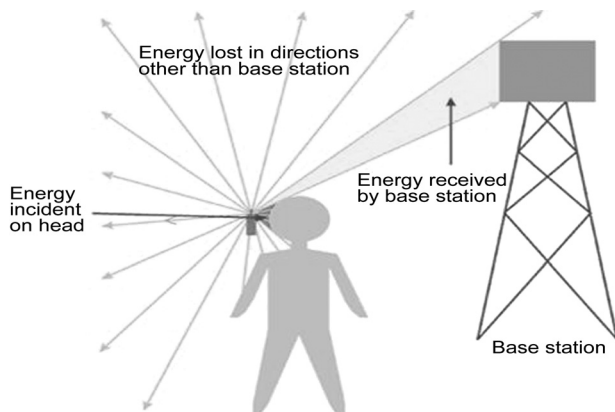


FIGURE 3. Energy radiations.

cause damage to tissues via thermal means of radiation damage.³⁰ Radiofrequency energy, on the other hand, produces heating of tissue. Although there is a small amount of experimental evidence that suggests RF energy can impact DNA in rats, these data have been contradicted by several other animal studies and are not well substantiated. The investigation into cell phone safety must look for nonthermal means of cancer promotion.

An indicator of uncontrolled cell growth is an increase in levels of ornithine decarboxylase (ODC), a rate-limiting enzyme. Its activity is elevated in all rapidly growing cells, such as transformed or cancer cells, and is markedly stimulated by tumor-promoting compounds. Overexpression of ODC in cultured cells facilitates and in some cases causes cell transformation. Its activity has been shown to be a possible indicator of EMF-induced cellular responses. Thus, ODC could be a biomarker of cell phone-induced genetic changes.^{31–35}

The intensity of EMR varies with the distance from the source according to the inverse square law. The specific absorption rate (SAR) measures the rate at which radiation is absorbed by the human body and is therefore relevant to exposure. For the head, the Federal Communications Commission (FCC) has set an acceptable SAR of 1.6 W/kg. In cellular telephony, the SAR depends on several factors, including the antenna type and position, head morphologic factor, the distance between the phone and the head, and the power output of the phone, which can vary. Exposure of the brain depends on the type of phone and position of the antenna but tends to be highest in the temporal lobe and insular region and overlying skull, scalp, and parotid gland tissues. Irrespective of the type of phone, exposure is highest on the side of the head against which the cell phone is held and seems to be even higher in children owing to thinner scalps and skulls, increased water content of their brain, and lower brain volume.^{14,27,36–38}

MAJOR STUDY AND ANALYSIS

This review covers all case-control studies on the risk of brain tumors from cell phone use published up to 2009 including epidemiological studies on the risk of brain tumors from exposure to other sources of EMFs. There are only 11 published studies examining long-term cell phone use (ie, use for 10 years) and the risk of developing a brain tumor.^{8,21,39–47} Because each set uses a common protocol, each can be considered a single study. The 2 sets are the industry-funded Interphone studies and the independently funded Swedish studies reported by Hardell team. The Hardell studies are comprehensive case-control studies looking at data exclusively from Sweden acquired between 1997

and 2003, whereas the Interphone study is a multinational collective of several comprehensive case-control studies looking at data acquired between 1999 and 2004.

Interphone Study

The objective of this 13 nations study was to assess whether RFR exposure from cell phones is associated with tumor risk, specifically, risk of glioma, meningioma, AN, and parotid gland tumors. This nonblinded, interview-based, substantially wireless industry-funded case-control study was designed to have enough statistical power to detect an increase in risk for the period of 5 to 10 years from the commencement of cell phone use. The salient fact of these early studies is the short duration of cell phone use. The following are the several flaws that were not investigated by the Interphone study:

1. Cell phones radiating higher power levels in rural areas are not investigated.

Unfortunately, the Interphone studies selected mostly metropolitan areas to locate brain tumor cases. When higher radiated power is not included, there is an underestimation of risk.⁴⁸

2. Exposure to other transmitting sources is not considered.

Subjects who use cordless phones, walkie-talkies, ham radio transmitters, and other devices are treated as unexposed in the Interphone study, although in fact, they are exposed. Treating exposed subjects as unexposed, again, underestimates the risk of brain tumors.^{43,44}

3. Tumors outside the cell phones radiation plume are treated as exposed.

The radiation plume's volume is a small proportion of the brain's volume. Treating tumors outside the radiation plume as exposed tumors results in an overestimation of risk. The adult brain absorbs the cell phones radiation almost entirely on the side of the head where the cell phone is held (ipsilateral); almost no radiation is deposited on the opposite side of the head (contralateral). In adults, the ipsilateral temporal lobe absorbs 50% to 60% of the total radiation and is approximately 15% of the brain's volume. The ipsilateral cerebellum absorbs 12% to 25% of the total radiation and is approximately 5% of the brain's volume.

4. There is an exclusion of brain tumor cases due to death or too ill to respond.

A large number of brain cancer subjects died before they could be interviewed or were too ill to be interviewed. Apart from this, other facts are exclusion of young adults and children, exclusion of brain tumor types, selection bias, insufficient latency time, definition of regular cell phone users, recall accuracy of cell phone use, and others.

Hardell Studies

These studies had no industry funding and are entirely independently funded Swedish studies led by Dr Hardell. The Interphone studies have handled more cases than the Hardell studies. However, the Hardell studies have more cases that used a cell phone for 10 or more years. The Hardell team concludes that the higher the cumulative hours of use, the higher the radiated power, the higher the number of years since first use, the higher the exposure, and the younger the user, then the higher the risk of brain tumor.^{1,14,23,27,43–45} Hardell et al⁴⁹ have performed 6 case-control studies in the area of cellular and cordless phones and tumors. Three of the studies concerned brain tumors: one, salivary gland tumors; one, NHL; and one, testicular cancer. In brief, significantly elevated risks of developing an ipsilateral

astrocytoma and an AN were found in analog and digital cell phone and cordless phone users. The aforementioned findings of Hardell et al⁴⁹ suggest specific or differential effects of cell phone radiation on tumor development. This study also has only 3 flaws; that is, tumors outside the cell phones radiation plume are treated as exposed, tumors outside the cell phones radiation plume are treated as exposed, and there is an exclusion of brain tumor cases because of death or too ill to respond.

Results of Meta-Analysis

The meta-analysis shows that long-term cell phone use can approximately double the risk of developing a glioma or an AN in the more exposed brain hemisphere. Each of the 3 tumor types studied is associated with different odds ratios and confidence intervals and elevated risks of only 2 of the 3 types, namely, glioma and AN, reached statistical significance. This work addresses an important and timely public health concern; namely, long-term cell phone use elevates the user's risk of developing a brain tumor.¹⁵

Overestimation and Underestimation

Recall bias noticed in the Interphone study has led to EMR-exposure overestimation and not underestimation.¹⁵ The overestimation due to recall bias may be countered by exposure underestimation secondary to 4 key methodological limitations.⁵⁰⁻⁵⁴ In Interphone studies, the first reference group were nonregular cell phone users. The published Interphone studies have not taken into consideration cordless phone use by participants, a risk factor for intracranial tumors⁴⁹; the reference group cannot be described as unexposed to near-field EMR. Second, in the analysis of laterality, persons who developed tumors on the opposite side of the head to the preferred side for cell phone use were classified as unexposed to cell phone EMR. Hence, exposure to microwaves from cell phone use is substantially lower on the contralateral side³⁷; the discrepancy is less pronounced for regions of the brain where glioma may originate. Third, in the Interphone study, which compared regularly exposed to unexposed individuals, the definition of a regular cell phone user is relatively minimalistic, namely, a person who uses a cell phone more than once a week for more than 6 months.^{4,55,56} Fourth, the Interphone study's participation rates for cases and controls were low compared with those of the Hardell studies. In the context of the aforementioned methodological issues, any statistically significant elevated risk in the Interphone studies may be expected to be an underestimate of the true risk.^{43,57}

Risk Agreement

The long-term epidemiological data suggest an increased risk of being diagnosed with an ipsilateral brain tumor related to cell phone use of 10 years or more. The data achieve statistical significance for glioma and AN, except for meningioma. It is concluded that the current long-term epidemiological data are consistent in determining an increased risk of brain tumors associated with ipsilateral long-term cell phone use. The findings of the laterality analysis of the Hardell group are consistent with those of the Interphone group when the long-term data are specifically assessed.^{21,43,45} It is observed that the results are subject to the effects of variations in subject participation rates and selection and recall biases. The currently available long-term epidemiological evidence points to the adverse health effects. Furthermore, the findings pertaining to brain tumors are strengthened by the long-term data recently reported by Sadetzki et al.⁵⁸ They have found significantly elevated odds for the development of ipsilateral parotid gland tumors among heavy cell phone users, effects observed to be dose dependent.

Findings from Hardell et al^{43,44} on brain and parotid tumors,⁵⁸ 2 groups that comprehensively assessed cell phone users in a dose-dependent manner, suggest time to tumor development and exposure or EMR dose, that is, cumulative cell phone use in hours.

Outdated Central Brain Tumor Registry of the United States Tumor Data

The Central Brain Tumor Registry of the United States maintains a comprehensive and unique record of age-adjusted incidence of primary central nervous system tumors. The current Central Brain Tumor Registry of the United States data suggest that malignant brain tumor age-adjusted incidence overall has not increased,^{59,60} and the most recent data are already at least 4 years outdated.

VARIOUS ADVERSE HEALTH OUTCOMES BY CELL PHONE USE

A brief overview of brain tumors and other adverse effects caused by cell phones exposures are as follows:

1. Glioma

Glioma is a malignant type of brain tumor and comprises approximately 60% of all central nervous system tumors. The survival rate from malignant glioblastoma multiforme is found very poor. The type of brain tumors is usually known after from the cells within the nerve tissue from which they originate. There are more than 100 different types of brain tumors, and the most common of these tumors originate from the supporting glial cells of the brain; hence, they are called gliomas. Gliomas do not affect tissues outside the nervous system and do not usually spread outside the brain and spinal cord. There are 4 main types of glioma: astrocytoma, ependymoma, oligodendroglioma, and glioblastoma multiforme. Gliomas are the most common malignancy of the central nervous system in adults, and the prognosis is extremely poor. Recently, considerable interest has focused on whether the use of mobile phones is associated with an increased risk of gliomas and other brain tumors, although little is known about potential mechanisms. The energy of the RF fields emitted by mobile phones is thought to be insufficient to cause malignant transformation through direct damage to DNA. Individual studies have found positive associations between high-grade astrocytoma and phone use ipsilateral to the side of the tumor and between brain tumors and phone use in rural areas and use of analog mobile phones.

Analog phones emit higher mean power levels than digital phones. If mobile phone use was causally linked to the development of glioma and risk was related to power level, we would predict a higher risk for analog phone use than for digital phones. In Sweden, Hardell et al reported raised risks for mobile phone use ipsilateral to the side of development of high-grade astrocytomas and for rural use in different analyses of the same study. The patients with glioma, who were aware of the location of their tumor, may have considered that mobile phone use was a cause of its development, resulting in systematically overreporting of phone use on the side of the head where their cancer occurred. Generally, individuals are likely to overestimate their actual use of mobile phones, and this may have exaggerated the effect of differential reporting for laterality. There is generally a lack of convincing and consistent evidence of any effect of exposure to RF field on risk of cancer. The positive association found between risk of glioma and ipsilateral mobile phone use was accompanied by a negative association for the opposite side of use to the tumor. Although it is possible that the ipsilateral association represents a real effect, this finding is probably

explained by recall bias, with patients with glioma systematically overreporting use on the same side as their tumor and consequently underreporting use on the opposite side. This study suggests that there are no substantially raised risks of glioma in the 10 years after first mobile phone use. Only future studies will be able to address longer latency periods for the development of glioma.^{11,40,42,44-47,55,61-64}

2. Acoustic neuroma

Acoustic neuromas are benign tumors that arise from the Schwann cells, which enfold the vestibulocochlear nerve. These tumors do not undergo malignant transformation. These tumors grow slowly, and the primary symptoms usually include unilateral hearing loss accompanied by tinnitus and dizziness. The tumor occurs mainly in people aged 50 years or older, except for rare tumors that develop during the course of neurofibromatosis type II, which are often diagnosed in younger persons. Women are more often affected than men, with a sex ratio close to 1.3. A number of environmental factors have been suspected to increase the risk of AN. The suspected factors include EMFs emitted by hand-held cellular telephones because this type of tumor is located in an anatomic region where a considerable amount of the power emitted from cell phones is absorbed. The power absorption is attenuated by more than 90% within 4 to 5 cm.

Electromagnetic radiation from a cell phone can penetrate the skull and deposit energy 4 to 6 cm into the brain. This can potentially result in a heating of the tissue of up to 0.1°C. Therefore, it has been debated whether these fields could initiate or promote cancer. Because RF signals are unlikely to cause genetic mutations, the biologic basis for a possible association between cell phone use and cancer risk has been proposed to be a thermal mechanism, such as changes in protein phosphorylation, or a nonthermal mechanism that promotes tumor growth, although the epidemiological studies have shown the association between use of cellular telephones and risk of AN. However, only the most recent case-control study of prevalence showed a significantly increased risk of AN among users of analog cellular telephones.^{41,43,55,61,63-69}

3. Meningioma

Meningioma arises from the pia or the arachnoid, which are the covering layers of the central nervous system. Most are benign tumors that are encapsulated and well-demarcated from surrounding tissue. Meningiomas are neoplasms originating from the meningeal tissue covering the brain and spinal cord. They are usually benign, with 1% to 3% exhibiting malignant growth. The incidence of meningiomas varies between populations, being higher among women than men. The etiology of meningiomas has remained elusive, with some hereditary syndromes and high doses of ionizing radiation among the few established risk factors. Radiofrequency EMF emitted by mobile telephones has been suggested as a possible risk factor for meningiomas, mainly based on the analogy with ionizing radiation and the proximity of the meningeal tissue to the handset. Although some positive findings have been reported, so far the totality of epidemiological evidence does not demonstrate an increase in risk of meningiomas related to mobile phone use.

Risk of meningioma among regular users of mobile phones was apparently lower than that among nonregular users (odds ratio, 0.76; 95% confidence interval, 0.65–0.89). The risk was not increased in relation to years since first use, lifetime years of use, cumulative hours of use, or cumulative number of calls. The findings were similar regardless of telephone network type, age, or sex.^{42,43,46,47,55,62-64,70}

4. Testicular cancer

An increasing incidence of testicular cancer has been noted in most Western countries during the recent decades. It is the most common cancer type in young men and is not regarded to be an occupational disease. Not only cryptorchidism is an established risk factor, but also perinatal exposure to persistent organic pollutants with hormone activity has been suggested to be another risk factor. There has been concern in the population that use of mobile phones might be a risk factor for testicular dysfunction.^{61,71,72} A study reported an 80% increased near significant risk (93.9%) of testicular cancer when the cell phone was kept in the left pocket, then the left testicle developed cancer; and kept in the right pocket, then the right testicle developed cancer. Because there have been no cell phone studies on female fertility, it is unknown if there are deleterious effects.⁷³

5. Salivary gland tumors

The salivary glands, especially the parotid gland, are targets for near-field microwave exposure during calls with wireless phones. Most salivary gland tumors are benign and occur in the parotid glands. A painless salivary mass is the most common sign and evaluated by fine needle biopsy. Salivary gland neoplasms represent the most complex and diverse group of tumors encountered by the head and neck oncologist. Their diagnosis and management are complicated by their relative frequency (1% of head and neck tumors), the limited amount of pre-treatment information available, and the wide range of biologic behavior seen with the different pathologic lesions. Further complicating the analysis of these tumors in the pediatric population is that fewer than 5% of all salivary gland tumors occur in patients younger than 16 years. Approximately 80% of salivary gland tumors are found in the parotid gland; 10% to 15%, the submandibular gland; and 5 to 10%, the minor salivary glands. Approximately, 80% of parotid tumors and 50% of submandibular tumors are benign. In the pediatric population, 35% of salivary gland tumors are regarded to be malignant. Proper management of these tumors requires an accurate diagnosis by a pathologist, correct interpretation by a surgeon, and knowledge of the surgical anatomy of salivary glands with a clear understanding of the factors leading to recurrence and complications. There was no association between the use of cellular or cordless phones and salivary gland tumors found, although few studies reported for long-term heavy use.^{11,74}

6. Brain tumor risk for use of mobile phone in urban and rural areas

There is a difference in output power of digital mobile phones between urban and rural areas. Adaptive power control regulates power depending on the quality of the transmission. In rural areas with, on average, longer distance to the base station, the output power level is higher than that in urban areas with a dense population and shorter distance to the base stations. The studies show risk for brain tumors in rural areas increasing as compared with that in urban areas.²⁷

7. Malignant melanoma of the eye

Baste et al⁷⁵ and Stang et al⁸⁰ conducted a hospital- and population-based case-control study of uveal melanoma and occupational exposures to different sources of RFR. An elevated risk for exposure to RF-transmitting devices was reported. It is concluded that several methodological limitations prevented their results from providing clear evidence on the hypothesized association.

8. Intratemporal facial nerve tumor

So far, only one investigation has studied the risk of intratemporal facial nerve tumor and the use of mobile phone. It is concluded that the short duration of use precludes definite exclusion as a risk for intratemporal facial nerve tumor development.^{61,76}

9. Male fertility damaged by radiation

Male fertility is damaged by cell phone radiation. This concern also is not about brain tumors but is of such potential consequence that it is discussed here. Men and particularly teenaged boys place their cell phone in the trouser pockets when they are not holding it to their heads in conversation. There are multiple studies showing deleterious effects on sperm including decreased sperm counts and reduced sperm motility.^{75,77,78} One study found a highly significant (99.99% confidence) 59% decline in sperm count in men who used cell phones for 4 h/d or more as compared with those who did not use cell phones at all.⁷⁷

10. Breast cancer

There is evidence from multiple areas of scientific investigations that low-frequency EMF is related to breast cancer. Over the last 2 decades, there have been numerous epidemiological studies on breast cancer in both men and women, although this relationship remains controversial. Many of these studies reported that EMF exposures are related to increased risk of breast cancer.⁷⁹ The investigations on women in workplaces suggest that low EMF is a risk factor for breast cancer for women with long-term exposure of 10 mG (1.0 μ T) and higher. Laboratory examination results of breast cancer cells have shown that low EMF exposure between 6 and 12 mG (0.6–1.2 μ T) can interface with protective effects of melatonin for the growth of these breast cancer cells. Investigations also show that breast cancer cells grow faster if exposed to low EMF at low environmental levels.

11. Non-Hodgkin lymphoma

A lymphoma is a cancer of the lymphatic system. The lymphatic system is a part of the body's immune system and helps filter out bacteria, viruses, and other unwanted substances. The non-Hodgkin lymphomas (NHLs) are a diverse group of blood cancers that include any kind of lymphoma except Hodgkin lymphomas. Types of NHL vary significantly in their severity, from indolent to very aggressive. Lymphomas are types of cancer derived from lymphocytes, a type of white blood cell. Cases of NHL have increased since the 1960s in Sweden and in many Western countries, which has a reliable cancer registry. Regarding NHL, some subgroup analyses yielded an increased risk, but their results were based on low numbers.⁶¹

SAFETY STANDARDS AND SAFETY PROTECTIONS

Safety Standards

Various public health agencies have taken the initiative to develop safety standards for occupational and public exposures to RFR. The Institute of Electrical and Electronic Engineers has developed RFR exposure standards. It is required by law that the standards developed thereof be periodically updated and reviewed.²⁰ The standards can be revised if new evidence is brought to light. The World Health Organization (WHO) is also investigating the possible effects of RFR exposure as a result of cell phone and Internet use and base stations. According to the WHO, exposure to RFR from base stations is actually only 0.0002% to 2% of the levels of international exposure guidelines, lower or comparable with exposure from radio or televi-

sion broadcast transmitters.²¹ The WHO, via the international EMF project, has established a program to monitor the EMF scientific literature to evaluate the health effects from exposure to RFR. By these means, the WHO is able to provide advice about possible hazards and to identify suitable mitigation measures. The WHO support has promoted research to fill gaps in the knowledge of RFR exposure concerns. Another multinational consortium of independent experts, the International Commission on Non-Ionizing Radiation Protection (ICNIRP), aims to review the current literature and offer advice on the effects of nonionizing radiation, which includes RFR from cell phones and base towers. The ICNIRP and the WHO periodically review the scientific literature and proceedings of scientific meetings in comparison with exposure guidelines published by the ICNIRP. Agencies and initiatives such as these are important in guiding future research directives by identifying gaps in current research. Based on extensive research done on RFR exposure till date, the FCC has issued a warning label for cordless phones.

Safe Radiation and Cell Phone Radiation Protection Tips

Because the expert groups have suggested that the radiation from mobile phones greatly exceeds safe levels even at normal use, even a short call can have harmful effects. Physicians and Scientists for Responsible Application of Science and Technology proposes to the European Union to require the production of mobile phones for young people allowing only short message service. There is now a considerable body of evidence proving that microwave radiation from mobile and cordless phones causes brain tumors, disturbed brain function, and other health disturbances. The reason is that their microwave radiation has harmful effects at intensity levels far below the values declared as safe. Present safety norms have no tenable scientific support and must be updated, now that it is suggested by a considerable body of evidence that they permit far too strong radiation.

Here are some steps one can take to reduce exposure to electromagnetic energy from cell phones:

1. Limit the use of cell phones to essential calls and keep calls short.
2. Children should be allowed to use a cell phone in cases of emergency only. Because of their developing skulls, the radiation can penetrate much more deeply.
3. Wear an air tube headset (not regular wired headset). The regular wired headset has been found to intensify radiation into the ear canal. The wire not only transmits the radiation from the cell phone but also serves as an antenna, attracting EMFs from the surroundings.
4. Do not put the cell phone in a pocket or a belt while in use or while it is on. The body tissue in the lower body area has good conductivity and absorbs radiation more quickly than the head. One study shows that men who wear cell phones near their groin could have their sperm count dropped by as much as 30%.
5. If using the phone without a headset, wait for the call to connect before placing the phone next to the ear.
6. Do not use the cell phone in enclosed metal spaces such as vehicles or elevators, where devices may use more power to establish connection.
7. Do not make a call when the signal strength is 1 bar or less, which means the phone must work harder to establish a connection.
8. Purchase a phone with a low SAR. Most phones have a SAR level listed in its instruction manual. The SAR level

is a way of measuring the quantity of RF energy that is absorbed by the body.

9. Use a scientifically validated EMF protection device. There are advanced technologies available nowadays that strengthen the bioenergy field and immune system against the effects of EMF.
10. Use text instead of talk.
11. Use landlines.
12. Keep cell phone off most of the time. Let people leave messages and then call them back from a landline.
13. Limit the use of cell phones in rural areas.

Precautionary Principle

A precautionary principle (PP) should be used when there is a reasonable ground for concern. Accordingly, if there is some evidence that a problem exists and remedial actions are possible, then these actions should be undertaken. If cell phones induce brain tumors, the potential public health costs are large.

There is also a simple action that can reduce the absorbed cell phone radiation by several orders of magnitude. Cell phone radiation decreases as the square of the distance from the phone. As a result, even small changes in distance have a dramatic effect. With the use of a headset connected, the cell phone is not held directly against the ear, and thus, the absorbed cell phone radiation could be reduced by several orders of magnitude. An appropriate PP action would be to mandate all cell phone manufacturers to remove the existing cell phone speaker that is placed to the ear and replace it with a headset directly connected to the cell phone.

CONCLUSIONS

There is no credible evidence from the Environmental Health and Safety Office about the cause of cancer or brain tumors with the use of cell phones. It is illogical to believe that evidence of unusual brain tumors is only because of hundreds of millions of people using cell phones worldwide. One study has indicated that cell phones can potentially affect the functioning of pacemakers but only when the phone was held near the chest. Continued valid research will eventually resolve the current uncertainties, and public policy will be reanalyzed and adjusted accordingly.

Most studies do not find association between the development of an AN and cell phone use, but some studies that followed cases for 10 years or more did show an association. The evaluation of AN risk factors is challenging owing to its long latency. Some studies of longer-term cell phone use have found an increased risk of ipsilateral AN. Telecom-funded studies have been reporting highly questionable results in comparison with the independent studies. The Swedish team studies, independent of industry funding, have reported a link of brain tumor risk from cell phone use and cordless phone use. The results indicate that using a cell phone for 10 years approximately doubles the risk of having a diagnosis of a brain tumor on the same (ipsilateral) side of the head as that preferred for cell phone use. People should be very restrictive with using mobile phones, as there is a significant body of compelling scientific evidence indicating serious hazards from their use. Therefore, it is advisable to reduce the use to very few and brief calls. People younger than 20 years should have mobile phones that allow short message service messages only, but no talking, because the risks are far higher in young people. Moreover, it has been repeatedly confirmed that the radiation from base stations is harmful to health. The existing ICNIRP and FCC exposure limits are based on a false premise that only thermal effects cause harm.

The PP clearly applies in this case because the problem is possible but not certain and low-cost ameliorating actions are easily implemented by the industry. With more than 300 million people using cell phones and with children among the heaviest users, it is time for governments to mandate precautionary measures to protect their citizens. We conclude that the current standard of exposure to microwave during mobile phone use is not safe for long-term exposure and needs to be revised.

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