An Epidemiological Review of Mobile Telephones and Cancer

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Abstract

Mobile telecommunication technology became commercially available about 20-25 years ago in different countries around the world. The industry has grown exponentially over the years and, currently, the number of mobile phone users is estimated to be over 3.8 billion, more than half the world's population. Thus, because of such a large population-at-risk, any health hazard from these devices promises to have a large epidemiological impact. Intense speculation and investigation into the relationship between mobile phone usage and cancer has led to the publication of numerous, often contradictory, reports on this subject. This review aims to provide a large body of reported evidence to help medical professionals disseminate evidence-based information to their patients.

INTRODUCTION

The mobile telecommunications industry has seen astounding growth since it was first introduced about 20-25 years ago in various countries. At present, there are about 3.8 billion mobile phone users in the world, accounting for more than half the total population. With such high usage in the general population and with use beginning in childhood, we can expect a large number of people to be exposed to electromagnetic radiation for a long period of time. The relation of mobile phone usage and cancer has been a long-standing suspicion and, often, contradictory reports have been presented on this subject. This review attempts to present a comprehensive body of recent data on this issue to help medical professionals disseminate evidence-based information to their patients.

BASIC PHYSICS PERTAINING TO MOBILE PHONES

Mobile phone handsets are devices that transmit and receive radio frequency (RF) waves. These RF waves are transmitted bidirectionally between the handset and the base station towers located terrestrially. The most commonly used wireless protocol is the Global System for Mobile communication (GSM) standard (accounting for 80% of all users), followed by the Code Division Multiple Access (CDMA) standard.

Mobile phones can further be of two types – analog and digital. Analog phones transmit and receive at a much higher power than do digital phones. This is because loss of data in analog transmission tends to be higher and, to counteract this effect, power has to be higher to maintain smooth transmission. In contrast, digital technologies involve binary encoding of data (voice) that resist data loss better. Hence, digital phone transmissions occur at a lower power. All mobile phones generate an electromagnetic field (EMF). An EMF is the space around a transmitter that contains waves of electromagnetic radiation. Human tissues absorb radiation to different extents, depending on their frequency (or wavelength, which is proportional to 1/frequency). For example, visible light (375-750 THz; 1THz=10^6 MHz) will be absorbed to a different extent compared to radio waves (1800 MHz), even if both are being transmitted at the same power (power=energy emitted per unit time; Watts). Thus, the specific absorption rate (SAR) is a measure of radiation absorption per unit weight of tissue and is expressed as watts per kilogram (W/kg). The radiation absorption of the human body is maximally efficient at frequencies between 30-300 MHz. The International Commission on Non-Ionising Radiation Protection (ICNIRP) has laid regulations to control whole-body SAR below 2 W/kg (averaged over 10 grams of tissue) for users of mobile phone handsets.

HUMAN STUDIES OF MOBILE PHONES AND CANCER

A large proportion of research on incidence of cancer in mobile phone users has taken place in Europe, followed by North America, while Asian studies, mainly from Japan, are relatively few. Studies have attempted to study a wide variety of neoplastic phenomena affecting different body systems. The most frequently studied malignancies include the intracranial tumors, such as astrocytomias, gliomas and acoustic neuromas. The studies have mostly been case-control studies using patient-reported usage information to correlate duration and intensity of usage to the association with cancer.

Several studies have found a greater association of long-
term mobile phone usage with intracranial malignancies. Mild et al.\(^3\) showed a significant association between analog phone use and brain tumors, with the greatest risk being for grade III-IV astrocytoma after a latency period of >10 years after first use. The association with tumors after a >10 year latency was significant for analog, digital as well as cordless phones. Lakhola et al.\(^4\) showed that there was no increased glioma risk with regular mobile phone use, even when analog or digital phones were analyzed separately. However, ipsilateral tumor risk was borderline for usage ≥ 10 years, while risk for contralateral usage was not significant. A study by Hardell et al.\(^5\) that sought to observe the prevalence of various cancers amongst regular mobile phone users found a significant association between acoustic neuromas and astrocytomas in users of analog, digital and cordless phones. The same study did not find significant associations for other tumors, such as salivary gland tumors, non-Hodgkin lymphoma (NHL) or testicular cancer. Another study by Hardell et al.\(^6\) quantified exposure in terms of >2000 hours of cumulative usage of mobile phones and studied associations with various cancers. At this level of exposure, the risk for malignant brain tumors was significantly higher for all three types of mobile phones. Also, ipsilateral exposures with these phones were associated with risk for cancer. The same study also found that the risk for developing high-grade astrocytoma was higher with usage >10 years with analog phones and digital phones, but not with cordless phones. Another study using the 10-year exposure criteria, by Schuz et al.,\(^7\) found an association with gliomas, though not with meningiomas or any tumors with lower durations of exposure. Hepworth et al.\(^8\) found that glioma occurrence was associated with ipsilateral mobile phone usage, while Schoemaker et al.\(^9\) made a similar observation for acoustic neuromas. Another study by Hardell et al.\(^10\) found that use of analog phones increased the risk for brain tumors, which increased on ipsilateral usage. High-risk groups identified in this study were persons aged 20-29 years having an exposure for >5 years from either analog or cordless phones. Two recent meta-analyses showed that long-term (>10 years) usage of mobile phones was associated with a greater risk of intracranial tumors,\(^11\) with the greatest risk being for ipsilateral gliomas and ipsilateral acoustic neuromas.\(^12\)

In-vitro studies of human glioma cells (MOS4), measuring phosphorylation of various heat-shock proteins, showed no increased tumorigenic effects of mobile phone radiation.\(^13\) Several studies,\(^14\)-\(^18\) however, have not shown any association between intracranial malignancies and mobile telephone usage. Some of these studies have included exposures of >10 years,\(^16\) exposure from cordless phone base-units,\(^17\) or even predominant unilateral use.\(^16\) Two time-trend analyses have been published highlighting the change in incidence of various tumors since the introduction of mobile phone technology. Both showed no significant rise in the incidence of intracranial malignancies despite the exponential growth of the mobile telephone industry.\(^19\)-\(^20\) A Norwegian cohort study\(^21\) found that all standardized incidence ratios (tumor incidence in exposed group divided by incidence in general Norwegian population) included 1 in the 95% confidence interval for brain tumors, acoustic neuromas, salivary gland tumors, eye tumors, leukemias, including after long-term (≥ 10 yrs exposure) to mobile phone radiation.

Sadetzki et al.\(^22\) showed that there was a significant association between the occurrence of benign or malignant parotid neoplasms and the use of mobile phones. The study found that individuals with high exposure and non-hands-free users were an at-risk group for developing these tumors on the side of predominant usage. Hardell et al.\(^23\) studied the association between NHL and mobile phone usage. The study found that B-cell type malignancies were not associated with mobile phone use. T-cell NHL after >5 years of use had a higher occurrence in users of cordless phones, but not digital or analog mobile phones. Also, risks for certain subtypes like cutaneous T-cell lymphoma and T-cell lymphoma/leukemia were raised for users of digital and cordless phones, but not analog phones. Studies on other cancers by Hardell et al.\(^24\) found no association between mobile phone usage and testicular cancers (seminoma and non-seminoma tumors). Linet et al.\(^25\) studied lifetime exposures to mobile phone radiation as <10 hours, 10-100 hours and >100 hours and found no associations, for any of the groups, with incidence of NHL. A study of malignant parotid tumors by Lonn et al.\(^26\) showed no association with mobile phone exposure, even when exposures exceeded 10 years.

Though the evidence is largely conflicting and there is no clear, unanimous association with any particular cancer, certain trends have been prominent. Use of analog technology is probably associated with more malignant tumors than digital. This is probably the effect of the higher power of transmission associated with analog phones. Cordless phones have also been implicated in several studies. Exposure to mobile phones for greater than 10 years has been found in many studies to raise the risk of cancer. Usage of the mobile handset predominantly on a particular side has been shown to raise the risk of cancers arising on that side, probably after many years of exposure. One study\(^27\) highlighted important urban-rural differences in incidence rates of cancers associated with mobile phone usage. Given the fact that most of the Indian population lives in rural areas, this may be an important epidemiological factor mitigating the overall impact of cellular technology on cancer in India. Given the current evidence, these factors can, at best, be considered as possible risk factors and be avoided as much as possible.

Though significant associations between mobile phone usage and cancer have been shown, it must be kept in mind that the most reliable studies – prospective cohort studies – are lacking.\(^28\) In the absence of these, a causal relationship cannot be established for mobile phone radiation and cancer. However, these case-control studies and retrospective analyses direct further research and help in formulating study design for large cohort studies.
ANIMAL STUDIES OF MOBILE PHONES AND CANCER

Various animal models have been used to test effects of RF radiation on cancer. Salient findings from relevant animal studies have been summarized in Table 1. Radiation exposures simulating mobile phone use are usually standardized using the SAR and the specific frequencies associated with mobile telephones or cordless phones. Studies have been performed to assess risk of RF radiation in causing cancers in animals, as well as the risk of enhancing tumor activity caused by known carcinogens. Several studies have used chemical- or radiation-induced tumors as controls and compared effects of RF radiation on the test group. Other studies have used transgenic animal models, while some have used virus-infected animal models to initiate tumorigenesis and then observe effects of RF on tumor behaviour. In vitro studies have also been performed using animal neural cell lines. On the whole, the available data suggest that RF radiation exposure simulating mobile telephone usage neither initiates, nor promotes carcinogenesis in animal models.

CONCLUSION

There is considerable public concern about effects of mobile phone radiation on carcinogenesis. Since the head

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SAR, specific absorption rate; DCS is also known as GSM-1800 MHz; GSM, global system for mobile communications (originally from Groupe Spécial Mobile); UMTS, universal mobile telecommunications system or 3GSM; W-CDMA, wide-band code division multiple access; DMBA, 7,12-dimethylbenz(a)anthracene; FDMA, frequency-division multiple access; RF, radio frequency.
receives the highest RF radiation exposure from mobile phones, research has been most intensive in this region. Some tumors, like astrocytomas, gliomas and acoustic neuromas, have been shown by several studies to be associated with mobile phone usage. However, research into this field is fraught with certain drawbacks, such as recall bias, inaccurate radiation dose quantification, selection bias and so on.\textsuperscript{49,50} Animal studies have provided no consistent relation between cancer and non-thermal range RF exposure. Based on the human studies reviewed, certain factors come forth as having a possible risk towards development of cancer, such as use of analog or cordless phones, predominant unilateral usage and exposure \(>10\) years. While it may well be prudent to avoid these practises, it must be emphasized that clear, long-term cohort studies have not been conducted to prove any causative role of mobile phone radiation in cancer pathogenesis.

\textbf{REFERENCES}


