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# Cell Phones, Cancer, and Children

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We live in a high-tech world of electronics, constantly strolling through invisible fields of radio waves, television waves, microwaves, radar, and Wi-Fi networks. In the 1980s in the Nordic countries and in the 1990s in the United States, a new source of radio frequency waves came into widespread use: The cell phone, which emits nonionizing radio waves through an antenna commonly held close to the head. By 2009, the cell phone had become an integral part of everyday life, with more than 285 million subscribers to cell phone service in the United States (91% of the population) and more than 5 billion worldwide. This ubiquitous exposure to an emerging technology prompted the initiation of large-scale health studies (some started over 20 years ago) in the United States (1,2) and throughout the world (3,4). The results of these epidemiological investigations have been largely consistent and reassuring, with the World Health Organization (WHO) and the US National Cancer Institute concluding that there is no conclusive or consistent evidence that nonionizing radiation emitted by cell phones is associated with cancer risk (5,6).

Amid this encouraging evidence from human observational studies, coupled with the negative findings from virtually all experimental animal and in vitro studies and the absence of any known biological mechanism by which weak nonionizing radio waves emitted from cell phones could damage DNA and lead to cancer (7–9), it may therefore seem surprising that a monograph committee of the International Agency for Research on Cancer (IARC), an agency of the WHO, recently announced that cell phones may be "possibly carcinogenic to humans" (10). The change from "no conclusive evidence" to "possibly carcinogenic" was not new research (11), and it has understandably led to widespread public as well as media concern and confusion (12). The footnote accompanying the IARC press release (10) is often missed—that a "possibly carcinogenic to humans" (2B) classification by IARC is based on "limited evidence of carcinogenicity" and that "chance, bias, or confounding could not be ruled out with reasonable confidence" for the few positive associations reported in the literature. A published summary of the IARC Working Group conclusions (13) noted that some members found the epidemiologic evidence to be inadequate to support the 2B classification. Viewed in this context, "possibly carcinogenic" is not a signal to abandon mobile phones and return to landline phones. Rather, it is a signal that there is very little scientific evidence as to the carcinogenicity of cell phone use. This assessment is reflected in a recent paper by the International Commission on Non-Ionizing Radiation Protection (14) which concluded: "Although there remains some uncertainty, the trend in the accumulating evidence is increasingly against the hypothesis that mobile phone use can cause brain tumours in adults".

Although evidence that children may be especially sensitive to nonionizing radio waves when compared with adults is not at all clear (15), there is genuine concern for the obvious reasons that children are young, growing, and have many years of life remaining (16). In this issue of the Journal, Aydin et al. (17) provide results from the first study specifically designed to address cell phone use among children and adolescents diagnosed with brain tumors (primarily glioma). They conducted an international case–control study of children and adolescents between 7 and 19 years of age in Denmark, Norway, Sweden, and Switzerland. Children who were diagnosed in 2004–2008 with a brain tumor (n = 352) were identified from various clinic- and population-based registry records, and controls (n = 646) were randomly selected from the general population. Cell phone use was estimated based on face-to-face interviews with a parent present and from cell phone subscriber records when available.

Consistent with virtually all studies of adults exposed to radio frequency waves (4,11,14,18), no convincing evidence was found that children who use cell phones are at higher risk of developing a brain tumor than children who do not regularly use cell phones. There were no consistent exposure–response relations for any of the metrics evaluated, whether by time since first phone use, cumulative duration of calls, cumulative number of calls, or location of the brain tumor with respect to ear (side of the head) most often used during calls. Over 100 odds ratios were computed to cover multiple combinations of cell phone use and brain tumor risk, and the authors concluded that the few statistically significant findings were likely due to bias, confounding, or chance. For example, risk was lowest in areas of the brain having the highest energy absorption to emitted radio waves; statistically significant positive trends were seen for cell phone use when the tumor occurred on the opposite side of the head (contralateral use) and statistically significant negative trends were seen for cell phone use when the tumor occurred in the center of the brain. These results parallel those from the 13-country Interphone study on adult brain tumors of which the summary article (4) reads like a textbook on how the biases and flaws that may creep into cell phone case–control interview studies may render results virtually uninterpretable. Potential sources of error abound and include exposure misclassification, recall bias, selection bias, and a variation of confounding by indication (or reverse causality) in cases in which developing a brain disorder prompts the increased use of the exposure of interest [eg, prodromal symptoms before the diagnosis of childhood cancer may have caused parents to provide their child with a cell phone in response to the developing ill-health and the perceived need for emergency contact (17)]. The case–control methodology based on personal interview to

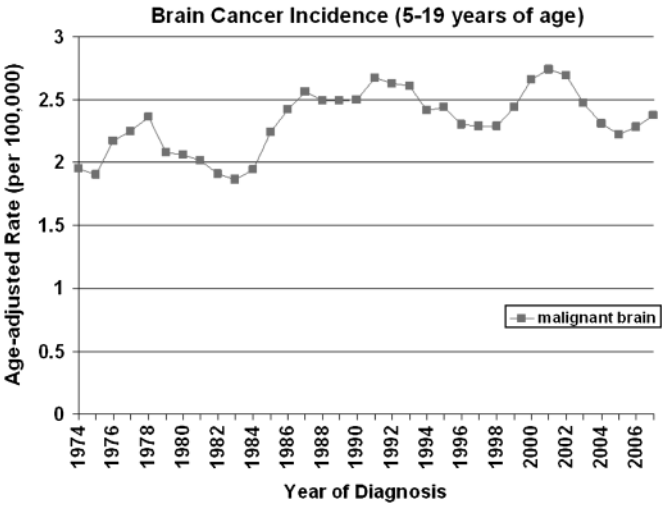


**Figure 1.** Annual age-adjusted incidence rates (3-year moving average) of brain cancer among children in the United States aged 5–19 years (1974–2007). Cell phone use in the United States was not widespread until the early 1990s. The increase in brain cancer rates in the mid-1980s has been attributed to improved diagnoses of brain tumors due to advances in medical imaging and computerized tomography scanning (21). Data are from the National Cancer Institute Surveillance, Epidemiology, and End Results Program (nine original registries).

obtain information on cell phone use, even when executed with great vigilance, appears inherently limited and should be avoided (19).

Aydin et al. (17) also evaluated brain tumor incidence rates over the years 1990–2008 among Swedish children and adolescents aged 5–19 years—and found that the rates appeared to decrease in the presence of increasing and now substantial regular usage of cell phones by children and adolescents, over 50% in the current study, and approaching 100% by age 20 years in many countries (20). In the United States, we find similarly that the incidence of brain cancer among American children, adolescents, and teenagers has not increased over the past 20 years (1986–2007) based on data from the National Cancer Institute's population-based Surveillance, Epidemiology, and End Results Program registries (Figure 1).

There have been other recent studies presenting brain tumor incidence trends among adults and children over the last 20 years in the United States (21,22); the United Kingdom (23); New Zealand (24); and Denmark, Norway, Sweden, and Finland (14,25,26). It is especially encouraging that these nationwide time-trend studies are uniformly and remarkably consistent in showing no evidence of increases in brain tumors over recent calendar years, up to and including 2009 in Sweden (14). Increases would have been expected if radio frequency waves were causally associated with brain cancer, given the steady and marked rise in the use of cell phones throughout the world since the 1980s. In an instructive exercise, Aydin et al. (17) asked if radio waves from cell phones do cause brain cancer, what trends in brain cancer rates would we have observed by now among Swedish children? They assumed two scenarios based on their empirical findings that regular use is associated with a doubling of risk (OR = 2.15) with a 3-year latency period, and that regular use is associated with a moderate increase in risk (OR = 1.36) with no latency period. The hypothetical rising trends assuming a cell phone risk diverged substantially from the actual, and slightly decreasing, observed time trend in the rates of brain tumor in the Swedish population. If Aydin et al. (17) had assumed an odds ratio of 5.2 after a 1-year latency as reported in a previous Swedish study for first use of a cell phone under age 20 years (27), the discrepancy would have been even more striking. Overall, the trend data in Sweden do not support the possibility that cell phones increase the risk of brain tumor in children or adults nor do they support case–control studies that report large or even moderate risk ratios. Consistent with the time-trend data, the one large nationwide cohort study of over 420 000 cell phone subscribers also found no evidence for an association between cell phone use and brain cancer (28).

Although Aydin et al. (17) have filled an important gap in knowledge by showing no increased risk of brain tumors among children and adolescents who are regular cell phone users, it is impossible to prove a non-effect, and it will be debated whether and at what level additional research funds should be spent in assessing health effects associated with nonionizing radiation especially in times of limited resources. Ongoing research includes a large-scale study of rodents exposed to cell phone frequencies that is being conducted by the National Toxicology Program (29), a prospective study that is recruiting 250 000 cell phone users in five European countries (30), and a case–control study of 2000 young people who were diagnosed with brain tumor aged between 10 and 24 years and an equal number of control subjects from 13 countries (31). The IARC announcement, however, has led to the usual call for "more research," especially among long-term cell phone users (a constantly moving goal post because "long" appears to be defined as a few years beyond what the last study was able to evaluate) and among young users [the latter addressed in the current investigation (17)]. So what, if anything, should be done? We concur with Aydin et al. (17) that the incidence rates of brain cancer in the general population should continue to be monitored. This descriptive epidemiological approach might be the most viable, informative, timely, and relatively unbiased method available to researchers, given that the population use of cell phones is well over 90% in most developed countries and increasing. In considering the need for future cell phone health research, it should be kept in mind that in addition to the negative epidemiological data, there is no known biologically plausible mechanism by which nonionizing radio waves of low energy can disrupt DNA and lead to cancer. The photoelectric effect is not a matter of opinion; radio frequency energy absorption cannot break DNA molecules (7), and carcinogenicity studies in animals are rather consistent in showing no increases in cancer following radio frequency energy absorption (8,9).

Nonetheless, if an individual is still concerned about remote possibilities, he or she might consider keeping calls short and using an earpiece or speaker option on the cell phone. And, heeding what is known about real risks, one should avoid using a cell phone while driving a car, because such distractions have been clearly documented to increase the risk of accidents and serious injuries (32,33).

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