Are cell phones actually safe for our children? Or for us?

Dr. Marianne Trevorrow, ND, MA

Cellular telephones have become an almost universal feature of contemporary life across both developed and developing countries. Health Canada reports that more than 2/3 of Canadians now own cell phones.[1] As cellular technology has developed, mobile phones are increasingly becoming indispensable as personal computer-like devices; allowing users to access the Internet, download and send emails, store music and photo files, watch videos, play games, as well as use increasing numbers of sophisticated software applications. For many of us, using cell phones has become a daily activity, to the point where some people report 'withdrawal-like' symptoms when they are away from their phones for more than a few hours.[2]

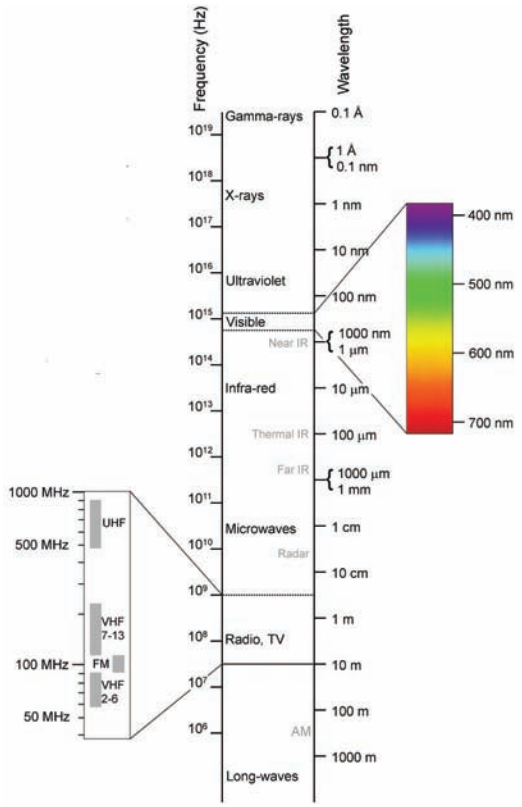
Many consumers assume that government agencies are regulating these devices to make them safe. In the meantime, however, there is growing awareness that we may actually know very little about the extent to which exposure to radio frequency (RF) signals from cell phones pose an actual health risk. A large multi-national epidemiological study commissioned by the World Health Organization (WHO) and the International Agency for Research on Cancer (IARC) recently suggested a possible increased risk of certain types of brain tumours—specifically gliomas and meningiomas—in heavy users of cell phones[3]. Still, results have been conflicting, with some longer-term use studies showing clear associations and others showing either equivocal relationships or no associations. Of particular concern are the possible effects of long-term exposures to RF signals from cell phones on children, who could potentially be heavy users of this technology for periods of 40 or 50 years or more. In this sense, we are entering a worldwide population experiment where the cellular radiation exposure is at least 10-15 years ahead of the epidemiological studies we need to establish whether these kinds of heavy exposures are, in fact, safe.

What is RF radiation and why does it matter?

Current cell phones emit electromagnetic radio frequency (RF) waves in the 800-900 megahertz (MHz) or 1800-1900 MHz bands, which enables phones to connect to the network's base station or cell tower. RF waves are emitted continuously during calls from antennae located inside the handset, but are also emitted in pulses while the cell phone is turned on and resting in order for the base stations to keep track of the location of cell phones in their network.

The numbers 800 MHz and 1800 MHz refer to the frequency range of waves emitted by cell phones antennae, similar to the frequency of AM or FM radio stations. This is why cellular radiation is referred to as RF radiation; it operates in similar

THE ELECTROMAGNETIC SPECTRUM



regions of the electromagnetic spectrum (Figure 1). RF radiation has long been considered safe, since its wavelengths are much longer than more dangerous forms of radiation such as gamma rays, x-rays or computerized tomography (CT).

These better known forms (termed ionizing radiation) can break ionic bonds in living cells, potentially damaging tissue in humans and other living beings. Since they lack this ability, Micro- or RF waves from devices such as cell phones, TVs, and WLAN networks, on the other hand, are known as non-ionizing radiation. Because of this, they were not believed to have biological effects, although this picture is changing with new evidence of biological effects in several *in vitro* studies[4,5,6,7,8]

In addition to frequency, another variable of electromagnetic fields important to understanding potential health effects of cell phones is the power density of the field, measured in watts per square metre (W/m^2). Modern digital phone handsets have a peak power of 1-2 watts, although the actual power generated during a call is almost always much less. This level is established dynamically at the moment a call is initiated and varies over the period that the call is taking place. Most digital phones in use since the mid-1990s use a feature called 'Adaptive Power Control' (APC) whereby the phone continually adjusts the power it transmits to the minimum needed for the base station to receive a clear signal—

one important feature that differentiates these phones from earlier 'analogue' cell phones. In listening mode, for example, the output RF power is minimal, but increases as the user speaks into the phone, when there are physical obstacles between the phone and the base station, or when the phone is a large distance from the base station[9]. Still, APC or not, some transmitted RF waves are absorbed by the body, particularly the area closest to the handset antenna, including the ear, cheek and temporal lobe of the brain.[10]

The rate at which energy is absorbed into the body over time, called specific absorption rate (SAR), has been extensively studied and is expressed in units of watts per kilogram (W/kg). It should not be surprising that RF energy from cell phones can cause heating in body tissues because microwave ovens use similar electromagnetic wavelengths. However, unlike microwave ovens, cell phones are held against the head or body for extended periods of time, increasing the potential for absorption of RF radiation. Limits to RF radiation levels, measured as SAR, are recommended by groups such as the International Commission on Non-ionizing Radiation (ICNIRP) and the International Committee on Electromagnetic Safely (ICES). In North America, the FCC (Federal Communication Commission) in the US and Health Canada have set an acceptable SAR of 1.6 W/kg for exposure to the head and trunk [11,12]. In Canada, cell phone manufacturers must also perform SAR testing on cell phones and all RF devices that are intended for use within a 20cm radius of the body.[13]

SAR regulatory limits for cell phones are based on exposure studies performed on several different adult human head models (called 'Phantoms' in the cell phone industry) which are filled with liquid and have electrical properties similar to human brain tissue.[14,15] Using computer modelling of readings similar to MRI imaging, research teams have found that individual SAR doses from cell phones depend on a number of factors, including antenna type and position, head morphology, distance between the phone and the head, and power output of the phone.[9,16]

Additionally, these SAR effects of cell phones appear to be highly localized. An often-cited 2008 study by scientists at two International Agency for Research into Cancer (IARC) labs conducted on over 100 different cell phone models found that between 50-60% of total RF energy was absorbed by the temporal lobe of the brain on the side the phone was used.[10] The researchers also found little difference in SAR with the phone held in different positions (i.e. against the head or with the mouthpiece tilted away) or whether there was an extended antenna or not. According to their computer modelling, average SAR appeared to diminish rapidly with tissue depth; indicating that absorption was highest in the outermost layers of the brain. This finding replicated an earlier 1996 US public/cell phone industry study that had found that 20-30% of RF energy is absorbed by the brain as a whole—with the most RF being absorbed by the skin, salivary glands and the external ear on the ipsilateral side of phone use.[17] Other groups have similarly found that energy absorption in the brain is highest in the glial and meningeal tissues located in the outermost layers of the temporal, frontal and parietal lobes. [15,18] These findings raise particular concerns about cancers arising from these tissues with long term exposures to cell phone radiation—namely acoustic neuromas, gliomas, meningiomas and parotid gland tumours.

In trying to determine cell phone RF risks specific to children, there is also considerable debate over whether the "Phantom" models named above account for differences in children's body size, shape and tissue conductivity. Several studies suggest that children's heads actually absorb more RF radiation than adults.[19,20,21,22] In 2008, scientists from France Telecom analyzed cell phone SAR in a number of child and adult head models using MRI-type 'slicing' and found significantly increased mean SAR levels in children's brain tissues in all of the models used, suggesting that established SAR safety levels in adults may lead to excessive RF exposures for children under regular cell phone use.[23] Similar to the previous authors, Wiart et al. concluded that the increased SAR levels they found would be expected due to the smaller thicknesses of the skin, external ear (pinna) and skull of children leading to reduced distance from the cellular antenna to a child's brain tissue. Given that researchers from both academia and the cellular industry also agree that SAR measurements are subject to considerable variability due to differences in individual head morphology,[10,21,23] this presents the possibility that children may be exposed on a regular basis to SAR levels above the current Health Canada safety limits. As widespread as current cell phones use is among children and teenagers in Western countries, there is the potential for an unprecedented level of RF exposures long term, with a health risk that is currently yet to be determined.

The Cancer Studies: the INTERPHONE group vs. Hardell et al.

The most serious health effects linked to cell phone use — and the subject of considerable debate between researchers and public health experts — are brain tumours.

In 1998, the IARC sponsored an international case-control study, known as INTERPHONE, to address public safety concerns about long term exposure to cell phone radiation as a possible link to brain cancer.[24] Some studies published prior to INTERPHONE indicated no correlation between cell phone use and brain tumours over the short term;[17,25,26,27] however given the long induction time for many brain tumours, and the dramatic increase in use of cell phones worldwide, serious concerns remained.

Thirteen countries including Canada contributed data to INTERPHONE using a common core protocol which included data from diagnosed cases of glioma, meningioma, acoustic neuroma and parotid gland tumours—the tissues most likely to be exposed to RF radiation from cell phones.[28] The objective was to determine whether exposure to RF fields from cell phone use was associated with an increased incidence of these relatively rare cancers, and specifically, whether cell phone RF radiation is tumorigenic. Eligible cases were sampled from residents of the study areas aged 30-59 with a confirmed first case of primary glioma (2765 cases), meningioma (2425 cases), malignant parotid gland tumours (109 cases) or acoustic neuroma (1121 cases) during the study period of 2000-2004. These cases were matched with 7658 controls of "never regular users" randomly selected from the source populations and matched for age, sex and study

region. History of cellphone use was ascertained through personal interviews for both cases and controls. Interestingly, "regular use" of cell phones was defined as those subjects who recalled an average of at least one call per week for six months or more.

The final results and conclusions of the INTERPHONE study on brain tumours were published in May 2010 in the *International Journal of Epidemiology*, six years after the conclusion of the study period.[3] Overall, they found a reduced odds ratio (OR) if ever having been a regular cell phone user for glioma (OR=0.81) and meningioma (OR=0.79). These reduced ORs held for ipsilateral (same side) main use for regular use in > 1 year for both meningiomas (OR=0.86) and gliomas (OR=0.84). In the entire study, the only increased odds ratio they found was for gliomas and meningiomas in the highest exposure groups, defined as "ever" cell phone use of over >1640 hours for 10 years, or approximately 30 minutes a day. However, the authors ascribed this finding to 'implausible values' and 'potential bias'. Overall, INTERPHONE authors believe that selection, recall and other biases make their results inconclusive in determining whether long term use of cell phones actually confers an increased risk of brain tumours.

How to lower exposure to RF radiation from cell phones for children or adults:

1. Do not keep a cell phone in a pocket or on a belt unless turned off.
2. If the phone needs to be on, store in a purse or backpack.
3. Do not keep a cell phone turned on close to where you sleep.
4. Use text rather than speaking and when texting, hold the phone at least 10 cm away from your body.
5. For children; use headphones or speakerphone when talking on a phone, and keep use to a minimum.
6. For adults, consider wired headphones, low powered Bluetooth or speakerphone when talking on the phone.
7. Don't use radiation shields or similar devices, as these may reduce connection quality and actually increase the RF signal strength.

Source:

Environmental Working Group. Cell Phone Radiation: Science Review on Cancer Risks and Children's Health [2009; cited 2010 Oct 2] Available from: http://www.ewg.org/project/2009cellphone/cellphoneradiation-fullreport.pdf

Davis, Devra, PhD, MPH. Disconnect: The truth about cell phone radiation, what the industry has done to hide it, and how to protect your family. New York: Penguin Group (USA) Ltd. 2010. (www.devradavis.com)

Individual study centre participants in INTERPHONE have also published their findings, mostly finding either inconclusive or negative associations between cell phone use and brain tumours.[29,30,31,32] For acoustic neuromas, several INTERPHONE reports found mixed results: 5 studies found than cell phone use of less than 10 years exposure was associated with no increased risk of acoustic neuroma[33,34,35,36,37] although one of these 'negative' studies did find an increased OR for ipsilateral use 10 years or longer (OR=1.8).[37] The other study that focused on exposures over 10 years also found increased risk of acoustic neuromas.[38]

For malignant parotid gland tumours, an INTERPHONE group from Israel found increased risk of tumours from ipsilateral and 'both sides' use in the heavier categories of use, which they defined as >266 hours of use over 5 years.[39]

In 2008, well after the end of the INTERPHONE study, but before the final conclusions were published, a Swedish research group lead by Lennart Hardell published a meta-analysis using several of their data sets along with their own case-control studies on cell phone use in Sweden, and some of the earlier studies from Inskip and others. In contrast to INTERPHONE however, the Hardell group found that using a cell phone for 10 years or more approximately doubles the risk of ipsilateral brain tumours.[40] For gliomas, the risk was doubled; while that for acoustic neuromas increased by 2.4 times. No increased risk was found specifically for meningiomas. This supported several previous case-control studies published by the Hardell group.[41,42,43,44] The following year, a meta-analysis limiting inclusion to studies where subjects had used phones for 10 years or more found approximately a twofold risk for ipsilateral brain tumors of any type.[45]

Researchers from both INTERPHONE and the Hardell groups have criticized each other's methodology, particularly the problems of potential recall and/or response error related to subjects' reporting of cell phone activity and laterality. Because both groups relied on participants' own recollection of their previous cell phone patterns, exposure levels were subject to considerable precision errors in both groups.[46] Validation studies carried out as part of INTERPHONE showed that many subjects substantially over- or under-estimated both the number of calls they made and their duration. [47] Given that substantial precision errors may exist even in relation to short term recall of cell phone use, the uncertainty in estimated vs. real exposures has led several researchers to question whether INTERPHONE's methodology has led to underestimation of the risks.[45,46] In turn, several of the INTERPHONE researchers have questioned whether the Hardell group's methods may have overestimated the risks.[28,48,49] These issues aside, a significant question that remains to be answered is the possible mechanism(s) by which RF radiation may induce head and neck tumours, or whether the role of RF tumorigenesis is via induction or promotion.[4] In a sense, it is not surprising that both sides of the epidemiological debate have suggested that further investigation is needed.

Still, given that the latency period for many brain tumours caused by radiation is estimated to be 10-15 years[50], these findings are troubling; all the more so because the rate of cell phone use in children and young adults across many countries has been rising dramatically since 2000.

What does this all mean and what do we do with our phones now?

At this point few epidemiological or lab studies have explored the possible effects of cumulative RF radiation exposures on children, despite indications of increased vulnerability due to

factors such as developing neuronal systems and greater RF radiation penetration relative to head size.[51] As several reviewers have noted, children who are currently using cell phones can expect to have lifetime cumulative doses of RF radiation well in excess of current use. This is sobering for those of us who work with children and teenagers and we cannot help but wonder; will there be an epidemic of head and neck tumours for these kids 20 years down the road? Where does this leave us with our patients? After reading the current evidence, I believe that we should encourage our patients (and ourselves) to look at ways to decrease cell phone radiation exposure whether it is by using speaker-phones, wired or wireless headsets, or simply by using cell phones less.

For children, the best options would be to encourage them not to use their phones for conversations unless they are using headphones or speaker settings. They should be taught to use the phones held away from the body as much as possible—including not storing the phones in pockets or close to the body—and to turn their phone off when not in use. Overall, I think the most important message is that we need to stop assuming that RF radiation from cell phones is safe at any dose and for any period of time. As consumers, we need to demand lower SAR phones and that SAR specifications be clearly labelled on all cell phone packaging. We also need to lobby regulatory agencies such as Health Canada to decrease allowable SAR levels to accommodate use by children. As clinicians, we need to educate ourselves about actual cell phone risks and ways to minimize RF radiation exposures in order to help our patients make informed decisions for themselves—and their children—about whether to use cell phones, and if so, how to use them safely (see the box below for guidelines). Personally, I will be encouraging parents not to buy cell phones for children under 12, and to encourage their adolescents to use various hands-free devices or text rather than holding the phone against the head. Other clinicians may want to make different recommendations but the key is education and shared informed decision making. The information is out there now—we just need to put our phones down long enough to start paying attention to it.

About the Author

Dr. Marianne Trevorrow, ND, MA holds degrees from McGill University, the University of Chicago, and Bastyr University, where she graduated with her ND in 2006. She did post-graduate work in Nutrition and Anti-Aging Medicine at Bastyr from 2006 to 2007 and is currently in private practice in Victoria, BC. Her clinical focus is on environmental health and developmental disorders in children, including ADHD, autism, Down's syndrome, allergies, asthma and other chronic conditions of childhood. She has been a Defeat Autism Now! certified clinician since 2006.

Dr. Trevorrow is increasingly interested in the links between nutrition, environment and toxicity and regularly counsels her patients to minimize environmental hazards from exogenous pesticides, hormones and hormone analogues, particularly compounds contained in many regular household and cosmetic items. She can be reached at drmarianne@inspired-health.ca

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