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Effects of Mobile Phones on Children's and Adolescents' Health: A Commentary

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The use of digital technology has grown rapidly during the last couple of decades. During use, mobile phones and cordless phones emit radiofrequency (RF) radiation. No previous generation has been exposed during childhood and adolescence to this kind of radiation. The brain is the main target organ for RF emissions from the handheld wireless phone. An evaluation of the scientific evidence on the brain tumor risk was made in May 2011 by the International Agency for Research on Cancer at World Health Organization. The scientific panel reached the conclusion that RF radiation from devices that emit nonionizing RF radiation in the frequency range 30 kHz–300 GHz is a Group 2B, that is, a “possible” human carcinogen. With respect to health implications of digital (wireless) technologies, it is of importance that neurological diseases, physiological addiction, cognition, sleep, and behavioral problems are considered in addition to cancer. Well-being needs to be carefully evaluated as an effect of changed behavior in children and adolescents through their interactions with modern digital technologies.

It takes a multidisciplinary professional community to produce this special section. It is a fruitful pairing to include articles from both child development and the bioelectromagnetics community, which gives an overview of the extensive scientific and public health knowledge on this topic. With respect to health implications of digital (wireless) technologies, it is of the utmost global importance in this conversation that cancer and neurological diseases, in addition to physiological addiction, cognition, sleep, and behavioral problems, be reported.

The use of digital technology has grown rapidly during the last couple of decades. During use, mobile phones emit radiofrequency (RF) radiation, and no previous generation has been exposed during childhood and adolescence to this kind of radiation. The extent and severity of long-term health risks in total are not yet observable as brain tumors, other cancers, and neurological diseases (neurodegenerative diseases) often take decades to appear.

Cancer risks for glioma and acoustic neuroma from mobile phone use are already epidemiologically visible, and that should warn us that this looks to be a very effective carcinogen to act so quickly in terms of observable increases in cancer risk. When the wireless phone is used, the brain is the major target organ of RF radiation which has given rise to a concern for an increased risk for brain tumors. This fact prompted the International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) in May 2011 to evaluate current knowledge. The scientific panel reached the conclusion that RF radiation in the frequency range 30 kHz–300 GHz is a Group 2B possible human carcinogen (IARC 2013). The IARC decision on mobile phones was based mainly on case-control human studies by the Hardell group from Sweden and the IARC Interphone study (for overview, see the IARC Monograph, 2013). These studies provided supportive evidence of increased risk for brain tumors, that is, glioma and acoustic neuroma. Further research has strengthened the increased risk (Coureau et al.,

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2014; Hardell & Carlberg, 2015; Hardell, Carlberg, Söderqvist, & Hansson Mild, 2013).

Of large interest is the report released in 2016 from the National Toxicology Program under the National Institutes of Health in the United States on the largest ever animal study on cell phone RF radiation and cancer (Wyde et al., 2016). An increased incidence of glioma in the brain and malignant schwannoma in the heart was found in rats. Acoustic neuroma or vestibular schwannoma is a similar type of tumor as the one found in the heart, although benign. Thus, these results corroborated findings in human epidemiological studies. Wireless phone use and glioma risk were recently evaluated using the Bradford Hill viewpoints from 1965 on association or causation (Carlberg & Hardell, 2017).

As evidenced in this special section, mobile phone technologies integrate functions that broadly include communication, information, and computation. High-quality cameras and video capabilities expand daily uses for personal and business use. Mobile phones incorporate many other handy functions like GPS, web surfing, gaming, sensors, daily planners, calculators, flashlights, and Internet connections for e-mail and texting that have enabled people to rely on just one critical device rather than several. The almost constant use by adults has pattered children to see the mobile phone as an integral part of daily life. Adults often pacify very young children by giving them a mobile phone as a toy or distraction, which reinforces how integral they will later become to the developing child and adolescent.

Previous Research

Among the earliest studies on brain tumor risk associated with use of wireless phones were epidemiological studies from our group in Sweden. A statistically significant increased risk for glioma and acoustic neuroma was found for tumors in the most exposed area of the brain (ipsilateral) to RF radiation from both mobile and cordless phones (Hardell & Carlberg, 2015; Hardell et al., 2013; IARC 2013). Of special concern is that the risk was highest in subjects with first use of the wireless phone before the age of 20 years. Of further concern is that decreased survival of patients with glioblastoma multiforme was associated with long-term use of mobile and cordless phones, with highest hazard ratio in patients with first use before the age of 20 years (Carlberg & Hardell, 2014).

There are few studies on brain tumor risk for children from use of wireless phones. MOBI-Kids is

one study that is ongoing (Sadetzki et al., 2014). A multicenter case-control study included children and adolescents aged 7–19 years. A statistically nonsignificant increased risk for brain tumors among regular users (one call per week for at least 6 months) of mobile phones was found; odds ratio (OR) = 1.36, 95% confidence interval (CI) = [0.92, 2.02]. This OR increased somewhat with cumulative duration of subscriptions and duration of calls (Aydin et al., 2011). No data for long-term use were given; the longest latency period (time from first use until tumor diagnosis) was only 5 years. Further support of a true association was found in the results based on operator-recorded use for 62 cases and 101 controls, which for time since first subscription > 2.8 years yielded a statistically significant OR of 2.15, 95% CI = [1.07, 4.29], with a statistically significant trend ($p = .001$).

Children have smaller heads and thinner skull bone than adults. Their brain tissue has also higher conductivity, and these circumstances give higher absorption from RF radiation than in adults (Gandhi et al., 2012). The developing brain is more sensitive to toxins, and it is still developing until about 20 years of age. The greater absorption of RF energy per unit of time, the greater sensitivity of their brains, and their longer lifetimes with the risk to develop a brain tumor or other health effects leaves children at a higher risk than adults from mobile phone radiation.

The evidence so far poses the following questions: When, where, how, and why do children and adolescents use mobile phones, and what are the health consequences? What are the health consequences of chronic exposure to electromagnetic fields and RF radiation (wireless emissions) from direct use of mobile phones by children? What are the consequences on fetal brain development from in utero maternal use, and how does this affect subsequent memory, learning, language and speech, behavior, and stress responses?

According to the opinion of the Russian National Committee on Non-Ionizing Radiation Protection in a 2008 report to WHO, the following health hazards are likely to be faced by the children mobile phone users in the nearest future: disruption of memory, decline of attention, diminishing learning and cognitive abilities, increased irritability, sleep problems, increase in sensitivity to the stress, and increased epileptic readiness. Expected (possible) remote health risks include brain tumors, tumors of acoustical and vestibular nerves (in the age of 25–30 years), Alzheimer's disease, "got dementia," depressive syndrome, and the other types of degeneration of the nervous

structures of the brain (in the age of 50–60; <http://www.who.int/pehemf/project/mapnatreps/RUSSIA%20report%202008.pdf>).

Disturbed sleep among adolescents seems to be a growing problem, and several reports suggest negative effects from use of mobile phones. Certainly further studies should explore potential adverse health effects from RF radiation. One example is the β -trace protein (lipocalin-type prostaglandin D synthase) that is a key enzyme in the synthesis of prostaglandin D₂, an endogenous sleep-promoting neurohormone. Cumulative use of wireless phones was associated with lower concentrations of β -trace protein in subjects aged 18–30 years, thus indicating a mechanism for cell phone impact on sleep (Söderqvist, Carlberg, Zetterberg, & Hardell, 2012). Results from this study indicate that more research should be aimed at mechanistic studies.

Epigenetics as a new mechanism can account for rapid genetic changes (de novo mutations) that might be linked to the epidemic of neurodevelopmental problems of children including attention deficit hyperactivity disorder and autism. Given the very fast uptake of this technology by children of all ages around the world and the emerging health risks posed by chronic exposure to wireless devices, it is imperative that precautionary warnings be widely circulated now to parents and schools by health professionals with expertise in this subject (Reykjavik Appeal on Wireless Technology in Schools, 2017, see Appendix S1).

Conclusion

Mobile phone addiction and mobile user well-being are two main topics among nearly 100 letters of intent submitted to this special section. These topics are of large importance. Information technology addiction was reported among up to almost 20% students, and the benefits in education are largely unproven (Spitzer, 2014). In addition, urgent and critical issues and challenges have emerged from the daily use of millions of young users and need to be studied timely and effectively, as exemplified in the four studies of this special section on mobile privacy, mobile peer influences, mobile joint attention, and mobile touch screen effects. Even for the well-studied topics such as texting behavior, daily use, mobile bullying, sleeping disturbance, sexting, distracted driving, and radiation effects, much more innovative research efforts are needed to further understand these mobile phone behaviors

among young users, as shown in this the special section.

In addition to the important contributions to the field, the special section shows the need to understand potential serious health threats from digital devices and the wireless technology emissions they produce, as well as the unprecedented effects of changed behavior in children and adolescents that take place through their interactions with mobile phones and other modern digital technologies.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Appendix S1. Reykjavik Appeal on Wireless Technology in Schools, 2017