Pre- and post-natal exposure to wireless radiation may impair child neurodevelopment

Electromagnetic Radiation Safety
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Part 1: Prenatal exposure to cell phone radiation interacts with maternal blood lead levels contributing to neurodevelopmental delays and ADHD in children

The results of this neurodevelopmental study help explain the results of a behavioral study published by Byun and colleagues in 2013.

Neurodevelopment for the first three years following prenatal mobile phone use, radio frequency radiation and lead exposure

Kyung-Hwa Choi, Mina Ha, Eun-Hee Ha, Hyesook Park, Yangho Kim, Yun-Chul Hong, Ae-Kyoung Lee, Jong Hwa Kwon, Hyung-Do Choi, Nam Kim, Suejin Kim, Choonghee Park. Neurodevelopment for the first three years following prenatal mobile phone use, radio frequency radiation and lead exposure. Environmental Research, 156:810-817, July 2017.

Highlights

• RFR exposure was measured by mobile phone use questionnaire and 24-h personal exposure meter among pregnant women.
• Child neurodevelopment was assessed by trained examiners at 6, 12, 24, and 36 months of age.
• Associations were not observed between prenatal exposure to RFR and child neurodevelopment during the first three years.
• A potential combined effect of prenatal exposure to lead and mobile phone use was suggested.

Abstract

Background Studies examining prenatal exposure to mobile phone use and its effect on child neurodevelopment show different results, according to child's developmental stages.

Objectives To examine neurodevelopment in children up to 36 months of age, following prenatal mobile phone use and radiofrequency radiation (RFR) exposure, in relation to prenatal lead exposure.

Methods We analyzed 1198 mother-child pairs from a prospective cohort study (the Mothers and Children's Environmental Health Study). Questionnaires were provided to pregnant women at ≤20 weeks of gestation to assess mobile phone call frequency and duration. A personal exposure meter (PEM) was used to measure RFR exposure for 24 h in 210 pregnant women. Maternal blood lead level (BLL) was measured during pregnancy. Child neurodevelopment was assessed using the Korean version of the Bayley Scales of Infant Development-Revised at 6, 12, 24, and 36 months of age. Logistic regression analysis applied to groups classified by trajectory analysis showing neurodevelopmental patterns over time.

Results The psychomotor development index (PDI) and the mental development index (MDI) at 6, 12, 24, and 36 months of age were not significantly associated with maternal mobile phone use during pregnancy. However, among children exposed to high maternal BLL in utero, there was a significantly increased risk of having a low PDI up to 36 months of age, in relation to an increasing average calling time (p-trend=0.008). There was also a risk of having decreasing MDI up to 36 months of age, in relation to an increasing average calling time or frequency during pregnancy (p-trend=0.05 and 0.007 for time and frequency, respectively). There was no significant association between child neurodevelopment and prenatal RFR exposure measured by PEM in all subjects or in groups stratified by maternal BLL during pregnancy.

Conclusions We found no association between prenatal exposure to RFR and child neurodevelopment during the first three years of life; however, a potential combined effect of prenatal exposure to lead and mobile phone use was suggested.

https://www.ncbi.nlm.nih.gov/pubmed/28511138

Excerpts

... a study showing that child mobile phone use increases the risk of attention deficit hyperactivity disorder (ADHD) in children, particularly among those with high blood lead levels (BLL), suggests an effect modification of blood lead level in association with RFR exposure due to mobile phone use and child neurodevelopment (Byun et al., 2013). However, a possible interaction effect of prenatal RFR exposure and lead on neurodevelopment has not been examined.

... Heavy mobile phone use was defined as making ≥6 mobile phone calls per day or using a mobile phone ≥30 min per day. Several months of call data obtained by participants in the present study from their respective telecommunication companies showed moderate-to-high correlations with the questionnaire information about mobile phone use (correlation coefficient, 0.50–0.60) (Choi et al., 2016).

The exposure meter detects 10 different bands of frequency ranging from 88 MHz to 2.17 GHz, such as FM, TV7, TETRA, TV47, uplink and downlink of CDMA, uplink and downlink of PCS, and uplink and downlink of IMT-2000, with electric field strength ranging from 0.05 to 5.0 V/m.

BLLs were dichotomized, according to the 75th percentile (1.69 and 1.61 μg/dL), for analysis of mobile phone use and RFR by PEM, respectively.

Of the subjects, 30.9% used a mobile phone ≥6 times per day and 12.1% used a mobile phone for ≥30 min per day.

The median (range) PEM measurement in 210 pregnant women was 5.0 (1.0–122.0)×10−5 V/m for the total exposure index, and 2.4 (0.3–119.3)×10−5 V/m for the exposure index of mobile communication, with a skewed distribution to the right (data not shown).

Among children of mothers with higher BLLs during pregnancy, more prenatal maternal mobile phone use was more likely to be associated with having decreasing MDI over time (calling frequency: p-trend=0.007; calling time: p-trend=0.05) or maintaining a low level of PDI over time (calling time: p-trend=0.008). However, children of mothers with lower maternal BLLs during pregnancy showed significantly decreasing patterns of risk, having decreasing MDI over time (p-trend=0.01) or having low PDI over time (p-trend=0.04), in association with an increase of maternal mobile phone use during pregnancy (Table 3). The association between prenatal maternal mobile phone use and the risk of decreasing MDI was modified significantly by prenatal maternal BLL (p-interaction<0.02).

MDI and PDI scores at 6, 12, 24, or 36 months of age were not significantly associated with RFR exposure measured by PEM in all children, and in those of mothers with both low and high maternal BLL during pregnancy (Table 4).

After stratification with prenatal maternal BLL, we found significant contrasting trends between the lower and the higher maternal BLL group; the latter showed a significantly increased risk of having poor or delayed neurodevelopment up to 36 months of age in association with maternal mobile phone use during pregnancy. A previous study reported possible modifying effects of lead exposure in children, although it was not in utero exposure, in relation with mobile phone use and the risk of ADHD in children (Byun et al., 2013). In addition, lead is a well-known neurotoxicant in the developing brain (Jedrychowski et al., 2009; Kim et al., 2013; Liu et al., 2014 ; Vigeh et al., 2014). These studies suggest that prenatal RFR exposure due to maternal mobile phone use and simultaneous exposure to lead have synergistically adverse effects on the neurodevelopment of children. A neuro-protective effect in children of women with low BLL during pregnancy, particularly with regard to calling frequency, may be due to unknown confounding factors, such as the child rearing environment.

Multiple biological mechanisms of the effects on the brain of infants exposed to RFR in utero have been proposed. First, RFR exposure creates an energy transfer, which increases the permeability of the blood brain barrier (BBB) to macromolecules (Stam, 2010). Even though RFR energy from the mother's mobile phone use or holding a mobile phone near the body would be at a very low level when it reaches the fetal brain (Varsier et al., 2014), the immature fetal BBB may be susceptible. Alongside this, an increased level of lead in cord blood, which is a well-known neuro-toxicant, could transfer to the fetal brain, resulting in adverse neurodevelopmental effects. In addition, lead in maternal blood crosses the blood placenta barrier (BPB) and enters the cord blood (Goyer, 1990). It is also conceivable that more lead crosses the BPB if RFR energy increases the permeability of the BPB as well. However, there have not been studies on RFR effects on the BPB.

Secondly, RFR exposure appears to disrupt the release of melatonin from the pituitary gland, which may affect metabolic and/or sex hormones of the pregnant mother and affect fetal brain development (Hocking, 2009). In the present study, however, we did not observe any significantly different findings between sexes, which does not offer support from this study for a hypothesis of sex hormone involvement (data not shown). Lastly, RFR exposure may also affect fetal stem cells, including future neuronal cells (Bellieni and Pinto, 2012). Although interesting, none of these hypotheses have been confirmed to date (Feychting, 2011).

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This 2013 study found that among pregnant mothers with elevated blood lead levels, the amount of mobile phone use during pregnancy predicted the likelihood their children had symptoms of ADHD.

Mobile phone use, blood lead levels, and attention deficit hyperactivity symptoms in children: a longitudinal study

Byun YH, Ha M, Kwon HJ, Hong YC, Leem JH, Sakong J, Kim SY, Lee CG, Kang D, Choi HD, Kim N. Mobile phone use, blood lead levels, and attention deficit hyperactivity symptoms in children: a longitudinal study. PLoS One. 2013;8(3):e59742. doi: 10.1371/journal.pone.0059742.

Abstract

BACKGROUND: Concerns have developed for the possible negative health effects of radiofrequency electromagnetic field (RF-EMF) exposure to children's brains. The purpose of this longitudinal study was to investigate the association between mobile phone use and symptoms of Attention Deficit Hyperactivity Disorder (ADHD) considering the modifying effect of lead exposure.

METHODS: A total of 2,422 children at 27 elementary schools in 10 Korean cities were examined and followed up 2 years later. Parents or guardians were administered a questionnaire including the Korean version of the ADHD rating scale and questions about mobile phone use, as well as socio-demographic factors. The ADHD symptom risk for mobile phone use was estimated at two time points using logistic regression and combined over 2 years using the generalized estimating equation model with repeatedly measured variables of mobile phone use, blood lead, and ADHD symptoms, adjusted for covariates.

RESULTS: The ADHD symptom risk associated with mobile phone use for voice calls but the association was limited to children exposed to relatively high lead.

CONCLUSIONS: The results suggest that simultaneous exposure to lead and RF from mobile phone use was associated with increased ADHD symptom risk, although possible reverse causality could not be ruled out.

Open Access Paper:
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0059742

Excerpts

Studies have shown cognitive impairment in rats related to RF EMF exposure from mobile phones [8] and hyperactive and impaired memory in mice exposed to mobile phone RF during fetal period [9]. Increased behavioral problems including hyperactivity and conduct problems in children with perinatal exposure to mobile phones have also been reported [5-6], but no studies have shown an association between prenatal exposure to mobile phones and neurodevelopmental delays in younger children [10-11].

The neurotoxicity of lead includes demyelination or hypomyelination of neurons, death of brain cells through apoptosis and excitotoxicity, and disruptive effects on the dopaminergic system [12]. Children exposed to relatively low levels of lead have inattention [13], cognitive loss [14] and may develop Attention Deficit Hyperactivity Disorder (ADHD) [15-16].

The blood brain barrier (BBB) is an intricate hydrophobic barrier formed by vascular endothelium of cerebral capillaries with tight junctions between these endothelium cells and plays a pivotal role maintaining homeostasis of the central nervous system by protecting the brain from potentially harmful substances in the blood through strict control of selective diffusion [17-21]. A debate is ongoing over the effect of RF EMF exposure on BBB permeability. Numerous studies have reported no changes in BBB permeability after exposure to RF EMF [17], [22], [23]; changes in permeability (if present) have been attributed to an increase in temperature-induced blood flow [17], [20], [24], [25]. However, other studies [19], [26-29] have consistently reported increased BBB permeability after exposure to EMF.

ADHD is a behavioral syndrome that is usually diagnosed early in childhood and is characterized by impaired behavioral inhibition, inattention, and physical restlessness [30-31]. Despite the heterogeneous nature of ADHD, dysfunction of the dopamine modulated frontostriatal circuit of the brain is regarded as one of the core mechanisms associated with ADHD [30-32].

Subjects

CHEER recruited mostly first-grade students from elementary schools in 2005 and 2006 and followed them biennially to 2009 and 2010 ... All participating children underwent physical examinations and clinical tests. Among a baseline cohort of 7,059 children in CHEER, 2,516 children whose parents or guardians responded to the questionnaire about children’s mobile phone use, which was administered initially in 2008, were eligible for the present study. A total of 2,422 children were analyzed after excluding children with incomplete information on the questionnaire or an absence of blood lead levels (Fig. 1). The 2008 survey was primarily aimed to follow-up children who were enrolled in the CHEER study in 2006 (average participation rate, 85%) and the follow-up rate in 2008 was 75.6 % (2,193 of 2,899). The newly enrolled 269 children in 2008 from the study schools were not asked to participate but volunteered.

Information on Mobile Phone Use

Information on mobile phone use was obtained from the questionnaires administered to parents or guardians in 2008 and 2010, i.e., the ownership of a mobile phone by children (no, yes), mobile phone accessibility (do not own or use a mobile phone, do not own a mobile phone but use others own a mobile phone), age when first owned a mobile phone (11, 10, 9, 8 years old), monthly mobile phone bill (<20, 20–24, 25 10^3 KRW, 1 USD equals approximately 1,300 KRW as of 2008, 12, 22), average time of mobile phone use per day (no use, <30, 30 minutes), number of received (outgoing) calls per day (no use, 1–2, 3), average time spent per voice call (no use, <30 seconds, 30 seconds to <1 minute, 1 minute), number of received (sent) text messages a day (no use, 1–2, 3), average time spent playing games on a mobile phone per day (no use, <3, 3 minutes), and use of the Internet on a mobile phone (no, yes).

We created a variable of cumulative time spent for voice calls using their own mobile phone (0, <30, 30–69, 70 hours) using four variables: number of received calls per day plus the number of outgoing calls per day (input 0, 1.5, and 4.5 calls for each category, consecutively) and then multiplied by the average time spent per voice call (input 0, 15, 45, and 105 seconds for each category, consecutively) and duration of mobile phone owned (attained age minus age for first mobile phone). Children who did not own but used someone else’s mobile phone were excluded from creating this variable because of a lack of information for duration of mobile phone use among them.

Statistical Analysis

To examine the association between mobile phone use and ADHD symptoms considering blood lead levels in children, logistic regression analyses were performed at each time point of 2008 and 2010 and the repeatedly measured data from October–November 2008 and October–November 2010 were analyzed using the GEE. The adjusted odds ratios of positive ADHD symptoms and 95% confidence intervals associated with mobile phone use (as time-varying variables in the GEE model) were estimated, adjusted for age, gender, number of siblings, residential area, household income, maternal smoking during pregnancy, child’s history of neuropsychiatric illness, parental marital status, parental history of neuropsychiatric disease (as time-independent covariates in the GEE model), and blood lead levels (as time-varying variables in the GEE model). The p-value for the trend was calculated using the ordinal scale of the mobile phone use variable in the corresponding model.

Analyses were repeated after stratification by blood lead level (cut-off of 2.35 μg/dl; upper 75% point of the distribution of the higher one of two blood lead values measured in 2008 and 2010). The p-values for multiplicative interactions were estimated using the corresponding models including the interaction term to examine the modifying effect of blood lead on the association between mobile phone use and ADHD symptom. The analyses were performed again using the model simultaneously adjusted for three mobile phone use variables, i.e., age at first ownership of a mobile phone, average time spent per voice call, and average time spent playing games. All significance tests were two sided at the 0.05 level, and the analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC, USA).

Results

Study Population and Mobile Phone Use Pattern (Longitudinal Study)

The prevalence of ADHD symptoms in the present study was 10.4% in 2008 and 8.4% in 2010 (Table 1). Ownership of a mobile phone increased almost three times and the cumulative time spent for voice call use increased almost two times over 2 years. The geometric mean (geometric standard deviation) level of blood lead decreased slightly for the 2 years. Very few mothers smoked cigarettes during pregnancy and 1.4% of parents had a history of neuropsychiatric disease (Table 1).

Adjusted for Lead Exposure

Table 2 shows the results of analyses adjusted for several covariates and blood lead on the association between mobile phone use and ADHD symptom for each time point and combined with data of two time points. Ownership of a mobile phone, age at first ownership of a mobile phone, and text message mobile phone use was not associated with ADHD symptoms. **Voice-call use variables (number of outgoing calls per day, average time spent per voice call, and cumulative time spent for voice calls) showed increased risks for ADHD symptoms according to increasing mobile phone exposure. In particular, statistical significance was observed for ADHD symptom risk and dose-response trends for number of outgoing calls per day and average time spent per voice call. Mobile phone use for playing games or internet use was significantly associated with ADHD**

symptoms. Compared to the unadjusted models, the models adjusted for several covariates and blood lead level showed a higher risk for ADHD symptoms in the voice-call use variables, whereas the estimated risk for ADHD symptoms did not change substantially between models for other kinds of mobile phone use, i.e., games or internet. A significant confounding effect of blood lead was observed between ADHD symptoms and voice call use but not other kinds of mobile phone use.

Stratified by Lead Exposure

In the stratified analysis by blood lead level (Table 3), **the variables of voice call use (number of outgoing calls per day, average time spent per voice call, and cumulative time spent for voice calls) showed significant associations and/or trends only in children with a high blood lead level. In contrast, use of a mobile phone for playing games or using the internet was significantly associated with ADHD symptoms only in children with a low blood lead level.** Mobile phone ownership, age at first ownership, and text message use were not significantly associated with low or high blood lead levels in either group. Multiplicative interaction tests between mobile phone exposure and blood lead in association with ADHD symptoms were significant or borderline significant for the variables of ownership, age at first ownership of a mobile phone, and the number of outgoing calls per day, and the risk of ADHD symptoms was higher in the high lead group than that in the low lead group.

Discussion

This study showed that voice call mobile phone use was associated with increased ADHD symptom risk in a dose-response manner, but only in children with a high blood lead level. However, playing games on a mobile phone was associated with ADHD symptoms in a dose-response manner regardless of blood lead level and was statistically significant in children with a low blood lead level.

The finding that voice call mobile phone use was associated with ADHD symptoms supports the hypothesis that RF exposure to children's heads from mobile phone use increases their vulnerability to lead exposure and ADHD, i.e., possible modifying effects of blood lead on the association between RF exposure from mobile phone use and ADHD symptoms. In contrast, the increased risk in children who spent more time playing games on a mobile phone suggested that such behavior might be as a consequence of ADHD, i.e., reverse causality, or might be one of the risk factors for ADHD-like symptoms [34] rather than the effect of RF exposure to the brain.

The present study used prospectively and repeatedly measured data about mobile phone use, blood lead, and prevalent ADHD symptoms over time. However, the causal time direction from RF exposure to the effects could not be validated in the present study because the ADHD symptoms were not newly developed during the 2 year study period, i.e., mobile phone use might not be an initiating factor for ADHD symptoms and the possibility of reverse causality still remained.

Mobile phone use (voice call use with simultaneous exposure to lead and mobile phone use to play games independently with lead exposure) may aggravate or sustain the ADHD symptoms. In the present study population, the decreasing rate of ADHD symptom prevalence for 2 years was much higher among children who quit mobile phone use compared to the average decreasing rate (2.0%) in all children: 7.1 and 7.5% in quitters for voice call use and mobile phone use for playing games, respectively (Fig. 2). Therefore, preventing the use of mobile phones in children may be one measure to keep children from developing ADHD symptoms regardless of the possible roles of mobile phone use in ADHD symptoms, i.e., whether potentiating the effect of lead exposure due to RF exposure and voice calls or behavioral aggravation due to high rates of playing games on a mobile phone.

Lead affects heme synthesis and, thus, has an adverse effect on mitochondria that use heme-containing enzymes. This causes significant damage to the BBB that possesses abundant mitochondria and requires a copious supply of ATP [38]. Breakdown of the BBB increases the permeability of lead flowing in the bloodstream and brain parenchyma. Furthermore, lead passes through the BBB through a Ca-ATPase pump [12].

The possible effect of RF EMF's on the BBB by increasing permeability has been inconsistently reported [39]. In addition, increasing blood flow in the brain induced by thermal effects of EMF continues to be debated with positive [40-41] or negative effects [42-43]. Furthermore, meta-analyses of human experimental studies show that EMFs emitted by mobile phones have a small impact on human attention and working memory [44], but no effect on human cognitive performance [45] or cognitive and psychomotor function [46].

An epidemiological study showed a relationship between exposure and health outcome and did not necessarily consider the usually long causal chain and molecular or biological mechanisms in the pathway from exposure to health outcome [47]. Our results suggest that exposure to RF associates with increased ADHD symptom risk with simultaneous exposure to lead, and that RF exposure alone may have a weak or no effect on ADHD symptoms, i.e., a combined or cooperative toxic action of RF and lead on the developing brain. Future studies are needed to confirm this hypothetical mechanism.

Conclusion

The results showed an increased risk for ADHD symptoms in association with heavier voice call mobile phone use among children exposed to lead. Further prospective studies to repeat these findings including incident ADHD cases and to elucidate the possible biological mechanisms are needed.

My Note: High blood level = 2.34 microgram/dl or more (upper quartile). In the high lead exposure group (N=600), significant OR's for 3 or more outgoing calls/day (2.46), 1 minute or more avg time/call (2.82), 70 or more cumulative hours for voice calls (2.50). Also p-trend was significant for all analyses except marginal for cumulative time.

Also see: Pregnancy & Wireless Radiation Risks

Part 2: “Contemporary Mobile Technology and Child and Adolescent Development"

The journal, ***Child Development***, recently published several papers online for a special section, “**Contemporary Mobile Technology and Child and Adolescent Development**,” edited by Zheng Yan and Lennart Hardell. Two papers focus on the health risks from exposure to the electromagnetic fields (EMF) produced by this technology.

Cindy Sage and Ernesto Burgio discuss the epigenetic research that accounts for some of the neurodevelopmental and neurobehavioral changes found with exposure to wireless technology. They cite recent studies which found harmful effects on memory, learning, cognition, attention, and behavioral problems as a result of EMF and radio frequency (RF) radiation exposure. They argue that both epigenetic drivers and genetic damage are likely contributors. The authors recommend adoption of wired devices for education to avoid health risks.

Lennart Hardell prepared the commentary for this section of the journal. He notes that no previous generation has grown up with cell phones and cordless phones, and that the brain is the main organ exposed to the RF radiation emitted by wireless phones. He discusses the World Health Organization's classification of RF radiation in 2011 as a "possible" human carcinogen as well as other health implications of wireless technology including neurological diseases, physiological addiction, cognition, sleep, and behavioral problems.

Child Development has published original contributions on topics about child development from the fetal period through adolescence since 1930. Its readership includes psychiatrists and psychologists, educators, and social workers as well as researchers and theoreticians.

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Yan, Z. (2017), Child and Adolescent Use of Mobile Phones: An Unparalleled Complex Developmental Phenomenon. Child Dev. doi:10.1111/cdev.12821

http://onlinelibrary.wiley.com/doi/10.1111/cdev.12821/full

Abstract

This article addresses why children's use of mobile phones is an unparalleled complex developmental phenomenon in hopes of providing a broad context for this special section. It first outlines mobile phones as a sophisticated personalized and multifunction technology. Then it presents mobile phone use by children as an unparalleled complex developmental phenomenon on the basis of its four behavioral elements, two mobile cultures, and two developmental processes. It further illustrates the existing knowledge about children's mobile phones use that has been accumulated over the past 23 years and highlights 12 most studied topics, especially distracted driving and radiation exposure. It concludes with three types of scientific contributions made by the 12 articles in the special section.

Excerpts

Sage and Burgio's (in this section) review on child radiation exposure features a variety of the latest bioelectromagnetic findings and epigenetic discussions, two major contributions in synthesizing the existing literature. Although the materials covered are highly technical, the authors as two bioelectromagnetic scholars have worked diligently to make the review highly accessible to a wide readership through a traditional narrative review, a still-dominant review genre in the field of bioelectromagnetics. More importantly, the review for the first time synthesized the extensive literature on the harmful health effects of electromagnetic fields and radiofrequency radiation on children's neurodevelopmental and neurobehavioral changes from a new perspective of epigenetics, a novel approach that is coincidently the theme of another special section recently published in *Child Development* (Lester, Conradt, & Marsit, 2016). As a result, it helps us understand the particular importance and tremendous complexity of examining radiation exposure from the novel epigenetic perspective rather than only from the typical behavioral or neurological perspective. It also suggests promising research programs investigating epigenetic markers related to radiation exposure in child development and child health disease."

Hardell, Carlberg, and Hansson (2011) is among the earliest studies on brain tumors and mobile phone use among youth. In this study conducted by three Sweden researchers in oncology and radiation physics, the case–control design was used to compare the group of "case" (subjects who have a disease) and the group of "control" (subjects who do not have the disease but are otherwise similar) to examine the potential link of a possible risk factor and a disease. With 1,251 cases and 2,438 controls in the study, they found that (a) overall, the mobile phone users had 1.3 times more likely to have malignant tumors than the control group; (b) the highest risk was found among those who had the largest latency period of > 10 years or the longest cumulative life time use of > 200 h, with 2.5–3.0 times more likely to have malignant tumors than the control group; and (c) the highest risk was also found among those who were the youngest group (< 20 years old), with 2.9 times more likely to have malignant tumors than the control groups. Hardell and his collaborators have published nearly 50 articles covering different aspects of this topic. The 22-year extensive research conducted in this area, as exemplified in the Hardell, Carlberg, and Hansson article, has cumulated substantial evidence and helped the WHO's International Agency for Research on Cancer (IARC) to classify mobile phone use and other radiofrequency electromagnetic fields as Group 2B, possibly carcinogenic to humans (IARC, 2011) based on IARC's four-group classification of carcinogens (i.e., Group 1 carcinogenic, Group 2A probably carcinogenic, Group 2B possibly carcinogenic, Group 3 unclassifiable, and Group 4 probably not carcinogenic). Considering the critical importance, technical complexity, and extensive literature on this topic, Lennart Hardell will write an expert comment to end on a high note for this special section.

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Sage C, Burgio E. Electromagnetic Fields, Pulsed radiofrequency radiation, and epigenetics: How wireless technologies may affect childhood development. Child Development. Published online May 15, 2017.

Abstract

Mobile phones and other wireless devices that produce electromagnetic fields (EMF) and pulsed radiofrequency radiation (RFR) are widely documented to cause potentially harmful health impacts that can be detrimental to young people. New epigenetic studies are profiled in this review to account for some neurodevelopmental and neurobehavioral changes due to exposure to wireless technologies. Symptoms of retarded memory, learning, cognition, attention, and behavioral problems have been reported in numerous studies and are similarly manifested in autism and attention deficit hyperactivity disorders, as a result of EMF and RFR exposures where both epigenetic drivers and genetic (DNA) damage are likely contributors. Technology benefits can be realized by adopting wired devices for education to avoid health risk and promote academic achievement.

Conclusions

Public health implications of wireless technologies are enormous because there has been a very rapid global deployment in homes, education, transportation, and health care in the last two decades. Even a small risk from chronic use wireless technologies may have a profound global health impact. Impacts on the fetus via parental exposures to wireless devices preconception and during in utero development, infant rearing (baby monitors, wireless surveillance, Wi-Fi routers, DECT cordless phones, etc.), and childhood preschool and academic environments all may contribute in incremental ways to a perpetually saturated habitat of wireless emissions, and health impacts from the chronic, stressful body burden of EMF and RFR.

The wide array of pathophysiological effects of EMF and RFR exposures from wireless sources do not require "the breaking of molecular bonds" as done by ionizing radiation in order for physiologically damaging effects to occur. Epigenetic mechanisms alone can change fetal development in profound ways, disrupting health by causing changes in gene activation and expression without change in gene sequences. Environmental epigenetic influences in the fetal and neonatal development (i.e., epigenetic regulation of genes rather than direct genetic effects by gene mutation) have been plausibly established to cause pathophysiological changes that can result in altered neurological development. Symptoms of neurodevelopmental problems in children like retarded memory, learning, cognition, attention, and behavioral aberrations that are similarly expressed in autism and ADHD have been reported in numerous scientific studies to occur as a result of EMF and RFR exposures, where epigenetic drivers are the most likely causes, and persistent exposures contribute to chronic dysfunction, overwhelming adaptive biological responses.

Electronic educational technologies have not resulted in better academic achievement globally and lend support to scientific studies showing adverse health and developmental impacts (OECD, 2015). Reductions in preventable exposures to EMF and RFR should be a top public health and school district priority. Technology benefits can be realized by adopting wired devices for education, to avoid health risk and promote academic achievement. Wider recognition that epigenetic factors are a plausible mechanism for EMF/RFR to regulate expression of DNA and thus impact child development is a critical need. Whether future research can identify safe levels of wireless exposures is unknown, but further investigation of epigenetic markers related to EMF/RFR exposure in child development and disease is warranted.

http://onlinelibrary.wiley.com/doi/10.1111/cdev.12824/abstract

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

Lennart Hardell. Effects of Mobile Phones on Children's and Adolescents' Health: A Commentary. Child Development. Published online May 15, 2017.

Abstract

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.

http://onlinelibrary.wiley.com/doi/10.1111/cdev.12831/abstract

Excerpts

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.

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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"Contemporary Mobile Technology and Child and Adolescent Development" Papers

Electromagnetic Fields, Pulsed Radiofrequency Radiation, and Epigenetics: How Wireless Technologies May Affect Childhood Development (Cindy Sage, Ernesto Burgio) 2017-05-15 07:06:18.804771

Effects of Mobile Phones on Children's and Adolescents' Health: A Commentary (Lennart Hardell) 2017-05-15 07:05:49.091169

Child and Adolescent Use of Mobile Phones: An Unparalleled Complex Developmental Phenomenon (Zheng Yan) 9 MAY 2017 DOI: 10.1111/cdev.12821

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