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Stephanie Santos
Dominican University of California

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Stephanie Santos, PA-S

PA 5650

Dominican University of California

Abstract

This study explored the possible adverse outcomes of cell phone use during the prenatal period. Previous literature has lacked in the analysis of all the potential adverse outcomes of cell phone use during pregnancy. This gap in literature, is needed to determine if a reduction in cell phone usage during pregnancy should be recommended in future clinical practices. For my research, I reviewed three published studies that have been done on cell phone use during pregnancy. These studies include the potential adverse effects in causing ADHD, developmental milestone delays, and low birth weights in children. Of the three studies analyzed, it was found that medium (2-3 calls/day), and high frequency usage (≥ 4 calls/day), had an Odds Ratio (OR) of 1.28 times the risk for having a child with Attention-deficit/Hyperactivity disorder, compared to low frequency usage (0-1calls/day). Furthermore, research shows no correlation between cell phone use during pregnancy and cognitive/language or motor developmental delays at the age of 18-months or low birth weights among infants. While there appears to be some evidence demonstrating a potential link between cell phone use during pregnancy, and increased risk of having a child with ADHD, more research needs to be conducted prior to recommending cell phone usage reductions during pregnancy.

Introduction

Attention deficit hyperactivity disorder is one of the most common neurodevelopmental disorders of childhood (Center for disease control and prevention, 2019). It is a brain disorder that is defined by a pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development (Diagnostic and Statistical Manual of Mental Disorders, 5th edition). Inattention can be described as person whom has difficultly sustaining attention, wanders off, or is disorganized. Hyperactivity and impulsivity are categorized as excessive talking or fidgeting, or excessive interruption of others (The National Institute of Mental Health, 2016). The child often exhibits both inattention and hyperactivity/impulsivity, that can continue throughout adolescence and adulthood. In 2016, it was estimated that 6.1 million children were diagnosed with ADHD, with an age range of 2-17 years old being the most common ages for diagnoses (Center for disease control and prevention, 2019). According to the CDC, boys are three times more likely to be diagnosed with ADHD than girls. This is because girls present their symptoms differently, which can make diagnosing the condition more difficult.

Unfortunately, researchers are not certain on what causes ADHD; however, they do propose some possible risk factors that include, hereditary causes, environmental causes such as, cigarette and alcohol use during pregnancy, or exposure to toxins during pregnancy. Another possibility is low birth weight, or brain injuries (The National Institute of Mental Health, 2016). Although there is no cure for ADHD, there are current medications such as stimulants and non-stimulants, and therapies that include psychotherapy, and education and training that can help alleviate the symptoms associated with the disorder. Not only does this disorder affect children, it affects their parents, and the healthcare system financially. Two studies in *The Journal of the American*

Academy of Child & Adolescent Psychiatry, indicate the average direct cost that a parent incurs per patient is $1,574, plus $2,278 a year for family members when indirect costs like productivity losses are taken into account. Furthermore, overall national annual costs are a staggering 143 to 266 billion dollars.

The possible concerns with the use of cell phones during pregnancy, stems from how a wireless device actually operates. Cell phones emit a type of radiofrequency radiation, called radio waves. This is a form of non-ionizing radiation that is emitted from their antennas. The radio waves are transmitted to a base tower, which then transmit that signal to the person on the other line (Wang, 2014). Also, the antennas are used to pick up signals such as, Wi-Fi from nearby internet devices. According to Ng, the antennas submit non-ionizing radiation, which usually interacts with tissue through the generation of heat. While the body can absorb this non-ionizing radiation, its hazards to the body depend on the ability to penetrate, and the absorptive characteristics of the various types of tissues. Therefore, researchers are unsure of its effects to the body, and the potential issues that could arise. Moreover, since the year 2000, the number of cell phone subscribers has increased from 109 million to 400 million in 2017 (Cellular Telecommunications and Internet Association, 2017). The exposure of non-ionizing radiation that one receives depends on such factors as, frequency of use, length of use, and duration of use. Additionally, these factors are used in studies to determine the potential side effects of cell phone radiation during pregnancy, which may potentially cause neurocognitive disorders such as, ADHD, developmental milestone delays or adversely affect infant birth weights.

Methods

Materials:

In this study, a search was conducted using the Iceberg database within Dominican University of California Library. The articles were narrowed down by using the phrases “Cell phone use and low birth weight”, and “Cell phone use and behavioral problems in young children”. The articles selected contained previous studies specific to my research. These studies included research on cell phone use and developmental milestones, cognitive delays, and low birth weight. The three research studies I chose for my best practices design were, *Maternal cell phone use during pregnancy and child behavioral problems in five birth cohorts,* by Birks et al., 2017. *Prenatal cell phone use and developmental milestone delays among infants,* by Divan et al., 2011., and *Association of excessive mobile phone use during pregnancy with birth weight: an adjunct study in Kumamoto of Japan Environment and Children’s Study,* by Xi et al., 2017.

Birks et. al. (2017) studied 317 cases from 1996 to 2008. This included study five cohorts from the various countries of Denmark, Korea, Netherlands, Norway, and Spain. The cohorts were further broken down into frequency of calls made or received for the day, categorized as; none, low (0-1 calls/day), medium (2-3 calls/day), and high (≥ 4 calls/day). Child behavioral problems were assessed by mothers at the ages of 5 through 7 using either the Strengths and Difficulties Questionnaire or Child Behavior Checklist, and were classified into the borderline/clinical and clinical ranges.

Divan et al. (2011) conducted research on developmental milestones in a Danish cohort of patients 1996 to 2002, which a total of 41,541 cases. Data was collected via a total of four

telephone interviews, two during their pregnancy, and two at the ages of 6 months and 18 months. Questions given during the last two interviews were developed by child neuropsychologist using validated instruments to assess the child's "motor, cognitive, and language milestone delays as reported by the mother" (Divan et al., 2011). The 18-month interview included a total of 20 questions, 14 of these pertaining to their motor development, and the remainder 6 pertaining to their cognitive and language development. Motor criteria was scored from 0-5 points, and cognitive & language from 0-6 points, assigning 1 point for each "no" answer given by the mother. They defined a "delay" for infants whom had a score for motor or cognitive/language development that corresponded to the highest 5% for each of the measures given at the ages of 6 months and 18 months.

Mothers were then to complete an internet or paper-based Age-7 questionnaire for children in the cohort who were born between the years of 1997 to 2002 and whom had reached age 7 by January 2009 (Divan et al., 2011). Questionnaire data included information regarding prenatal cell phone use including details of, " (1) historical use of cell phone by mother (years since first use, trimester of use during pregnancy), (2) average times spoken daily on phone during pregnancy, (3) location of the phone when not in use (handbag or clothing pocket) during pregnancy, (4) proportion of time that phone was powered on during pregnancy, (5) use of earpiece (hands-free equipment) during pregnancy" (Divan et al., 2011). For the purpose of the study, an association with prenatal cell phone use and age 18-month developmental delays literature was reviewed.

Low birth weight, which is considered anything less than 2,500 grams, has been closely associated with neonatal mortality and morbidity, poor cognitive development, and inhibited

growth (Xi et al., 2017). This prompted Xi et al. (2017) to look at how prenatal mobile phone use could affect birth weight. The study contained 461 mothers whom preformed a survey on their maternal characteristics, infant characteristics, and maternal mobile phone use during their pregnancy (Xi et al., 2017). It was found that from the sample of 461 mothers, 415 reported ordinary mobile phone use, and 46 reported excessive mobile use. Mothers were placed in the ordinary mobile phone use category if they had ≤ 15 points on the Self-Perception of Text-Message Dependency Scale (STDS), and were placed in the excessive mobile phone use category if they had >15 points on the STDS. Researchers further divided the study into birth weight ranges from 1500-2500 grams, and a birth weight over 2500 grams.

Results

Birks et al. (2017) found that, "38.8% of mothers from the Danish cohort, reported no cell phone use during pregnancy, and these mothers were less likely to have a child with overall behavioral, hyperactivity/inattention or emotional problems" (Birks et al., 2017). It was also found that mothers who reported medium and high frequency cell phone use had a clinical range OR (odds ratio) of 1.28 (95% CI 1.12, 1.48) for having a child with an increased risk of hyperactivity/inattention problems. Furthermore, the association between cell phone usage and behavioral problems was found to be fairly consistent across and between the cohorts.

The results for the 18-month cognitive/language and motor delays showed there is no evidence between an association of prenatal cell phone use and motor or cognitive/language developmental delays among the age of 18 months. The study resulted an OR of 1.1 (95% CI 0.9 - 1.3) and 0.9 (95% CI 0.8 – 1.0), respectively.

Xi et al. (2017) study indicated that among the infants whose mothers reported ordinary cell phone use, total of (n = 415), there were 15 infants in the low birth weight range of (1500-2500g), and 400 with a birth weight over 2500g. Of the 46 mothers who reported excessive mobile phone use, one infant had low birth weight, while the other forty-five infants had a birth weight over 2500g. Both birth weight ranges had a p-value of 0.61 ($p < 0.05$), further demonstrating a negative association between prenatal cell phone use and low birth weight.

Discussion

The goal of the study was to reviewed literature to identify if behavior, developmental milestones, and birth weight in children might be affected by the use of cell phones during the prenatal period. In three studies reviewed, it was found that frequency of cell phone use was the most significant factor in determining if a child will have an increased risk of developing ADHD. Moreover, the results from Birks et al. (2017) support that women whom use a cell phone at medium (2-3 calls/day), and high frequencies (≥ 4 calls/day), were 1.28 times likely to have a child with ADHD over a 12-year study period (Birks et al., 2017). This supports the hypothesis, that increasing amounts of radiation during the prenatal period, can have a negative effect on children, specifically ADHD.

My findings by Birks et al. (2017), *Maternal cell phone use during pregnancy and child behavioral problems in five birth cohorts,* support previously published research on cell phone use and ADHD. However, in that study, the relationship between cell phone use and ADHD was observed in mice. The study, published by Yale authors, *Fetal Radiofrequency Radiation Exposure From 800-1900 Mhz-Rated Cellular Telephones Affects Neurodevelopment and*

Behavior in Mice, by (Aldad et al., 2012), showed a dose-dependent relationship between number of calls per day and hyperactivity behavior. The results for this study exhibited a dose-dependent decrease in the frequency of miniature excitatory postsynaptic currents (mEPSCs) with increasing number of calls, *(0 hour/day: 1.37±0.41, n = 9; 9 hours/day: 1.27 ± 0.21 Hz, n = 9; 15 hours/day: 1.04 ± 0.20 Hz, n = 10; 24 hours/day: 0.72± 0.13, n = 11) was statistically significant (linear correlation: Correlation Coef = −0.97, Unadjusted* r^2 *= 0.94, P<0.05),* (Aldad et al., 2012). In addition, a decrease in miniature excitatory postsynaptic currents, have demonstrated being a potential factor in the cause of ADHD.

While there is supporting evidence indicating a possible correlation between cell phone use during the prenatal period, and increased risk of ADHD in children, one cannot yet make the efforts in advising patients to reduce their cell phone usage during pregnancy until further research supports this conclusion. Nonetheless, while we cannot directly advise against its use, I do feel it is important to acknowledge the research that is out there on these subject matters. As clinicians we have a duty to inform/educate the patient, that while we need more evidence to make this conclusion, they can make their own decision upon whether they make a conscious effort to reduce the amount of cell phone usage they obtain in the mean-time or until there is further evidence that can show otherwise.

Conclusion

In conclusion, medium (2-3 calls/day), and high frequencies (≥ 4 calls/day) was found to be statistically significant for 1.28 times the risk for having a child with ADHD, compared to no-use or low frequency (0-1 calls/day). Although the Birks et al. (2017) research is suggesting a decrease in the use of cell phones during pregnancy, more research is needed to support the

clinical applications in practice. Prenatal cell phone use and motor or cognitive/language developmental delays at the age of 18-months had an OR of 1.1, thus, indicating that the results do not support a correlation between motor or cognitive/language delays at the age of 18-months. The data for an association between prenatal cell phone use and low birth weight (1500-2500g), was not statistically significant ($0.61(p < 0.05)$ for an increased risk of having a child with low birth weight. While the previous two studies implicate no links between prenatal cell phone use and developmental delays or low birth weight, more research is necessary to make these conclusions.

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