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Maternal cell phone use during pregnancy and child behavioral problems in five birth cohorts

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ABSTRACT

Introduction: Previous studies have reported associations between prenatal cell phone use and child behavioral problems, but findings have been inconsistent and based on retrospective assessment of cell phone use. This study aimed to assess this association in a multi-national analysis, using data from three cohorts with prospective data on prenatal cell phone use, together with previously published data from two cohorts with retrospectively collected cell phone use data.

Methods: We used individual participant data from 83,884 mother-child pairs in the five cohorts from Denmark (1996–2002), Korea (2006–2011), the Netherlands (2003–2004), Norway (2004–2008), and Spain (2003–2008). We categorized cell phone use into none, low, medium, and high, based on frequency of calls during pregnancy reported by the mothers. Child behavioral problems (reported by mothers using the Strengths and Difficulties Questionnaire or Child Behavior Checklist) were classified in the borderline/clinical and clinical ranges using validated cut-offs in children aged 5–7 years. Cohort specific risk estimates were meta-analyzed.

Results: Overall, 38.8% of mothers, mostly 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. Evidence for a trend of increasing risk of child behavioral problems through the maternal cell phone use categories was observed for hyperactivity/inattention problems (OR for problems in the clinical range: 1.11, 95%CI 1.01, 1.22; 1.28, 95%CI 1.12, 1.48, among children of medium and high users, respectively). This association was fairly consistent across cohorts and between cohorts with retrospectively and prospectively collected cell phone use data.

Conclusions: Maternal cell phone use during pregnancy may be associated with an increased risk for behavioral problems, particularly hyperactivity/inattention problems, in the offspring. The interpretation of these results is unclear as uncontrolled confounding may influence both maternal cell phone use and child behavioral problems.

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1. Introduction

Cell phone use is widespread throughout the world (World Bank, 2014) and radio frequency electromagnetic field (RF-EMF) exposure from cell phone use has been well documented (Cardis et al., 2011). Health consequences regarding this exposure have been researched but strong conclusions are not yet justified (Kostoff and Lau, 2013; Swerdlow, 2012). While short term exposure to RF-EMF is generally considered safe in adults, long term exposure have not been thoroughly explored (World Health Organization, 2002). If long-term RF-EMF exposure does in fact impact human health, there is concern that fetuses or children would be more vulnerable than adults to this potential influence, given the rapid development of neurological and organ systems in early life and the extended exposure over the entire lifespan (Kheifets et al., 2005; Leung et al., 2011). Therefore, cohort studies with prospective data on RF-EMF exposure and neuropsychological development in children have been identified as a high-priority research need (National Research Council, 2008; van Deventer et al., 2011). Some studies in rats or mice have shown that extended RF-EMF exposure in pregnant dams was linked to hyperactivity, altered neurons, or impaired cognition in offspring (Aldad et al., 2012; Haghani et al., 2013; Zhang et al., 2015), while another study in rats did not support these findings (Shirai et al., 2014); but the relevance of these studies to human health is not clear.

Recently, in a large prospective cohort study, researchers in Denmark produced two independent analyses (n = 12,796 and n = 28,745) showing that mothers who more often used cell phones (the main sources of RF-EMF exposure to the head) during pregnancy were more likely to have children with behavioral problems at age 7 (Divan et al., 2012, 2008). These results were corroborated in a further analysis (n = 51,190) where cell phone use (during pregnancy and at age 7) was associated with emotional and behavioral difficulties at age 11 (Sudan et al., 2016). In a smaller sample (n = 2532), researchers in The Netherlands did not find associations between prenatal cell phone use and behavioral problems in children at age 5 in their cohort (Guxens et al., 2013), but confidence intervals overlapped with estimates in the Danish analyses (Sudan et al., 2013). A main limitation in both studies was potential recall bias since mothers recalled their prenatal cell phone use when the child was 7 years old.

Considering that a true association would have a large health impact worldwide given the ubiquity of cell phones, it is necessary to explore this association among cohorts wherein mothers reported cell phone use prospectively during pregnancy, i.e. long before the onset of any behavioral symptoms in the child. Therefore, the aim of this study was to assess the association between maternal cell phone use during pregnancy and behavioral problems in children ages 5–7 using data from three birth cohorts from Korea, Norway, and Spain where mothers reported cell phone use prospectively at 1st and/or 3rd trimester of pregnancy, together with the data from the Danish and Dutch cohorts where maternal cell phone use during pregnancy was reported retrospectively when children were 7 years old.

2. Methods

2.1. Study population

As part of the Generalized EMF Research using Novel Methods (GERoNiMO) Project ("Generalized EMF research using novel methods,", 2014), five population-based prospective birth cohorts spanning Europe and Asia (Table 1) were harmonized for analysis regarding maternal cell phone use during pregnancy. These were: the Amsterdam Born Children and their Development Study (ABCD) (van Eijsden et al., 2011), the Danish National Birth Cohort (DNBC) (Olsen et al., 2001), the Spanish Environment and Childhood Project (INMA) (Guxens et al., 2012), the Norwegian Mother and Child Cohort Study (MoBa) (Magnus et al., 2006), and the Korean Mothers and Children's Environment Health Study (MOCEH) (Kim et al., 2009). Informed consent was obtained from all participants in accordance with each study's institutional review board or ethics committee. Enrollment in the five cohorts spanned 1996–2011 with >190,000 mother-child pairs (Table 1). Across all cohorts, 83,884 mother-child pairs met our inclusion criteria of having information on frequency of maternal cell phone use during pregnancy and having collected a behavioral assessment of the child at 5–7 years (Table 1).

2.2. Maternal cell phone use during pregnancy

When children were 7 years old in the Dutch and Danish cohorts, mothers were asked to recall frequency of cell phone use during pregnancy. In Spain, Norway, and Korea, mothers were asked during pregnancy to report frequency of cell phone use (Table 1). In each cohort, questionnaires captured frequency of maternal cell phone use using different questions and number of calls categorization (Table 2 and Supplemental Table S1). Mothers in the Dutch cohort were also asked to recall cordless phone use during pregnancy. For the purpose of this study, we created a frequency of use variable (none, low, medium, and high) to classify maternal cell phone use during pregnancy in all cohorts (Table 2). We created the same categories for maternal cordless phone use during pregnancy. The creation of these classifications was blind to child behavioral problems.

2.3. Behavioral problems

In all cohorts, overall behavioral problems, hyperactivity/inattention problems, and emotional problems were assessed. In the Danish, Dutch, and Spanish cohorts, child behavioral problems were assessed by using the parental Strength and Difficulties Questionnaire (SDQ) (Goodman, 1997) at ages 5–7, depending on cohort (Table 1). The SDQ is a short screening form, in this case completed by parents, consisting of 25 items with 5 for each dimension: emotional problems, conduct problems, hyperactivity/inattention problems, peer/social problems, and pro-social behavior (Goodman, 1997). Each item has a scaled response (very true, partly true, not true). Each dimension yields a score, and summation of 4 dimensions (pro-social behavior is excluded) yields an overall behavior difficulties score (Goodman, 1997). In the Spanish cohort, hyperactivity/inattention problems were also assessed by teachers at 5 years using the Attention Deficit and Hyperactivity Disorder criteria of the Diagnostic and Statistical Manual of Mental Disorders-IV (ADHD DSM-IV) (American Academy of Pediatrics, 2004). The ADHD DSM-IV consists of 18 symptoms, nine for inattention and nine for hyperactivity/impulsivity. Each symptom is rated on a 4-point scale (never or rarely, sometimes, often, or very often) (American Academy of Pediatrics, 2004). For the Spanish cohort, the SDQ assessment was used in our main analysis to be comparable with other cohorts, while the ADHD DSM-IV was used for a sensitivity analysis.

In the Korean cohort, children's behavioral problems were assessed at 5 years by the parental Child Behavior Checklist (CBCL) (Achenbach, 2011). The CBCL is a standardized form that parents fill out to describe their children's behavioral and emotional problems. The version for ages 1½ to 5 years includes 99 competence items and problems, asking the parent to indicate how each item applies to the child (not true, somewhat or sometimes true, and very true or often true) (Achenbach, 2011). The CBCL's questions are associated with various disorders from the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (American Academy of Pediatrics, 2004) and syndrome scales, including overall behavioral problems, hyperactivity/inattention problems, and emotional problems. The Norwegian cohort used an adapted 25-item version of the CBCL with selected items of five subscales of the full CBCL (Garthus-Niegel et al., 2010). In this adapted CBCL, almost all items from the complete CBCL are present for the attention deficit/hyperactivity problems subscale. After administering this shorter CBCL from years 2004–2009, in 2010 MoBa added two