



## Maternal cell phone use during pregnancy and child cognition at age 5 years in 3 birth cohorts



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### ABSTRACT

**Background:** There have been few studies of children's cognitive development in relation to mothers' cell phone use, and most were limited to outcomes at age 3 years or younger. We examined the relationship between maternal cell phone use during pregnancy and cognitive performance in 5-year old children.

**Methods:** This study included data from 3 birth cohorts: the Danish National Birth Cohort (DNBC) (n = 1209), Spanish Environment and Childhood Project (INMA) (n = 1383), and Korean Mothers and Children's Environment Health Study (MOCEH) (n = 497). All cohorts collected information about maternal cell phone use during pregnancy and cognitive performance in children at age 5. We performed linear regression to compute mean differences (MD) and 95% confidence intervals (CI) in children's general, verbal, and non-verbal cognition scores comparing frequency of maternal prenatal cell phone use with adjustments for numerous potential confounding factors. Models were computed separately for each cohort and using pooled data in meta-analysis.

**Results:** No associations were detected between frequency of prenatal cell phone use and children's cognition scores. Scores tended to be lower in the highest frequency of use category; MD (95% CI) in general cognition scores were 0.78 (−0.76, 2.33) for none, 0.11 (−0.81, 1.03) for medium, and −0.41 (−1.54, 0.73) for high compared to low frequency of use. This pattern was seen across all cognitive dimensions, but the results were imprecise overall.

**Conclusion:** We observed patterns of lower mean cognition scores among children in relation to high frequency maternal prenatal cell phone use. The causal nature and mechanism of this relationship remain unknown.

### 1. Introduction

There has been widespread growth in the use of cell phones in recent decades, with an estimated 7.7 billion cell phone subscribers at the end of 2017 worldwide (International Telecommunication Union,

2018). Despite the popularity and usefulness of this technology, there remain questions about its safety, including concern about the potential, but as-of-yet unconfirmed, health effects of radiofrequency (RF) fields emitted from cell phones. If RF exposure from cell phones is harmful to health, fetuses and children may be at increased risk due to

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**Table 1**  
Sample characteristics by cohort.

Cohort	Location	Enrollment		N with data on maternal prenatal cell phone use		N with data on cognition			N with data on exposure and outcome	
		Time period	N	Time of collection	N collected	Assessment	Age at assessment (months)		N collected	
							Mean (SD)	Min-max		
DNBC <sup>a</sup>	Denmark	1996–2002	92,979	Postnatal 7 years	50,040	WPPSI-R <sup>d</sup>	62.7 (0.9)	60.0–64.0	1,313 <sup>f</sup>	1209
INMA <sup>b</sup>	Spain	2003–2008	2270	Pregnancy	1999	MSCA <sup>c</sup>	59.1 (7.8)	49.4–82.3	1473	1383
MOCEH <sup>c</sup>	Korea	2006–2011	1751	Pregnancy	1481	WPPSI-R <sup>d</sup>	60.9 (3.1)	47.6–77.1	497	497
Total			97,000		53,520				3283	3089

<sup>a</sup> Danish National Birth Cohort.

<sup>b</sup> Spanish Environment and Childhood Project.

<sup>c</sup> Mothers and Children's Environmental Health Study.

<sup>d</sup> Welchsler Preschool and Primary Scale of Intelligence, Revised.

<sup>e</sup> McCarthy Scales of Children's Abilities.

<sup>f</sup> In the DNBC, children's cognition was measured in a subset of children (n = 1313) who took part in the Lifestyle During Pregnancy Study (LDPS) (Kesmodel et al., 2010).

their rapidly developing tissue systems (Kheifets et al., 2005; Wiart et al., 2008).

Studies in rodents have reported some links between extended exposure to RF-EMF in pregnant dams and hyperactivity, altered neurological development, oxidative stress, and impaired cognition in offspring (Haghani et al., 2013; Aldad et al., 2012; Zhang et al., 2015; Ozgur et al., 2013), while another study did not support these findings (Shirai et al., 2014). However, RF exposure modeling studies have demonstrated that a cell phone held close to the body by a pregnant woman would result in a very low specific absorption rate (SAR) of RF in the fetus (Cabot et al., 2014), which is unlikely to have biological effects (Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), 2015; Consales et al., 2012; Kovacic and Somanathan, 2010), but exposure levels could vary depending on the position of the phone and fetus (Varsier et al., 2014). An experimental study performed among pregnant volunteers reported changes in the protein profile of chorionic tissue in early pregnancy in relation to RF exposure from cell phones held close to the abdomen (Luo et al., 2013). Although experimental and modeling studies have provided some evidence for potential biological effects of RF-EMF, the relevance of these findings to human health is unclear, and in-utero RF-EMF exposure from a phone held close to the head would be much lower than exposure from a phone held close to the abdomen. A biological mechanism to explain the potential health effects of cell phones has not been identified, but several mechanisms have been proposed, including induction of oxidative stress, activation of heat shock proteins which increase the permeability of the blood brain barrier, and calcium ion leakage in neuronal tissues (Consales et al., 2012; Kovacic and Somanathan, 2010; Irmak et al., 2002; Altunkaynak et al., 2016).

Several investigations in the Danish National Birth Cohort (DNBC) have consistently found associations between maternal cell phone use during pregnancy and emotional and behavioral difficulties in children at ages 7 and 11 years of age. The strongest association was seen among children exposed both prenatally (mother used a cell phone while pregnant) and postnatally (child used a cell phone at age 7 years), with an odds ratio (OR) of 1.80 and a 95% confidence interval (CI) of 1.45 to 2.23 when compared to those with no exposure (Divan et al., 2008). These findings were replicated in a separate group of DNBC children who were born later, and with the two samples combined. Adjustment for numerous additional potential confounders weakened but did not eliminate the associations (Divan et al., 2012). A more recent prospective study from the DNBC found similar associations between prenatal cell phone exposures and cell phone use at age 7 years and behavioral problems in children at age 11 years (Sudan et al., 2016a). In the Amsterdam Born Children and their Development (ABCD) cohort from The Netherlands, investigators did not find associations between

prenatal cell phone use and behavioral problems in children at age 5 years (Guxens et al., 2013), but their results were not inconsistent with the findings in the DNBC as the CI's overlapped (Sudan et al., 2013). A recent analysis of individual participant data from 5 cohort studies, which included the DNBC and ABCD, reported increased odds of hyperactivity/inattention in 5–7 year-old children of mothers who were frequent cell phone users during pregnancy (Birks et al., 2017).

A few birth cohort studies have also examined associations between maternal prenatal cell phone use and early childhood development and cognition. Studies in the DNBC (Divan et al., 2011) and the Spanish Environment and Childhood Project (INMA) (Vrijheid et al., 2010) did not find associations between prenatal cell phone use and developmental or cognitive delays in early childhood at 6, 14, and 18 months of age. A study from the Norwegian Mother and Child Cohort (MoBa) (Papadopoulou et al., 2017) found decreased odds of low language and motor skills at age 3 years and no evidence of adverse neurodevelopmental effects in relation to prenatal maternal cell phone use. An investigation in the Korean Mothers and Children's Environmental Health Study (MOCEH) (Choi et al., 2017) reported no association between prenatal RF exposure and child neurodevelopment up to age 3 years, but did find a potential combined effect of prenatal exposure to lead and maternal prenatal cell phone use on neurodevelopment.

To date, few epidemiologic studies relating prenatal cell phone exposure to childhood cognition have been conducted. Given the widespread use of cell phones, further scrutiny of this relationship is warranted. Therefore, we investigated the association between cell phone use by women during pregnancy and cognition scores in their children in three birth cohorts.

## 2. Methods

This investigation is part of the Generalized EMF Research using Novel Methods (GERoNiMO) Project (GERoNiMO, 2014), and included data from 3 population-based prospective birth cohorts from Europe and Asia: the DNBC (Olsen et al., 2001), INMA (Guxens et al., 2012), and MOCEH (Kim et al., 2009) (Table 1). Enrollment in the three cohorts spanned 1996–2010 (Table 1). Across all 3 cohorts, data on both cell phone use during pregnancy and child cognition were available for 3089 mother-child pairs, which made up our analysis dataset. Among Danish mother-child pairs, only those that participated in the Lifestyle During Pregnancy Study (LDPS) were included in this analysis. The LDPS was designed to investigate the effects of prenatal lifestyle factors, primarily alcohol use, on the neuropsychological development of the children (Kesmodel et al., 2010). Women in the LDPS were sampled based on their self-reported alcohol use behaviors in the DNBC interviews, with oversampling for those with heavier alcohol exposure.

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