Maternal cell phone and cordless phone use during pregnancy and behaviour problems in 5-year-old children

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ABSTRACT

Background A previous study found an association between maternal cell phone use during pregnancy and maternal-reported child behaviour problems at age 7. Together with cell phones, cordless phones represent the main exposure source of radiofrequency-electromagnetic fields to the head. Therefore, we assessed the association between maternal cell phone and cordless phone use during pregnancy and teacher-reported and maternal-reported child behaviour problems at age 5.

Methods The study was embedded in the Amsterdam Born Children and their Development study, a population-based birth cohort study in Amsterdam, the Netherlands (2003–2004). Teachers and mothers reported child behaviour problems using the Strength and Difficulties Questionnaire at age 5. Maternal cell phone and cordless phone use during pregnancy was asked when children were 7 years old.

Results A total of 2618 children were included. As compared to non-users, those exposed to prenatal cell phone use showed an increased but non-significant association of having teacher-reported overall behaviour problems, although without dose-response relationship with the number of calls (OR=2.12 (95% CI 0.95 to 4.74) for <1 call/day, OR=1.58 (95% CI 0.69 to 3.60) for 1–4 calls/day and OR=2.04 (95% CI 0.86 to 4.80) for ≥5 calls/day). ORs for having teacher-reported overall behaviour problems across categories of cordless phone use were below 1 or close to unity. Associations of maternal cell phone and cordless phone use with maternal-reported overall behaviour problems remained non-significant. Non-significant associations were found for the specific behaviour problem subscales.

Conclusion Our results do not suggest that maternal cell phone or cordless phone use during pregnancy increases the odds of behaviour problems in their children.

There is concern about the potential effects of exposure of radiofrequency-electromagnetic fields (RF-EMF) on child health, especially on brain development.[1][2] Regarding child behaviour problems, results from two independent analyses of the Danish National Birth Cohort showed that mothers' cell phone use during pregnancy was positively associated with maternal reports of behavioural difficulties in children aged 7 years.[3][4] A true adverse effect of cell phone exposure on child behaviour problems would have a large public health impact given the ubiquity of the exposure.

Biological mechanisms behind this possible relationship are poorly understood. When calling, by far most of the RF-EMF energy emitted by cell phones is absorbed in the head,[5] and direct exposure to the fetus is extremely low.[6][7] A hypothesis involving melatonin secretion has been proposed.[8] Maternal exposure to RF-EMF from a cell phone held close to the jaw may affect signalling in the unmyelinated nerves and, in turn, influence melatonin secretion by the pineal gland.[8] Melatonin may affect fetal brain development via changes in maternal metabolism or the sex hormone environment.[8] Experimental studies with rodents and human studies that assessed whether exposure to RF-EMF may affect melatonin secretion showed mixed results.[9–11]

Together with cell phones, cordless phones represent the main exposure source of RF-EMF to the head. Although the type of RF-EMF emission between cell phones and cordless phones is not exactly identical, and the average output power (an indicator of the RF-EMF exposure) tends to be higher for the cell phones,[12] if a biological effect of the exposure to RF-EMF exists, we would expect to observe some similarities regarding the health effects. Therefore, the aim of the present study is to assess the association between maternal cell and cordless phone use during pregnancy and child behaviour problems at 5 years of age as reported by teachers and mothers.

METHODS

Design and study participants

This study was embedded in the Amsterdam Born Children and their Development (ABCD) study (http://www.abcd-studie.nl), a population-based prospective birth cohort study that examines the relationship of maternal lifestyle and psychosocial determinants during pregnancy to multiple aspects of development and health of the child.[13] Between January 2003 and March 2004, 8266 pregnant women were enrolled during their first prenatal visit to an obstetric care provider in the Municipality of Amsterdam (see online supplementary figure S1). Prenatal phone use was asked retrospectively when children were 7 years old, and child behaviour problems were assessed when children were 5 years old. Information on these variables was available for 2660 children. After excluding the subjects with missing information on potential covariates, 2618 (31.7% of eligible) children were included in the study. Approval of the study was obtained from the Central Committee on Research involving Human Subjects in the Netherlands, the Medical Ethical Committees of the participating hospitals and from the

Registration Committee of the Municipality of Amsterdam.

Prenatal cell phone and cordless phone use

When children were 7 years old, a questionnaire (postal or via web) was administered to the mothers. Questions on the frequency of maternal cell and cordless phone calls during pregnancy ('On average, how many calls did you have during pregnancy of your child with a mobile phone (private as well as business mobile phone)?' and 'On average, how many calls did you have during pregnancy of your child with a cordless phone (both at home and at work)?', respectively) were asked (see online supplementary table S1). Answer categories were: none, <1 call/week, 1–6 calls/week, 1 call/day or more (specifying the number of calls) and not known. We categorised the frequency of both phone uses into four categories: none, <1 call/day, 1–4 calls/day and ≥5 calls/day. Some mothers answered having 1 call/day or more but did not specify the number of calls (n=167 for mobile phone and n=152 for cordless phone). We imputed these cases in order to classify them into 1–4 calls/day or ≥5 calls/day categories; predictor variables were maternal education, country of birth, age, parity, depression and anxiety during pregnancy, pregnancy-related anxiety subscales and history of psychopathology. Given the introduction of Universal Mobile Telecommunications System technology in the Netherlands in the beginning of 2004, mobile phone use reports were expected to be nearly exclusively Global System for Mobile Communications (GSM) 900/1800 technology.

Based on the report of the frequency of hands-free equipment use during pregnancy, we recalculated the frequency of cell phone use. If mothers 'nearly never' used hands-free equipment, the reported number of cell phone calls was left unchanged. Frequency of cell phone calls were set to 75% of the number of calls for those reporting to use the hands-free equipment 'less than half of the calls', to 25% for those reporting to use it 'more than half of the calls', and to 0 for those reporting to use it 'nearly always'.

Child behaviour problems

Children's behaviour was reported by their primary schoolteachers and their mothers using the Strengths and Difficulties Questionnaire (SDQ)[14] when the child was 5 years old. The SDQ is a short screening questionnaire suitable for children and adolescents aged 4–16 years. The questionnaire consists of 25 items with scaled responses (very true, partly true, not true) divided into five subscales: emotional symptoms, conduct problems, hyperactivity/inattention problems, peer relationship problems and pro-social behaviour. All items, except pro-social behaviour, added together formed the total difficulties score that represented overall behaviour problems. Based on a specific numerical score, children were classified as normal, borderline and abnormal for overall behaviour problems and the five subscales.[14]

Covariates

At enrolment, information on maternal age, maternal educational level (based on the years after primary school: high (≥10 years), medium (6–9 years) and low (≤5 years)), maternal country of birth, maternal parity, maternal pre-pregnancy weight and height, maternal smoking, maternal second-hand smoke at home, maternal alcohol consumption during pregnancy, maternal pregnancy-related anxiety and maternal anxiety and depression during pregnancy was obtained by a questionnaire completed by the mother. Pregnancy-related anxiety was assessed using an abbreviated 10-item version[15] of the

Pregnancy Related Anxieties Questionnaire.[16] Each item was scored on a 4-point scale (from 'definitely not true' to 'very true'). Three subscales were defined: 'fear of giving birth', 'fear of bearing a physically or mentally handicapped child' and 'concern about one's appearance'. Maternal anxiety during pregnancy was assessed using the Dutch version[17] of the State-Trait Anxiety Inventory.[18] The 20 items regarding state anxiety (transient or temporarily experienced anxiety) were included in our questionnaire, with each item scored on a 4-point scale (from 'rarely or none of the time' to 'most or all of the time'). A global score was calculated. Maternal depression during pregnancy was assessed using the validated Dutch version of the 20-item Center for Epidemiological Studies Depression Scale.[19][20] This scale evaluates the frequency of depressive symptoms experienced over the preceding week. Each item scored on a 4-point scale (from 'rarely or none of the time' to 'most or all of the time'), and a global score was calculated. Postal questionnaire, when the children were 5 years old, provided information on maternal self-reported history of psychopathology ('ever', 'never') based on the question: 'Have you ever had any of the following psychological or psychiatric problems?': schizophrenia (or another psychotic disorder), manic depression, depression, anxiety disorders (eg, phobia), autism, learning problems (eg, dyslexia), attention disorders (eg, attention deficit hyperactivity disorder), alcohol addiction or misuse, drug addiction or misuse, or other problems (eating disorder, burn out, obsessive-compulsive disorder, dissociative disorder, personality disorder and post-traumatic stress disorder).

We matched children's birth addresses with a map of an area-level indicator of socioeconomic position, the percentage of persons with a low income, defined by the Central Bureau of Statistics as an income below the 40th percentile of the Dutch income distribution.[21]

Statistical analysis

Differences in maternal characteristics between included and non-included subjects were compared using χ^2 test or Student's t test. Maternal characteristics according to the prenatal frequency of cell and cordless phone use categories were described using means (SD) or proportions, with χ^2 or analysis of variance (ANOVA) tests applied.

Logistic regression models were performed in order to examine the association between prenatal cell and cordless phone use and each one of the child behaviour problem scales (normal vs borderline/abnormal). All models were adjusted for potential confounder variables, selected a priori on the basis of previous studies.[3][4] All models were repeated excluding non-users and using those mothers with <1 call/day as a reference category as well as including non-users and those with <1 call/day together as a reference category. The area-level indicator of socioeconomic position was additionally introduced into the models. All analyses were re-run using polytomous logistic regression models assessing each one of the child behaviour problem scales in three categories (normal, borderline and abnormal).

We also performed logistic regression models in order to examine the association of prenatal cell phone use, taking into account the use of hands-free equipment overall behaviour problem scales. Finally, we tested the interaction between prenatal phone use and maternal educational level and the country of birth as proxies of socioeconomic position, as well as between prenatal cell phone use and cordless phone use into two categories (low (<1 call/day) and high (≥1 call/day)) on child behaviour problems, and we performed stratified analysis.

Statistical tests of hypotheses were two-tailed with significance set at p<0.05. Statistical analyses were conducted using STATA V.12.0 (Stata Corporation, College Station, Texas, USA).

RESULTS

Compared with the lost to follow-up group, mothers included in the present analysis showed higher educational level, were more likely to be born in the Netherlands, were more often primiparous, older, tended to smoke less and consume more alcohol during pregnancy, and reported less pregnancy-related anxiety symptoms, anxiety-and-depression symptoms during pregnancy and a history of psychopathology (see online supplementary table S2).

Among all mothers, 6.1% reported not using a cell phone, 38.4% <1 call/day, 38.5% 1–4 calls/day and 17% ≥5 calls/day (table 1). Highly educated mothers, those living in a neighbourhood with a lower percentage of low income and those that were born in the Netherlands were more likely to be cell phone users. Cell phone use was related to primiparous and healthy-weight mothers, higher smoking levels, higher alcohol consumption, lower anxiety and depression during pregnancy and a history of psychopathology. Associations were similar when cell phone non-users were excluded.

Regarding cordless phone use, 13% reported not using a cordless phone, 46% <1 call/day, 33.5% 1–4 calls/day and 7.5% ≥5 calls/day (table 2). Highly educated mothers, multiparous and those that were born in the Netherlands showed a positive trend with the frequency of use (from no use to 1–4 calls/day), except for the higher users (≥5 calls/day) that showed an inverse relationship. Cordless phone users reported less smoking levels, less pregnancy-related anxiety and less anxiety-and-depression symptoms during pregnancy compared to non-users.

Overall, 9.6% of the children were classified as having overall behaviour problems (borderline/abnormal) based on the teacher reports, compared with only 3.3% based on the maternal reports. As compared to non-users, those exposed to prenatal cell phone use showed an increased but not significant association for having teacher-reported overall behaviour problems (table 3). This association did not show a dose–response relationship with the number of calls, and after excluding non-users or including non-users and those with <1 call/day as a reference category (see online supplementary table S3), we did not observe a trend with the level of use. ORs for having teacher-reported overall behaviour problems were below 1 or close to unity across categories of cordless phone use. After excluding non-users, the results remained similar. Regarding maternal-reported overall behaviour problems, we observed no evidence of an association with prenatal cell phone use and a non-consistent pattern with prenatal cordless phone use (table 4 and online supplementary table S4). Similar results were found for the specific behaviour of problem subscales (see online supplementary tables S5–S14). Associations of prenatal cell and cordless phone use with teacher-reported and maternal-reported overall behaviour problems were not affected when we adjusted for the area-level indicator of socio-economic position (data not shown). When child behaviour problem scales were analysed in three categories (normal, borderline and abnormal), the results were similar (data not shown).

Table 1 Maternal characteristics by prenatal frequency of cell phone calls (n=2532)*

	Prenatal frequency of cell phone calls					
	None (n=154)	<1/day (n=973)	1–4/day (n=974)	≥5/day (n=431)	p-Diff	p-Diff†
Education					<0.001	<0.001
High	62.3	67.0	73.9	75.2		
Medium	20.8	23.1	20.7	19.3		
Low	16.9	9.9	5.3	5.6		
Percentage of persons with low income in the neighbourhood‡	39.0 (7.9)	36.9 (8.5)	36.1 (8.7)	35.0 (8.9)	<0.001	0.001
Age					0.003	0.004
≤25 years	3.2	6.2	7.0	3.9		
26–30 years	22.1	21.1	27.5	24.4		
31–35 years	47.4	50.5	47.6	52.2		
≥36 years	27.3	22.3	17.9	19.5		
Country of birth (non-Dutch vs Dutch)	24.7	21.0	12.4	11.4	<0.001	<0.001
Parity (multiparous vs primiparous)	61.7	45.2	34.8	36.9	<0.001	<0.001
Prepregnancy BMI (overweight/ obese vs healthy weight/underweight)	27.3	20.1	16.9	14.2	0.001	0.018
Smoking during pregnancy (yes vs no)	2.6	6.5	7.7	10.2	0.009	0.052
SHS at home during pregnancy (yes vs no)	38.3	48.3	61.2	62.4	<0.001	<0.001
Alcohol during pregnancy (yes vs no)	16.2	23.3	34.2	36.9	<0.001	<0.001
Pregnancy-related anxiety						
Fear of giving birth	2.7 (1.9)	3.0 (2.0)	3.1 (2.0)	2.9 (2.0)	0.103	0.185
Fear of bearing a handicapped child	4.2 (2.3)	4.3 (2.2)	4.3 (2.2)	4.4. (2.4)	0.897	0.924
Concern about one's appearance	2.6 (1.7)	2.7 (1.9)	3.0 (1.9)	3.0 (2.0)	<0.001	<0.001
Anxiety symptoms during pregnancy	36.6 (9.4)	35.9 (9.6)	35.9 (9.3)	35.0 (9.0)	0.187	0.171
Depression symptoms during pregnancy	11.2 (7.3)	10.9 (7.5)	10.8 (7.5)	10.2 (7.2)	0.295	0.222
History of psychopathology (ever vs never)	24.0	22.8	20.9	20.0	0.517	0.417

*Values are percentages for the categorical variables and mean (SD) for the continuous variables.
†p-Value for differences excluding nonusers.
‡72 cases were missing.
BMI, body mass index; p-diff, p value for differences; SHS, second-hand smoke.

Table 2 Maternal characteristics by prenatal frequency of cordless phone calls (n=2536)*

| | Prenatal frequency of cordless phone calls | | | | | |
	None (n=313)	<1/day (n=1102)	1–4/day (n=941)	≥5/day (n=180)	p-Diff	p-Diff†
Education					<0.001	0.002
High	60.4	71.5	75.1	62.8		
Medium	24.3	20.5	19.9	26.7		
Low	15.3	8.0	5.0	10.6		
Percentage of persons with low income in the neighbourhood‡	39.0 (7.7)	36.2 (8.8)	35.9 (8.6)	35.9 (8.6)	<0.001	0.822
Age					<0.001	0.067
≤25 years	14.7	5.2	3.5	7.2		
26–30 years	28.8	24.0	23.2	24.4		
31–35 years	40.6	51.5	50.5	43.9		
≥36 years	16.0	19.3	22.8	24.4		
Country of birth (non-Dutch vs Dutch)	22.0	17.2	13.3	16.1	0.002	0.042
Parity (multiparous vs primiparous)	36.4	38.9	45.3	41.7	0.009	0.016
Pre-pregnancy BMI (overweight/obese vs healthy weight/underweight)	20.1	17.0	19.6	18.3	0.393	0.315
Smoking during pregnancy (yes vs no)	14.4	5.8	6.9	6.7	<0.001	0.583
SHS at home during pregnancy (yes vs no)	61.9	53.4	54.2	57.8	0.018	0.533
Alcohol during pregnancy (yes vs no)	25.9	27.3	32.4	31.1	0.035	0.038
Pregnancy-related anxiety						
Fear of giving birth	3.3 (2.0)	3.1 (2.0)	2.8 (2.0)	2.8 (2.3)	0.001	0.017
Fear of bearing a handicapped child	4.3 (2.3)	4.3 (2.2)	4.5 (2.2)	4.0 (2.6)	0.049	0.022
Concern about one's appearance	3.3 (2.0)	2.8 (1.9)	2.8 (1.9)	3.0 (2.1)	0.001	0.506
Anxiety symptoms during pregnancy	38.0 (9.8)	35.6 (9.4)	35.5 (9.3)	35.7 (9.9)	0.001	0.979
Depression symptoms during pregnancy	12.2 (8.1)	10.5 (7.2)	10.6 (7.3)	11.4 (8.9)	0.001	0.268
History of psychopathology (ever vs never)	25.6	20.5	22.2	21.7	0.285	0.634

*Values are percentages for the categorical variables and mean (SD) for the continuous variables.
†p Value for differences excluding non-users.
‡72 cases were missing.
BMI, body mass index; p-diff, p value for differences; SHS, second-hand smoke.

Among the prenatal cell phone users, 83.3% reported the use of a hands-free equipment nearly never, 10.6% about less than half of the calls, 3.6% about more than half of the calls and 2.8% nearly always. When the use of the hands-free equipment was taken into account in the estimation of the frequency of cell phone use, associations with teacher-reported and maternal-reported overall behaviour problems remain materially unaltered (data not shown). Associations of prenatal cell and cordless phone use with teacher-reported and maternal-reported overall behaviour problems were not affected among maternal

Table 3 Association between prenatal frequency of cell phone and cordless phone calls and teacher-reported child overall behaviour problems*

		Teacher-reported overall behaviour problems							
		All subjects				Excluding none calls			
		Unadjusted model		Adjusted model†		Unadjusted model		Adjusted model†	
	N (borderline-abnormal/normal)	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Prenatal frequency of cell phone call (n=2142)									
Number of calls									
None	7/118	Ref.		Ref.		–	–		
<1/day	92/742	2.09	0.95 to 4.62	2.12	0.95 to 4.74	Ref.		Ref.	
1–4/day	68/747	1.53	0.69 to 3.42	1.58	0.69 to 3.60	0.73	0.53 to 1.02	0.75	0.53 to 1.07
≥5/day	37/331	1.88	0.82 to 4.34	2.04	0.86 to 4.80	0.90	0.60 to 1.35	0.97	0.64 to 1.47
Prenatal frequency of cordless phone call (n=2142)									
Number of calls									
None	28/223	Ref.		Ref.		–	–		
<1/day	94/845	0.89	0.57 to 1.39	1.19	0.74 to 1.92	Ref.		Ref.	
1–4/day	70/729	0.76	0.48 to 1.22	1.07	0.65to 1.76	0.68	0.62 to 1.20	0.89	0.64 to 1.24
≥5/day	9/144	0.50	0.23to 1.09	0.61	0.27 to 1.35	0.56	0.28 to 1.14	0.51	0.25 to 1.05

*OR (95% CI) from logistic regression models that represents the odds for the children classified as 'borderline' or 'abnormal' for having overall behaviour problems compared to the ones classified as 'normal'.
†Models adjusted for maternal education, age, country of birth, parity, pre-pregnancy body mass index, smoking use during pregnancy, second-hand smoke at home during pregnancy, alcohol consumption during pregnancy, pregnancy-related anxiety subscales, anxiety and depression during pregnancy and history of psychopathology.

Table 4 Association between prenatal frequency of cell phone and cordless phone calls and maternal-reported child overall behaviour problems*

	N (borderline-abnormal/normal)	Maternal-reported overall behaviour problems							
		All subjects				Excluding none calls			
		Unadjusted model		Adjusted model†		Unadjusted model		Adjusted model†	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Prenatal frequency of cell phone call (n=2529)									
Number of calls									
None	6/148	Ref.		Ref.		–	–		
<1/day	36/936	0.95	0.39 to 2.29	0.89	0.36 to 2.20	Ref.		Ref.	
1–4/day	30/943	0.78	0.32 to 1.92	0.73	0.28 to 1.85	0.83	0.51 to 1.35	0.81	0.48 to 1.36
≥5/day	13/417	0.77	0.29 to 2.06	0.75	0.27 to 2.09	0.81	0.43 to 1.54	0.83	0.42 to 1.63
Prenatal frequency of cordless phone call (n=2533)									
Number of calls									
None	21/292	Ref.		Ref.		–	–		
<1/day	21/1079	0.27	0.15 to 0.50	0.35	0.18 to 0.67	Ref.		Ref.	
1–4/day	36/904	0.55	0.32 to 0.96	0.73	0.41 to 1.33	2.05	1.19to 3.53	2.06	1.18 to 3.59
≥5/day	5/175	0.40	0.15 to 1.07	0.43	0.15 to 1.21	1.47	0.55 to 3.94	1.18	0.41 to 3.39

*OR (95% CI) from logistic regression models that represents the odds for the children classified as 'borderline' or 'abnormal' for having overall behaviour problems compared to the ones classified as 'normal'.
†Models adjusted for maternal education, age, country of birth, parity, pre-pregnancy body mass index, smoking use during pregnancy, second-hand smoke at home during pregnancy, alcohol consumption during pregnancy, pregnancy-related anxiety subscales, anxiety and depression during pregnancy and history of psychopathology.

educational level and maternal country of birth strata (p interactions >0.15), as well as the association of prenatal cell phone use with teacher-reported and maternal-reported overall behaviour problems among low and high cordless phone users (p interaction>0.25).

DISCUSSION

To our knowledge, the present study is the first that assessed the role of both cell and cordless phone use during pregnancy separately on teacher-reported and maternal-reported child behaviour problems. Neither cell phone use nor cordless phone use was associated with behaviour problems in 5-year-old children, such as hyperactivity/inattention problems, conduct problems or emotional symptoms in a large population-based study.

The main strength of our study is the assessment of both cell and cordless phone exposures during pregnancy. It is of great interest to study the use of both phones since they represent the main exposure source of RF-EMF to the brain. Although the type of RF emission is not exactly identical, if a true effect exists, one would expect similarities of effects on health outcomes. The correlation between cell and cordless phone use was low (r=0.23), allowing one to study them independently. Another strength is the availability of teacher-reported child behaviour problems besides maternal reports. The assessment of child behaviour problems in different settings is more informative since psychological problems may be highly situational, and in addition, teacher reports seemed to show stronger psychometric proprieties.[22] Correlations between teacher-reported and maternal-reported child behaviour problems were low (from 0.21 to 0.38), similar to previous studies.[22] The consistent absence of association of cell and cordless phone use on child behaviour problems between teacher reports and maternal reports strengthen our findings. In addition, we adjusted the analyses for several socioeconomic, lifestyle and psychological characteristics of the mothers that can affect child behaviour problems and potentially be related to cell or cordless phone use during pregnancy. However, we acknowledge that we

cannot exclude confounding from genetic or other factors such as paternal psychological problems.

The present study has some limitations. Since maternal phone use was asked at 7 years' follow-up, a differential recall bias related to the outcome could have been introduced. However, given that child behaviour problems were assessed 2 years before the mothers reported phone use, it is unclear whether they could have systematically underestimated or overestimated their phone use report. In addition, we also used teacher-reported behaviour problems which would be unlikely to be related to maternal-reported phone use. A previous study showed that the number of retrospectively self-reported phone calls was slightly underestimated.[23 24] Another limitation is that our study is focused on the frequency of phone calls, which might be an imperfect proxy of exposure. It has been shown that besides the amount of use, the amount of RF-EMF exposure also depends on the duration of the calls, the use of hands-free equipment, the communication system and the frequency band used.[7] In our study, when the use of a hands-free equipment was taken into account, the results remain similar. Another limitation is that not all ABCD participants were included in this analysis and loss to follow-up was related to a lower socioeconomic position, limiting the generalisation of our results. However, since we observed no effect of prenatal cell and cordless phone use on child behaviour problems, it remains unclear how the potential biological mechanism behind this association would only have a role among low socioeconomic families.

Our findings are not in accordance with a previous study that reported an association between prenatal cell phone use and maternal-reported child behaviour problems in two independent analyses of the Danish National Birth Cohort.[3 4] Similar to our study, maternal cell phone use during pregnancy was asked at 7 years' follow-up and the same child behaviour problems questionnaire was used. The first analysis included children born between 1997 and 1999 where 27.5% of the mothers reported prenatal cell phone use.[3] The adjusted OR (aOR) was 1.5 (95% CI 1.3 to 1.8) on overall behaviour problems, with an increased significant odds of hyperactivity, conduct problems and peer-

relationship problems. In the second analysis, a new group of children born between 1998 and 2002 was included where 43.2% of the mothers reported prenatal cell phone use.[4] Although the effect estimate for overall behaviour problems was slightly lower compared with the first analysis, the associations remained statistically significant (aOR=1.3, 95% CI 1.1 to 1.5). A possible explanation for this slightly reduced effect estimate was that the early adopters of the cell phone technology, included in the first analysis, presented different characteristics than the late adopters. However, in both analyses, cell phone users were more often in the lower socioeconomic position, smoked more during pregnancy, were younger and reported higher prenatal stress. Conversely, in our study where children were born between 2003 and 2004, cell phone users (93.9%) were more often in a higher socioeconomic position and tended to report less anxiety during pregnancy. This distribution would better reflect the current cell phone use. The prevalence of child behaviour problems, reported by the mothers, was also different between the studies (7% in Divan et al vs 3% in our study). The prevalence of child behaviour problems reported by the teachers in our study was higher (10%), but despite that, we found consistent non-significant associations between teacher reports and maternal reports. Given the low prevalence of child behaviour problems, the low percentage of non-users and the small sample size of our study compared to Divan et al, our results could be unstable. However, when we included the non-regular users (<1 call/day) in the reference category, the results remained unchanged.

In conclusion, our results do not suggest that maternal cell or cordless phone use during pregnancy increases the odds of behaviour problems in their children at 5 years of age.

What is already known on this subject?

A previous study reported an association between maternal cell phone use during pregnancy and maternal-reported child behaviour problems at age 7. The biological mechanisms behind this possible relationship are poorly understood. However, a true adverse effect of cell phone exposure on child behaviour problems would have a large public health impact given the ubiquity of the exposure.

What this study adds?

Our results do not suggest that maternal cell phone or cordless phone use during pregnancy increases the odds of teacher-reported and maternal-reported behaviour problems in their children at 5 years of age such as hyperactivity, conduct problems, peer relationship problems or emotional symptoms. Together with cell phones, cordless phones represent the main exposure source of RF-EMF to the head. Although the type of radiofrequency-electromagnetic emission between both phones is not exactly identical, if a biological effect of the exposure to radiofrequency-electromagnetic exists, we would expect to observe similarities regarding the health effects. The consistent absence of the association of cell phone and cordless phone use on child behaviour problems assessed by teachers and mothers strengthens the findings of our study.

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