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Infant Sleep Duration is Related to Externalizing Behavior at the Age of 18 Months: Results from a Dutch Cohort Study

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Abstract

Background: Sleep is essential for children's daytime functioning. Sleep problems have been related to several behavioral disorders. In the last few decades, growing attention has been given to externalizing problem behavior. Previous work has indicated that children and adolescents presenting externalizing problem behavior are at risk for an array of disorders in adulthood, including anxiety, disruptive behavior, mood problems and substance use. Several studies have shown that sleep problems may be related to externalizing problem behavior; research however is limited, especially among children younger than 18 months.

Methods: Data from the Dutch mother-child cohort LINC (Linking Maternal Nutrition to Child Health) were used. Sleep patterns were assessed by sleep diaries, which were filled out by the parents or caretaker when the child was three, six, nine, twelve and eighteen months old. Using the sleep diaries, sleep duration, nocturnal awakenings and early awakenings were calculated for each child at each time point.

Externalizing behavior was assessed by using the scale 'Externalizing behavior' of the Child Behavior Checklist 1.5-5. Mixed model analyses were conducted to determine whether random intercepts and/or slopes had to be included in analyses regarding the development of the sleep variables over time (0-18 months).

A random intercept and random slope was included for sleep duration and nocturnal awakenings, while for early awakenings only a random intercept was added. Subsequently, linear regression analyses were carried out to study the relationship between sleep characteristics over time with externalizing behavior as continuous, dependent variable. Family history, educational level, smoking, alcohol use and illicit drug use during pregnancy were checked for possible confounding effects. In total, data from 85 to 91 mother-child pairs were included, depending on the sleep variable.

Results: The intercept of sleep duration was found to be significantly related to externalizing scores on the CBCL (β=-2.35; CI=-4.31, -0.16; p=0.03). No other significant results were found.

Conclusion/discussion: We found that sleep duration was significantly related to externalizing behavior at 18 months. More specifically our results indicate that children who sleep less on average show more externalizing behavior. However, results should be interpreted with caution as the sample size was limited. Future studies should make use of longitudinal designs and larger sample sizes to confirm the relationship between sleep patterns and behavioral development over time.

Keywords: Infant sleep duration; Dutch cohort study; Sleep problems; Behavioral disorders; Externalizing behavior

Abbreviations:

ADHD: Attention Deficit Hyperactivity Disorder; CBCL 1.5-5: Child Behavior Checklist 1.5-5.

Introduction

During our lives, we spend almost one third of our time sleeping. Despite extensive research, there is no consensus on the function of sleep. It has been suggested that adequate sleep represents a restorative function which is crucial to control attention, emotion and behavior [1-5]. Deviant sleep patterns have been related to various adverse neurobehavioral effects in children, such as reduced cognitive functioning and poor school performance [6-10].

Therefore, it might not be a surprise that in literature sleep problems have been related to emotional as well as behavioral problems in both children and adolescents, although causal effects could not be demonstrated. In a study by Vriend et al. among 8 to 12 year old children, sleep duration was reduced or increased with one hour for four nights [11].

Children then completed the opposite condition. Depending on the group, significant associations were found with emotional functioning, memory, attention, and math fluency. The authors therefore state that

even minor differences in sleep duration over a couple of nights can have significant consequences for children's emotional and cognitive functioning, emphasizing the importance of sleep duration for children's daytime functioning [11].

Furthermore, work from Sivertsen et al. has indicated that sleep problems, including short sleep duration, predict concurrent and later emotional as well as behavioral problems in children at the age of 18 months [12].

The sleep duration of children has steadily declined [13,14]. For example, in an Australian study Dollman et al. reported a decline in sleep duration between 1985 and 2004 of respectively 33 minutes in boys aged ten to fifteen years (from 9 hours 13 minutes to 8 hours and 40 minutes) [13]. For girls a decline of 28 minutes was reported: from 9 hours and 16 minutes to 8 hours and 48 minutes. In addition, in a Swiss study it was found that the sleep duration of 2-year old children decreased with 38 minutes between 1974 and 1986.

The authors suggest this trend is caused by an increasingly delayed bedtime, but unchanged wake time across decades [14]. Currently, 25% of the children is affected by sleep problems, including a disturbed sleep duration [15]. When left untreated, temporary sleep problems may persist to become chronic [16].

Simultaneously with increasing rates of sleep deprivation among children, prevalence rates of behavioral disorders among children are rising. Over the last 20 years, the number of children in contact with health care systems for the diagnosis and treatment of behavioral disorders has grown [17].

Increasing prevalence rates have been reported for obsessive-compulsive disorder, hyperkinetic disease, Tourette syndrome and Autism Spectrum Disorder [17]. With regard to Attention Deficit Hyperactivity Disorder (ADHD), prevalence rates in the United States were estimated at 7.8% in 2003, which increased to 9.5% in 2007 and 11.0% in 2011 [18]. Similar trends are also reported in other parts of the world, making it a global concern [19-21].

Several behavioral disorders have been related to sleep problems. In the last few decades, special attention has been given to externalizing problem behavior which is problem behavior directed toward the external environment.

In preschoolers externalizing problem behavior may include non-compliance, irritability, motor overactivity, aggressiveness or inattention [22]. Externalizing problem behavior has both concurrent and long-term consequences for the individual, family and friends, as well as the society in general [23].

Previous work has indicated that children and adolescents with externalizing problem behavior are at risk for an array of disorders in adulthood, including anxiety, disruptive behavior, mood problems and substance use [24-36]. Hence, externalizing problem behavior in childhood may predict behavioral problems later in life.

In a Canadian study parents had to rate sleep problems in their children on a 5-point Likert scale (1=almost never, 5=almost all the time). Problems included falling asleep, particular and long bedtime routine, nocturnal awakenings and restless sleep. An overall sleep problems score was calculated. The authors found that sleep problems accounted for a significant percentage of the variance in externalizing behavior, including inattentiveness, hyperactivity and physically aggressive behavior [37].

In another study, mothers had to indicate the presence and length of nocturnal awakenings of their 29-month old child. Three groups were created: no nocturnal awakenings, total nocturnal awakenings of less than 20 minutes and total nocturnal awakenings of more than 20 minutes. Using parental reports, children with nocturnal awakenings of more than 20 minutes scored higher on externalizing behavior [38].

Given the high prevalence rate of sleep problems among children and their possible impact on behavioral development in children, it seems essential to further investigate this relationship. Externalizing problem behavior in childhood may predict behavioral problems later in life; it therefore seems essential to further explore the role of this variable.

However, data on the relationship between sleep problems and externalizing behavior in preschool children are limited, especially with regard to preschool children. This is the first study to assess this relationship prospectively. We hypothesize that children with a shorter sleep duration, show more externalizing behavior. In addition, children presenting disrupted sleep patterns, are also expected to show more externalizing and problem behavior.

Methods

Study population

Data were used from the Dutch prospective mother-child cohort LINC (Linking EDCs in Maternal Nutrition to Child Health). The cohort was set up in the region of Zwolle, both a rural and urban setting in the Netherlands. Women were recruited from 2011 to 2013 during their first antenatal visit to the midwifery clinic. Women who were not able to fill out Dutch questionnaires were excluded from participation. Other exclusion criteria were pre-eclampsia, twin pregnancies and major congenital anomalies at birth.

After inclusion, participants were followed during pregnancy and after birth, until the child was 18 months old. During this period, the parents filled out questionnaires every three months on, amongst others, life style, mental wellness and environment. The LINC-study has been approved by the Medical Ethical Committee of the VU University Medical Centre (VUmc).

Sleep diaries

Sleep patterns were assessed by sleep diaries (appendix I), which were filled out by the parents or caretaker when the child was three, six, nine, twelve and eighteen months old. Parents could indicate for every hour of the day if the child was sleeping, was awake, was crying, or was being fed. Parents reported this for seven consecutive days in total. Using the sleep diaries, sleep duration, nocturnal awakenings and early awakenings were calculated for each child at each time point.

Daily sleep duration was calculated by summing up the total amount of time spent sleeping in one week, and dividing this number by seven. A child was defined as having nocturnal awakenings (yes: 1 or no: 0) if it woke up between 11pm and 5am, at least two times a week. A child was defined as having early awakenings (yes: 1 or no: 0) if it woke up between 5am and 6am, at least two times a week. Parents could make notes for each day separately in an additional table. If a child was ill, data from that day were excluded from further analysis.

Externalizing behavior

When children were 18 months of age, parents filled out the Child Behavior Checklist 1.5-5 to assess the behavioral development of the child [39]. The questionnaire consists of 99 items. Parents had to indicate on a 3-point Likert scale whether an item was very true (2), somewhat true (1) or not true (0) for the child. Scores were calculated according to the algorithm of the manual [39].

The subscale 'Externalizing' was used for the analysis. The scale 'Externalizing' consists of two other sub scales: 'Attention Problems' and 'Aggressive Behavior'.The scale consists of twenty-four items. A raw sum score (range 0-48) was used for the analyses. The software program Assessment Data Manager was developed by Achenbach for data management purposes of the CBCL and was used for the calculation of these raw scores.

According to Achenbach and Rescorla, for statistical analyses raw scores are usually preferable, as they directly reflect all differences among scores [39]. In addition, there are no effects of transformations and differences at the low end of the normal range are maintained.

Covariates

Covariates were selected based on literature [40-45]. Family history, educational level, smoking, alcohol use and illicit drug use during pregnancy were checked for possible confounding effects.

Questionnaires were used for the collection of these data. For family history, parents were asked if the child had family members with ADHD (yes or no). With regard to educational level, parents were asked to indicate the highest educational level they had completed, using eight different categories. The educational level was labeled as 'high' if at least one of either parent(s) had obtained a Bachelor's or a Master's Degree, and 'low' otherwise.

For the assessment of alcohol use the mother was asked if she had used alcohol during pregnancy (yes or no). Smoking and illicit drug uses during pregnancy were assessed similarly. Under 'Analysis', information if provided on the covariate selection for the statistical models.

Analysis

First, selective non-response was studied by comparing included and excluded mother-child pairs on a number of demographic variables (means of gestational age, maternal BMI, age of the mother at birth and level of maternal education).

Stata 12.1 was used to conduct mixed model analyses in order to analyze the development of the three sleep variables (sleep duration, early awakening and nocturnal awakenings) over the first 1.5 years of life. In these analyses we included random intercepts and/or slopes at the individual level based on the Akaike information criterion (AIC) of the models.

Linear mixed models were estimated for sleep duration and logistic mixed models were estimated for early awakenings and nocturnal awakenings. A continuous time variable was added to the models as a fixed effect. For nocturnal awakenings we assumed a quadratic development over time by adding time squared to the model, based on an improved fit of the model.

A random intercept and random slope was included for sleep duration and nocturnal awakenings, while for early awakenings only a random intercept was added. For example, with regard to sleep duration a random intercept of 1 would mean the child sleeps 1 hour more on average in comparison to the estimated mean sleep duration in the population.

The random slope ld refers to the degree to which the sleep duration of a child decreases or increases more rapidly over time than that of others. The individual intercepts and slopes based on these models were saved and used in the subsequent analyses.

Linear regression analyses were carried out to study the relationship of sleep characteristics over time with externalizing behavior as continuous, dependent variable. In these analyses the random intercepts and slopes from the analyses on sleep patterns (sleep duration, nocturnal and early awakenings) were added to the models as central independent variables. Bootstrap methods were applied, based on 1000 bootstrap samples, in order to estimate the confidence intervals. When bootstrapping, pseudo-samples (named bootstraps) are drawn from the original sample.

The method is convenient for nonlinear statistics or when the sample size is small as there are no distributional assumptions. Bootstrapping may provide more accurate confidence intervals than the standard methods in these cases. It should be noted that, although we believe that for the current study this was the most valid approach, null-hypothesis tests based on p-values did not resemble those based on the bootstrapping confidence intervals.

A confidence interval that did not cross the null was considered to be statistically significant. Adjusted analyses included covariates that changed the regression coefficients of the central determinants with 10% or more after adding them to the statistical models. All analyses were carried out in SPSS 21.

Results

Sample characteristics

A flow chart of the number of participants is presented in Figure 1. A total of 144 mother-child pairs was included in the study. Twenty-six pairs dropped out of the study.

In addition, one participant had a miscarriage, and from 18 mother-child pairs no CBCL or sleep data was available. Therefore, the total number of included mother-child pairs was 99.

The included mother-child pairs were compared to the 45 excluded pairs on a number of demographic variables, which were available for most pairs.

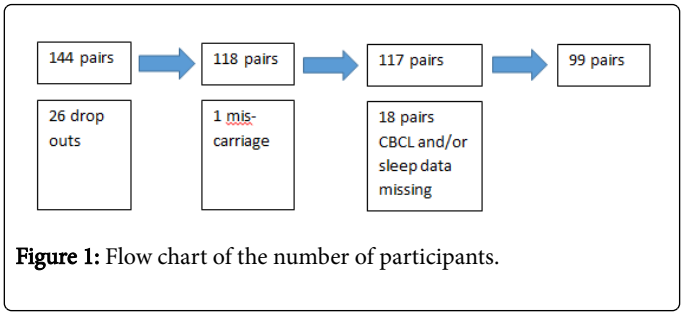

Figure 1: Flow chart of the number of participants.

No significant mean differences were found for gestational age, maternal BMI and the age of the mother at birth. The median level of maternal education was at least a Bachelor's degree in both groups.

Characteristic	N		Range
Gestational age in weeks (mean, SD)	92	39.9 (1.2)	36.4-42.1
Age mother in years (mean, SD)	97	30.5 (3.7)	21-40
Educational level (high, %)	85	74 (76.3)	-
Smoking pregnancy (yes, %)	97	5 (5.2)	-
Alcohol use pregnancy (yes, %)	97	11 (11.3)	-
Illicit drug use pregnancy (yes, %)	97	0 (0)	-
Family history ADHD (yes, %)	96	13 (13.5)	-
Externalizing behavior score (mean, SD)	99	10.4 (6.2)	0-27

Table 1: Maternal characteristics and externalizing behavior scores in 18 months old children. ADHD=Attention Deficit Hyperactivity Disorder; CBCL=Child Behavior Checklist; N=sample size; SD=standard deviation.

In Tables 1 and 2, an overview is provided of the characteristics of the study population. The mean score on the Externalizing Behavior scale was 10.4. More than 13 percent of the children had a family member affected by ADHD.

In Table 2, study characteristics are provided with regard to the sleep patterns. The number of included mother-child pairs varies over time, limiting comparability of the data.

When looking at the percentages, the data seems to indicate a slow decline over time for sleep duration, nocturnal and early awakenings.

However, when taking only the numbers into account, for nocturnal and early awakenings, the data does not seem consistent as the number of children with either nocturnal or early awakenings at 18 months seems to increase compared to the time point of 12 months.

	Sleep duration (hrs)		Early awakenings		Nocturnal awakenings	
	N	Mean (SD)	N	Yes (%)	N	Yes (%)
3 months	64	14.1 (1.6)	64	26 (40.6)	64	41 (64.1)
6 months	53	14.1 (1.3)	53	14 (26.4)	52	22 (42.3)
9 months	48	13.9 (1.4)	48	8 (16.7)	48	17 (35.4)
12 months	53	13.9 (1.1)	53	5 (9.4)	53	18 (34.0)
18 months	90	13.5 (1.1)	89	6 (6.7)	89	24 (27.0)

Table 2: Sleep behavior during the first 18 months of life. SD=standard deviation

Associations between sleep patterns and externalizing problems at 18 months

Mixed models were used to study the associations between sleep patterns and externalizing problems at 18 months, using random intercepts and random slopes. With regard to sleep duration, the random intercepts ranged from -2.47 to 1.85. This means that the variation in sleep duration ranged from 2.47 hours below, to 1.85 hours above the average sleep duration. The random slopes for sleep duration varied between 0.08 to 0.11. The range of the random intercepts for nocturnal awakenings varied from -37.10 to 2.83, while the random slope varied between -1.08 to 0.51. For early awakening, only a random intercept was added to a model, ranging from -1.07 to 2.46. In Table 3, the results of the crude and adjusted analyses for the relation between the random coefficients of the sleep variables and externalizing problems are presented. In the crude analysis, the intercept of sleep duration was found to be significantly related to externalizing scores on the CBCL (β=-2.35; CI=-4.31, -0.16; p=0.03). This means, that with every hour of increase in average sleep duration, a child scored 2.35 points lower on the externalizing scale of the CBCL (Table 3). As none of the covariates caused at least a 10% change in the regression coefficient after adding the variable to the model, no adjusted analysis was performed with regard to sleep duration. No other significant results were found.

Variable	Crude analysis				Adjusted analysis			
	N	β	95% CI	p-value	N	β	95% CI	p-value
Sleep duration[1]								
Random intercept	99	-2.35	-4.31, -0.16	0.03	-	-	-	-
Random slope	99	-32.31	-70.49, 6.19	0.09	-	-	-	-
Nocturnal awakenings[2]								
Random intercept	92	0.01	-0.17, 0.28	0.87	92	0	-0.19, 0.28	0.99
Random slope	92	3.4	-0.27, 6.97	0.05	92	3.51	-0.66, 7.19	0.06
Early awakenings[3]								

Random intercept	95	0.67	-0.93, 2.25	0.39	95	0.57	-1.13, 2.18	0.51

Table 3: Regression coefficients, confidence intervals and p-values for sleep and score on the scale 'Externalizing problems' of the CBCL 1.5-5. Significant at an alpha of 0.05, β=regression coefficient; CI: Confidence Interval; N: Sample Size; [1]No confounders caused a ≥10% change in the regression coefficient, [2]Adjusted for smoking pregnancy, Family history of ADHD, Alcohol use pregnancy, [3]Adjusted for smoking pregnancy, Alcohol use pregnancy.

Discussion

To our knowledge, this is the first study to prospectively examine the relationship between sleep patterns in the first 18 months of life and their relation with externalizing behavior at the age of 18 months. Sleep characteristics were assessed at different time points using sleep diaries, while for the assessment of behavioral development the CBCL 1.5-5 was used. We found that sleep duration was significantly related to externalizing behavior. More specifically our results indicate that children who sleep less on average show more externalizing behavior. As the sample size was small, results should be interpreted with caution.

We found a significant association between the intercept of sleep duration and externalizing behavior. Children who slept an hour more scored 2.60 points lower on the externalizing scale of the CBCL. The effect is moderate, as the maximum score on the scale is equal to 48. However, our findings are in line with previous studies conducted in somewhat older children. In a recent study from the United States in children of four years old, parents reported their children's bed and wake times on weekdays in order to assess sleep duration [5]. Parents also rated their child on six different types of externalizing behavior. Children sleeping <9.44 hours (1 standard deviation below the mean of 10.47 hours) presented a significantly higher odds of all aspects of externalizing behavior, including over activity, anger, aggression, impulsivity, tantrums and annoying behavior [5]. In a different study, a short sleep duration in eight year old children was related to an increased risk for externalizing behavior (2.9 to 3.9-fold increased risk) [46]. In addition, in a meta-analysis of 86 studies conducted in 2012, a shorter sleep duration was significantly related to more behavioral problems in children aged five to twelve years (r=0.09; CI: 0.07, 0.11). Subsequent analysis showed that both internalizing (r=0.09; CI: 0.06, 0.12) and externalizing behavior (r=0.08; CI: 0.06, 0.11) were positively associated to a shorter sleep duration [47]. Finally, in a longitudinal study, a reduced sleep duration and sleep quality in school-aged children (6-17 years old) predicted symptoms of externalizing behavior over time, as well as depression and anxiety [48]. To a lesser extent, behavioral problems predicted changes in sleep characteristics as well, indicating a potential reciprocal relationship.

Although research in especially preschool children is limited, studies conducted so far have reported similar results, with a shorter sleep duration being related to more externalizing behavior. In only one study, using teacher and parent reports, a shorter sleep duration was not significantly related to externalizing problems in children aged five to six [49]. However, the direction of the results was the same, with a shorter sleep duration being related to more externalizing problems.

Recent research indicates that emotional disruption might be the mechanism at work in the association between sleep patterns and externalizing behavior. In a review, Kouros and El-Sheikh suggest that emotional regulation may present a pathway linking sleep patterns and behavioral outcomes [1]. In a study by Yoo and colleagues, participants deprived from sleep for approximately 35 hours showed an increase of 60% in the response of the amygdala to negative stimuli, compared to the control group [3]. In addition, participants deprived from sleep showed a decrease in functional connectivity between the amygdala and the medial-prefrontal cortex, which has been related to affective processing.

Findings from the above studies should be interpreted with caution as a reduction in sleep duration is not equal to sleep deprivation. However, it has been suggested that a lack of sleep may modulate the response of the human brain to negative stimuli and that sleep deprivation may lead to a reduction in top-down, prefrontal control [3]. Sleep may provide a framework in which the neuronal systems that are involved in emotion regulation and the processing of recent emotional experiences are 'reset' [2,3]. Therefore, it is speculated that sleep deprivation could be implied in the etiology of behavioral disorders, especially mood disorders [1,3].

Strengths of the current study include the homogeneity of the study population in educational level and ethnicity, which decreases the likelihood of confounding by demographic factors. To assess externalizing behavior, the CBCL 1.5-5 was used. The CBCL is a well-known and widely used screening instrument in clinical practice for behavioral problems as it is considered both a reliable and valid instrument [50]. When examining the psychometric properties of the CBCL 1.5-5, with regard to the (test-retest) reliability of the scales, a mean correlation was found of 0.85 across all scales, with most correlations falling in the 0.80s or 0.90s [39]. Across all scales, a mean correlation of 0.61 was found with regard to both cross-informant agreement and the stability of the scale scores (using an interval of 12 months). The content and criterion-related validity were positively evaluated, as the questionnaire was found to significantly discriminate between referred and nonreferred children (p<0.01). Although the CBCL should be combined with observational techniques for diagnostical purposes, it is a useful screening method for behavioral problems [50]. Furthermore, data with regard to sleep patterns was collected over several days (one week) which may increase the reliability of the parameters assessed. Moreover, as data was collected at five different time points, individual sleep patterns could be analyzed. However, we did not assess information on daytime napping, which has been related to behavioral outcomes in preschool children in previous work [51,52]. In addition, the sleep diaries used in this study have not been validated previously, which is a possible weakness. Up to our knowledge, this is the first study using this sleeping diary, limiting comparability with other studies (hiscock & Jordan, 2004). As the sleep diaries depend on parental observation, information might be less accurate when compared to more objective measurements such as a sleep actigraphy or polysomnography.

Previous work has indicated that the sleep diary is cost-effective and useful when administered to larger samples, but is also characterized by lower response rates and a higher risk of missing or incomplete data [53-56]. In addition, only externalizing behavior was included in the current study, while sleep patterns may also be related to other behavioral outcomes. Unfortunately, the other subscales of the CBCL

1.5-5 were not normally distributed in our sample. Only the Attention Deficit Hyperactivity subscale was normally distributed. However, we did not find any significant results for this subscale (supplemental materials) in our cohort. This does not seem surprising, as most children do not receive a diagnosis of ADHD before the age of 7 (Visser et al.). Hence, the age of 18 months may be too young to successfully differentiate age appropriate from disturbed behavior. Finally, the sample size in this study was small, which reduced the power of our study. Therefore, the results should be interpreted with caution.

A healthy sleep duration is critical for the emotional well-being of children [5]. At this moment, sleep disturbances are often considered to be symptoms of other disorders [57]. Despite an overlap in symptoms, there are strong arguments not to regard sleep disturbances only as secondary to other disorders [58]. Sleep disturbances may already exist before other problems develop. In the current study, differences in sleep patterns were already observed in children from three to 18 months. Moreover, these differences were shown to be related to externalizing problem behavior. These results may be an indication to start interventions in children with sleep problems at a younger age. In addition, the treatment of sleep problems may lead to a reduction in symptoms of other disorders [57,58].

Conclusions and Recommendations

The objective of the current study was to explore the relationship between sleep patterns and externalizing behavior at the age of 18 months. In the current study, differences in sleep patterns were already observed in children from three to 18 months. Moreover, differences in sleep duration over time were negatively related to externalizing behavior. Although the results from the current study should be seen as exploratory, health care professionals are encouraged to advocate for a healthy sleep hygiene as well as regular sleep habits and bedtime routines for children. Future studies should make use of longitudinal designs and higher sample sizes to confirm the relationship between sleep patterns and behavioral development over time, while exploring the role of daytime napping.

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Appendix 1:

Characteristic	Mean	SD	Range	N and % of children subclinical or clinical
Emotionally reactive	1.5	1.6	0-7	3 (3%)
Anxious/depressed	0.9	1	0-5	0 (0%)
Somatic complaints	1	1.2	0-5	2 (2%)
Withdrawn	0.6	1	0-5	1 (1%)
Sleep problems	1.4	2.2	0-12	2 (2%)
Attention problems	2.3	1.7	0-6	3 (3%)

Aggressive behavior	8.1	5.1	0-22	2 (2%)
Affective problems	1.3	1.7	0-8	4 (4%)
Anxiety problems	1.6	1.7	0-10	2 (2%)
Pervasive developmental problems	1.5	1.6	0-8	1 (1%)
Attention deficit hyperactivity problems	3.7	2	0-8	0 (0%)
Oppositional defiant problems	3.3	2.3	0-10	5 (5%)
Internalizing behavior	4	3.5	0-17	3 (3%)
Externalizing behavior	10.4	6.2	0-27	7 (7%)
Total problems score	21	12.7	Feb-55	-2%

Table 1: CBCL scores in 18 months old children (n=99). CBCL = Child Behavior Checklist; N = sample size; SD = standard deviation.

Appendix 2:

Variable	Crude analysis				Adjusted analysis			
	N	β	95% CI	p-value	N	β	95% CI	p-value
Sleep duration[1]								
Random intercept	88	-0.45	-1.22, 0.01	0.15	88	-0.37	-1.00, 0.37	0.27
Random slope	88	-6.68	-19.21, 5.59	0.25	88	-5.37	-17.28, 6.37	0.35
Nocturnal awakenings[2]								
Random intercept	85	0.02	-0.06, 0.12	0.56	85	0.02	-0.05, 0.12	0.68
Random slope	85	0.36	-0.80, 1.38	0.51	85	0.45	-0.92, 1.53	0.46
Early awakenings[3]								
Random slope	85	0.2	-0.28, 0.69	0.42	85	0.13	-0.37, 0.67	0.6

Table 2: Regression coefficients, confidence intervals and p-values for sleep and ADHD score on the CBCL 1.5-5.β = regression coefficient; CI = confidence interval; N = sample size; [1] Adjusted for: Alcohol use pregnancy, Smoking pregnancy, [2] Adjusted for: Smoking pregnancy, Alcohol use pregnancy, Family history of ADHD, [3] Adjusted for: Smoking pregnancy, Alcohol use pregnancy, Family history of ADHD.