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Sleep problems and depressive symptoms in toddlers and 8-year-old children: A longitudinal study

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Abstract

Sleep and depression are interlinked throughout the lifespan, but very few studies have examined the directionality of the sleep–depression link in children. The aim of the current study was to prospectively examine the bidirectional association between sleep problems and internalizing problems and depressive symptoms in toddlers and children aged 1.5 and 8 years. Data stem from the large ongoing population-based longitudinal study, the Norwegian Mother, Father and Child Cohort Study, recruited from October 1999 to July 2009. A total of 35,075 children were included. Information on sleep duration, nocturnal awakenings and internalizing problems (Child Behaviour Checklist) was provided by the mothers at 1.5 years, whereas data on sleep duration and depressive symptoms (Short Mood and Feelings Questionnaire) were provided by the mothers when the children were 8 years old. Odds ratios (ORs) were calculated using logistic regression analyses. After accounting for previous internalizing problems, short sleep duration (≤10 hr) and frequent (≥3) nightly awakenings at 1.5 years predicted the development of depressive symptoms at 8 years of age (adjusted OR = 1.28; 95% confidence interval [CI] 1.08–1.51, and adjusted OR = 1.27, 95% CI 1.08–1.50, respectively). Also, internalizing problems at 1.5 years predicted onset of later short sleep duration (adjusted OR = 1.83, 95% CI 1.32–2.54) after accounting for early sleep problems. This prospective study demonstrated a bidirectional association between sleep and internalizing/depressive symptoms from toddlerhood to middle childhood. Intervention studies are needed to examine whether targeting either of these problems at this early age may prevent onset of the other.

KEYWORDS

epidemiology, longitudinal, mental health, population based, sleep

1 | INTRODUCTION

Sleep and depression are interlinked throughout the lifespan, with close associations being reported both in adults (Baglioni et al., 2011), adolescents (Sivertsen, Harvey, Lundervold, & Hysing, 2014) and young children (Hysing, Sivertsen, Garthus-Niegel, & Eberhard-Gran, 2016). Sleep and depression do not merely co-occur; they also seem to influence each other over time. A systematic review of longitudinal studies of both children and adults on the association between sleep and depression, suggested that there was some evidence for a significant bidirectional association. However, the review also concluded that definitive conclusions regarding bidirectionality could not be made due to the small number and heterogeneity of cohort samples, and that more research was needed to further explore the nature of the link, and across age cohorts (Alvaro, Roberts, & Harris, 2013).

Very few studies have examined the directionality of the sleep–depression link in children, with a few notable exceptions. In an investigation of 9–16-year-old children, a longitudinal sample from the US Great Smoky Mountain study found sleep problems to both predict, and be predicted by, depressive symptoms (Shanahan, Copeland, Angold, Bondy, & Costello, 2014). In contrast, a UK twin study found sleep problems at 8 years to significantly predict depression 2 years later, whereas there was no evidence of the converse (Gregory, Rijsdijk, Lau, Dahl, & Eley, 2009). Similar results have been found between sleep problems and internalizing problems, including both anxiety and depressive symptoms. A recent study of 4,983 Australian children aged 4–5 years, found that sleep problems were significantly associated with later internalizing problems through ages 12–13 years, whereas the reverse association was not significant (Quach, Nguyen, Williams, & Sciberras, 2018). Finally, investigating younger children, a large Dutch study found that early sleep problems at 2 months were associated with onset of internalizing problems at 36 months. They did not find support for the reverse association (Jansen et al., 2011).

There are also a few studies that have examined *one* of the directions but not the other. For example, an investigation following 292 children from preschool age (age 3–6) to 6 years later showed that early sleep problems significantly predicted depressive symptoms (Gregory & O'Connor, 2002; Gregory & Sadeh, 2016). Similarly, insomnia in 4-year-old Norwegian pre-schoolers significantly predicted symptoms of depression 2 years later (Steinsbekk & Wichstrom, 2015). Finally, a large Norwegian epidemiological study recently found that short sleep duration and frequent nocturnal awakenings in 18-month-old toddlers were associated with both internalizing and externalizing problems at 5 years (Sivertsen et al., 2015). The reverse directionality was left unexplored in all of these studies. As such, there are indications that the association between sleep problems and depression may be developmentally dependent, with the specific nature and strength of the associations possibly changing over time. Thus, it is important to assess the association longitudinally and across developmental time periods to get a better understanding of the sleep–depression link between preschool and early childhood. Adding to the existing literature of bidirectional studies, the current study was designed to examine the sleep–depression link across the ages from 1.5 to 8 years. This is important for two reasons. The first is a developmental reason. The age range (1.5 to 8 years of age) is representative of toddlerhood and childhood, respectively, which so far has not been explored in detail. The second is a pragmatic reason; these are the time-points that included the measures of interests.

An important, but much neglected aspect in this context, is to consider the often-found high individual stability of both sleep problems and depressive symptoms (Hysing et al., 2014). Based on these considerations, the aim of the current study was two-fold: (a) to assess if early sleep problems at 18 months can predict the development of depressive symptoms at 8 years of age, after accounting for early internalizing problems; and (b) to assess the opposite directionality by predicting development of later sleep problems at 8 years, from early internalizing problems at 18 months, also after accounting for early sleep problems at 1.5 years.

2 | METHODS

This study draws from the Norwegian Mother, Father and Child Cohort Study (MoBa). In brief, the MoBa is a prospective population-based pregnancy cohort study conducted by the Norwegian Institute of Public Health (Magnus et al., 2016). Pregnant mothers were recruited from all over Norway from 1999 to 2009 and 41% of invited women provided written consent to participate. The cohort included more than 114,000 children and 95,000 mothers. Follow-up is ongoing by the administration of questionnaires at regular intervals. Using data from the Medical Birth Registry of Norway (MBRN), it has been shown that although prevalence estimates of exposures and outcomes in the MoBa study may be biased due to self-selection, estimates of exposure–outcome *associations* are not affected by self-selection and therefore do not constitute a validity problem in terms of reduced representativeness (Magnus et al., 2006).

Mother-reported data in the current study come from Questionnaire 1 (gestational week 17 [data on maternal education]), Questionnaire 5 (18 months after birth) and Questionnaire 8 (8 years after birth), in addition to information from the MBRN. The present study is based on version 11 of the quality-assured data files released for research in September 2018. The current dataset comprises a longitudinal sample with valid data collected until 2018 on the dependent variables, including a total of 35,075 pregnancies. Figure 1 outlines the participant flow of the current sample. For the current study we did not employ any exclusion criteria.

The study was approved by The Regional Committee for Medical Research Ethics in south-eastern Norway (nr.2016/922).

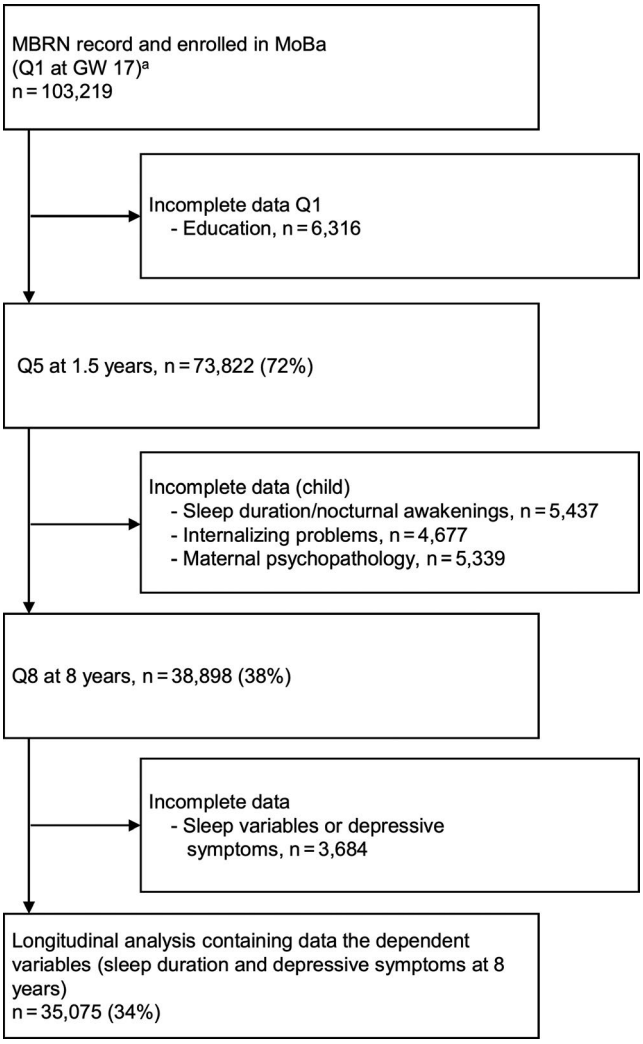

FIGURE 1 Participant flow chart. Note: Variables with incomplete data may overlap. GW, gestational week; MBRN, Medical Birth Registry of Norway; Q, questionnaire. [a]Q1 is the first Norwegian Mother, Father and Child Cohort Study (MoBa) questionnaire completed at gestational week 17; its completion implies enrolment in the study. About 10,000 pregnant women with an MBRN record did not complete Q1

2.1 | Measures

2.1.1 | Clinical and demographical variables

Information on maternal age, birth weight (measured in grams), gender, gestation (measured in weeks) and parity (percentage being the first, second, third and fourth child) was collected from the MBRN, whereas the mother's educational level (percentage with (a) primary education, (b) secondary education [high school], (c) <4 years of college/university and (d) 4 + years of college/university) was assessed by self-report. Maternal psychopathology when the child was 18 months was assessed using the SCL-8, an abbreviated version of the Hopkins Symptoms Checklist-25 (SCL-25). The SCL-8 comprises eight selected items (Tambs & Røysamb, 2014), of which four items capture symptoms of anxiety and four items tap symptoms of depression. The SCL-8 scores have been estimated to correlate by 0.94 with the total score from the original instrument (Tambs & Moum, 1993). These measures were included as potential confounders.

2.1.2 | Internalizing problems (1.5 years)

The Child Behaviour Check List (CBCL) (Achenbach, 1992) version for preschool children (CBCL/1.5–5) assesses a range of emotional, social and behavioural problems. The CBCL/1.5–5 consists of 99 items, which may be aggregated into two subscales measuring internalizing and externalizing behaviour problems. The CBCL version for older children has been validated in a Norwegian study (Novik, 1999), whereas the CBCL/1.5–5 has been validated in Dutch and Danish samples (Koot, Van Den Oord, Verhulst, & Boomsma, 1997; Kristensen, Henriksen, & Bilenberg, 2010). The MoBa was designed to cover a range of areas relevant to child health and development. As such, the full CBCL/1.5–5 was not included due to space restrictions. The 18 months' questionnaire in the MoBa included CBCL/1.5–5 items that were intended to represent all CBCL subscales with two or three items. In the current study, internalizing problems were assessed using the following five items: "Disturbed by any change in routine", "Clings to adults or too dependent", "Gets too upset when separated from parents", "Too fearful or anxious" and "Doesn't eat well". This abbreviated version of the internalizing scale strongly correlated ($r = .71$) with the full internalizing scale (Helland, Roysamb, Wang, & Gustavson, 2017), and all subscales of the CBCL showed good test–retest reliability from 18 to 36 months (only 18 months are included in this study [$r = .71$–$.93$, $p < .001$]). Also, inter-parental agreements were high and significant ($r = .63$ and $r = .60$ at ages 18 and 36 months, respectively) and all stability coefficients were significant at $p < .001$ over a 1.5-year period. Cronbach's alpha of the five included items in the current study was 0.41. The original CBCL scoring manual defines scores above the 93rd percentile as being in the clinical range (corresponding to a *T*-score above 65), and the same procedure was used on the corresponding subscale of the abbreviated internalizing subscale in the current study.

2.1.3 | Depressive symptoms (8 years)

Symptoms of depression were assessed using the parent-reported short version of the Mood and Feelings Questionnaire (SMFQ) (Thapar & McGuffin, 1998). The SMFQ is comprised of 13 items assessing depressive symptoms, of which none are sleep related, each rated on a 3-point Likert scale: "not true", "sometimes true" and "true". Examples of items included in the SMFQ are "S/he felt miserable or unhappy", "S/he was very restless", "S/he didn't enjoy anything at all", "S/he thought s/he could never be as good as other kids", and "S/he felt miserable or unhappy". The total SMFQ is calculated by summing the values (0–2) on each of the 13 item responses, yielding a range of 0–26. High internal consistency between the items and a strong unidimensionality have been shown

in population-based studies (Sharp, Goodyer, & Croudace, 2006) and was also recently confirmed in a Norwegian population-based study of adolescents (Lundervold, Posserud, Stormark, Breivik, & Hysing, 2013). Cronbach's alpha of the SMFQ in the current study was 0.79.

2.1.4 | Sleep variables (1.5 and 8 years)

Sleep duration at both 18 months and 8 years was assessed by the question: How many hours in total does your child sleep in 24 hr? Due to the developmentally expected change in sleep duration from 18 months to 8 years, the response categories at 18 months were "10 hr or less", "11–12 hr", "13–14 hr" and "15 hr or more", whereas the corresponding options at 8 years were: "8 hr or less", "9 hr", "10 hr", "11 hr" and "12 hr or more". The two latter categories were combined to form the reference category, based on the most frequent sleep durations in this age group. The cut-off of ≤10 hr per night for short sleep duration at 18 months was based on recent recommendations from the American Academy of Sleep Medicine (AASM) (Hirshkowitz et al., 2015). Nocturnal awakenings at 18 months were assessed with a single question: How often does your child usually wake during the night? Response categories were "3 or more times every night", "once or twice every night", "a few times a week", and "seldom or never". The latter category was set as the reference category.

2.2 | Statistical analyses

All analyses were performed using the SPSS 25 (SPSS Inc., Chicago, IL, USA). Logistic regression analyses were used to estimate associations between sleep variables at 18 months and depressive symptoms at 8 years, as well as the reverse association: if internalizing problems in toddlers were associated with later sleep problems. Both crude/unadjusted and adjusted analyses were conducted. Adjustment variables included maternal age and education, maternal psychopathology, duration of pregnancy, parity, birth weight and gender. For sensitivity purposes, we additionally adjusted for the internalizing problems and short sleep duration at 18 months when examining the effect on depressive symptoms and short sleep duration, respectively, at 8 years. We also analysed the SMFQ continuously by calculating the estimated marginal means (EMM), allowing for both crude and adjusted analysis. Missing data were handled using listwise deletion.

Statistically significant differences between those with complete data at both time-points and those who dropped out after the 18 months assessment were found for some variables. Those mothers not dropping out by 8 years were characterized by having higher education (72.6% vs. 61.8%, $p < .001$) and being slightly older (30.7 years vs. 30.0 years, $p < .001$) and the children had somewhat lower scores on the CBCL internalizing subscale (8.9 vs. 9.7, $p < .001$). No differential attrition between 18 months and 8 years was observed for any of the other variables ($p > .05$).

3 | RESULTS

3.1 | Demographic and clinical characteristics

The longitudinal sample analysed for the present study comprised 35,075 mothers, with an average age of 30.8 years (*SD* 4.4) at gestational week 17; 74.2% of the mothers reported an educational level beyond high school; 48.9% of the children were girls. At 18 months, the majority (59.6%) of the children slept 13–14 hr, whereas 35.8% and 1.8% slept 11–12 hr and ≤10 hr, respectively; 25% of the children reported one or more awakenings at 18 months. At 8 years, the majority (60.9%) of the sample slept 10 hr, whereas 17.2% and 1.3% slept 9 hr and ≤8 hr, respectively (see Table 1 details).

3.2 | Sleep problems at 18 months and odds of depressive symptoms at 8 years

Short sleep duration at 18 months significantly increased the odds of later developing depressive symptoms. Compared to sleeping 13–14 hr per night, toddlers sleeping <10 hr had a 50% increased odds of scoring above the 90th percentile on the SMFQ at age 8 (OR = 1.50; 95% CI, 1.27–1.76; Table 2). The odds were somewhat attenuated after adjusting for demographic and clinical characteristics (OR = 1.34; 95% CI, 1.14–1.58). To examine if the association between short sleep and depressive symptoms could be explained by early internalizing problems when the toddler was 18 months old, we additionally adjusted for the CBCL internalizing subscale at this time-point. However, this had little impact on the association (OR = 1.28; 95% CI, 1.08–1.51). Toddlers sleeping 11–12 hr per night also had significantly increased odds of later developing depressive symptoms, although the ORs were smaller (see Table 2 for details). As also detailed in Table 2, we found that very long sleep duration (≥15 hr per night) was associated with later depressive symptoms (OR = 1.15; 95% CI, 1.06–1.24), and this association also remained significant in the fully adjusted model (OR = 1.14; 95% CI, 1.05–1.23).

As detailed in Table 2, nocturnal awakenings at 18 months also significantly predicted later depressive symptoms, and in a dose-response manner. Adjusting for demographics only slightly reduced the ORs, and even additional adjustment for the CBCL internalizing subscale at 18 months had little effect on the magnitude of the odds (adjusted OR = 1.27; 95% CI, 1.08–1.50). Compared to having nocturnal awakenings "seldom or never", parents reporting that their child experienced such awakenings "a few times per week" and "1–2 awakenings per night" were also significantly associated with later onset of depressive symptoms, even after adjusting for earlier internalizing problems.

Similar findings were observed when examining the SMFQ total score continuously. Figure 2 displays the estimated marginal means (EMM) of depressive symptoms at 8 years by sleep duration and nocturnal awakenings at 18 months. Toddlers sleeping 10 hr or less per night had significantly higher levels of depressive symptoms at 8 years compared to those sleeping 11–12 hr or 13–14 hr.

TABLE 1 Demographic and clinical variables by child gender in the longitudinal sample (n = 35,075)

Demographics and clinical variables	%	*n*
Parity (% first born) (missing = 64)		
1st child	46.9	16,413
2nd child	34.8	12,195
3rd child	14.5	5,088
4th+ child	3.7	1,315
Maternal educational (% with a degree beyond high school) (missing = 2,370)		
Primary	1.2	395
Secondary (high school)	24.6	8,047
College/university (<4 years)	45.0	14,702
College/university (4+ years)	29.2	9,561
	Mean	***SD***
Birth weight (g) (missing = 82)	3,567	573
Gestation (weeks) (missing = 212)	39.4	1.9
Maternal age (years) (missing = 66)	30.8	4.4
Maternal symptoms of anxiety/depression (SCL-8) (missing = 3,975)	10.2	2.9
	Mean	***SD***
CBCL internalizing problems at 18 months (missing = 3,292)	8.9	10.1
SMFQ total score at 8 years (no missing)	1.9	2.5
	%	***n***
Sleep duration at 18 months (none missing)		
≤10 hr	1.8	567
11–12 hr	35.8	11,262
13–14 hr	59.6	18,740
≥15 hr	2.8	884
Nocturnal awakenings at 18 months (none missing)		
≥3 awakenings/night	3.4	1,192
1–2 awakenings/night	21.6	7,563
'A few times/week'	33.0	11,588
'Seldom or never'	42.0	14,732
Sleep duration at 8 years (none missing)		
≤8 hr	1.3	6,049
9 hr	17.2	21,346
10 hr	60.9	7,077
11 hr	20.2	147
≥ 12 hr	0.4	6,049

Of note, we also found in here that very long sleep duration (≥15 hr per night) was associated with elevated levels of depressive symptoms at 8 years. These findings also remained in the fully adjusted model, which included controlling for demographic and clinical characteristics, as well as internalizing problems at 18 months (see Figure 1).

A dose–response association between number of nocturnal awakenings and later depressive symptoms was observed for both the crude and adjusted models; the more frequent awakenings the child had at 18 months, the higher SMFQ total score at 8 years (see Figure 2 for details).

3.3 | Internalizing problems at 18 months and odds of short sleep duration at 8 years

We then analysed the reverse association: whether internalizing problems in toddlers were associated with later sleep problems. In

TABLE 2 Longitudinal associations between short sleep duration and nocturnal awakenings at 18 months and later symptoms of depression at 8 years.

	Outcome: symptoms of depression (SMFQ dichotomized at 90th percentile) at 8 years		
	Model 1[a]	Model 2[b]	Model 3[c]
Exposure at 18 months	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sleep duration			
≤10 hr	1.50 (1.27–1.76)***	1.34 (1.14–1.58)***	1.28 (1.08–1.51)**
11–12 hr	1.19 (1.10–1.30)***	1.17 (1.07–1.27)***	1.14 (1.05–1.25)**
13–14 hr	1.00	1.00	1.00
≥15 hr	1.15 (1.06–1.24)***	1.15 (1.06–1.24)***	1.14 (1.05–1.23)**
Nocturnal awakenings			
≥3 awakenings/night	1.49 (1.27–1.75)***	1.34 (1.13–1.68)***	1.27 (1.08–1.50)***
1–2 awakenings/night	1.20 (1.10–1.30)***	1.17 (1.07–1.27)***	1.14 (1.05–1.25)**
'A few times/week'	1.15 (1.07–1.24)***	1.14 (1.06–1.24)**	1.14 (1.05–1.23)**
'Seldom or never'	1.00	1.00	1.00

Abbreviations: CI, confidence intervals; OR, odds ratio; SMFQ, Short Mood and Feelings Questionnaire.

[a]Unadjusted model.

[b]Adjusted for maternal age and education, maternal psychopathology, duration of pregnancy, parity, birth weight and gender.

[c]Additional adjustment for the Child Behaviour Check List (CBCL) internalizing subscale at 18 months.

**$p < .01$.

***$p < .001$.

short, we found that scoring high on the internalizing problems subscale at 18 months significantly increased the odds of short sleep duration at 8 years. Compared to sleeping 10–11 hr per night, toddlers with a *T*-score above 65 on the CBCL internalizing subscale had more than twice the odds of sleeping 8 hr or less at age 8 (OR = 2.35; 95% CI, 1.74–3.18; Figure 3). The associations were somewhat reduced when controlling for maternal age and education, maternal psychopathology, duration of pregnancy, parity, birth weight and gender, but the odds remained significant after additional adjustment for sleep duration at 18 months (OR = 1.72; 95% CI, 1.13–2.59). As also depicted in Figure 3, significant ORs were found when examining a sleep duration of 9 hr at age 8 as the outcome (but with smaller ORs). Finally, internalizing problems were also significantly associated with *long* sleep duration (12 hr or more) at age 8 (adjusted OR = 1.92; 95% CI, 1.01–3.63).

4 | DISCUSSION

In this large-scale population-based study, several noteworthy findings emerged. First, short sleep duration and frequent nightly awakenings at 18 months predicted the development of depressive symptoms at 8 years of age, also after accounting for early internalizing problems. Second, the reverse association was also confirmed in that early internalizing problems predicted later short sleep duration, also after accounting for early sleep problems. Third, the number of nocturnal awakenings at 18 months was associated with later onset of depressive symptoms in a dose–response manner.

Together, these findings demonstrate a bidirectional association between sleep and internalizing/depressive symptoms from toddlerhood to later in childhood. This is consistent with the emerging evidence of a close relationship between depression and sleep throughout the lifespan (Baglioni et al., 2011; Hysing et al., 2016; Sivertsen et al., 2014), and thus supports the conclusion from a recent review that highlighted the reciprocal nature of the relationship (Alvaro et al., 2013). However, to the best of our knowledge, this is the first study to examine this association spanning over so many years from early toddlerhood and well into childhood. As such, our findings extend previous research using shorter follow-ups and which concluded that early sleep problems predict later internalizing problems (Gregory & O'Connor, 2002; Gregory & Sadeh, 2016; Jansen et al., 2011). Interestingly, prior studies have suggested that the evidence accumulated to date is stronger for sleep problems predicting later depression (Gregory & Sadeh, 2012). However, the present study demonstrates that the opposite directionality is equally strong. Interestingly, we also found a link between very long sleep duration (15 hr or more) at 18 months and later symptoms of depression, indicating a curvilinear relationship between the two variables.

These results may be interpreted in light of the new conceptualization of sleep and depression. Although sleep problems historically were regarded as an epiphenomenon of depression (Lichstein, 2006), our understanding of this has now changed, as also demonstrated in the reciprocal association reflected in the DSM-5 insomnia disorder criteria. Although the current study does not shed light on possible mechanisms that might be involved in

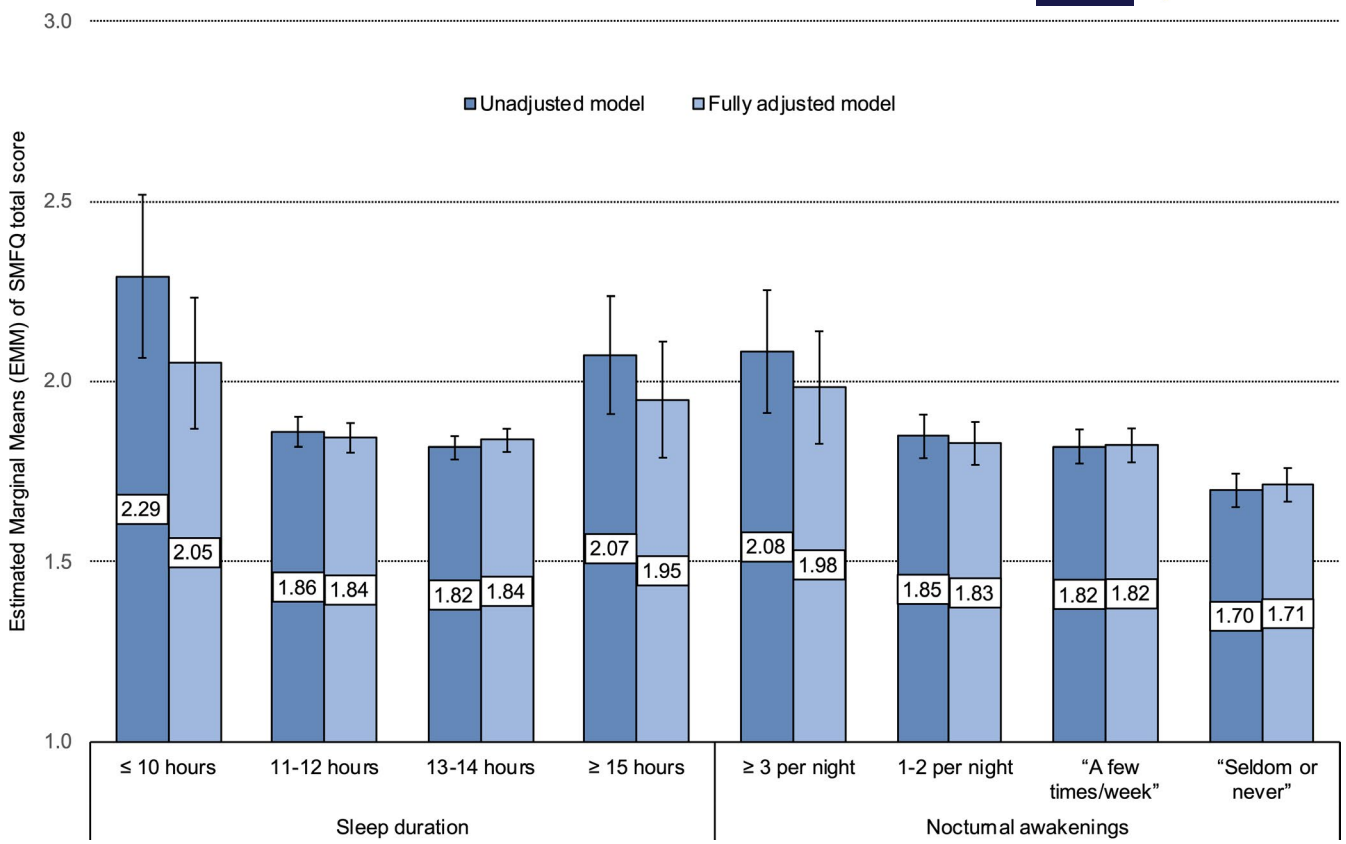

FIGURE 2 Estimated marginal means of depressive symptoms at 8 years by sleep duration and nocturnal awakenings at 18 months. Fully adjusted model: adjusted for maternal age and education, maternal psychopathology, duration of pregnancy, parity, gender, birth weight and internalizing problems at 18 months. SMFQ, Short Mood and Feelings Questionnaire

explaining the sleep–depression link, previous studies have emphasized a likely combination of both genetic and environmental factors. Genetic factors have been found to explain most of the association between sleep and depressive symptoms at 8 years of age in twins (Gregory, Rijsdijk, Dahl, Mcguffin, & Eley, 2006), and are also important in explaining the association 2 years later (Gregory et al., 2009). Although the cross-lagged association between sleep problems at 8 and depression at 10 years in the twin study was largely due to genes, the finding was non-significant. The possibility that the association between sleep problems and depressive symptoms found in the present study could in part reflect common genetic factors is supported by results from a recent genome-wide association study of sleep disturbance traits, where a significant genetic correlation between major depression and insomnia symptoms was found (Lane et al., 2017). Environmental factors, such as parenting factors, are likely to be more influential in early childhood (Van den Oord, Boomsma, & Verhulst, 2000) and may thus be of importance for development from 18 months to preschool years. For example, we have previously found a direct effect between maternal depression and child nocturnal awakenings at 18 months (Ystrom et al., 2017). The importance of parental behaviours for the association between early sleep problems and later anxiety and depressive symptoms was demonstrated in the generation R study, where lack of parental set bedtimes and parental presence during sleep preceded anxiety and depression at 3 years (Jansen et al., 2011). The underlying mechanisms involved in the association between short versus long sleep duration and later depression are not yet fully understood (Zhai, Zhang, & Zhang, 2015). Studies in adults may show that short sleepers have increased levels of daytime tiredness, which in turn is a risk factor for later depression (van Noorden, Van Fenema, Van Der Wee, Zitman, & Giltay, 2012), whereas long sleep duration is associated with lower levels of physical activity, which also increases the risk of later depression (Stranges et al., 2008).

The public health implications of the directionality of sleep and depression are important. Sleep problems are a growing public health concern, with increasing levels of short sleep duration documented later in childhood (Pallesen et al., 2008). There is also concern over the increasing impact of depressive symptoms (Vos et al., 2012). Although these trends are most likely a result of multiple risk factors, the sleep–depression interplay may be one important explanatory variable. The long-term consequences of sleep problems were highlighted in a longitudinal study reporting that severe sleep problems at 5 years of age predicted depression in adulthood (Greene, Gregory, Fone, & White, 2015). Although there have been very few, if any, efforts to examine if treatment of one disorder may prevent onset of the other at least in this age cohort, evidence from adults has shown that prevention in itself is important, as comorbidity in general is associated with poorer prognosis, leaving perhaps both disorders more difficult to treat (Kessler, 2004). Thus, the close association between sleep and

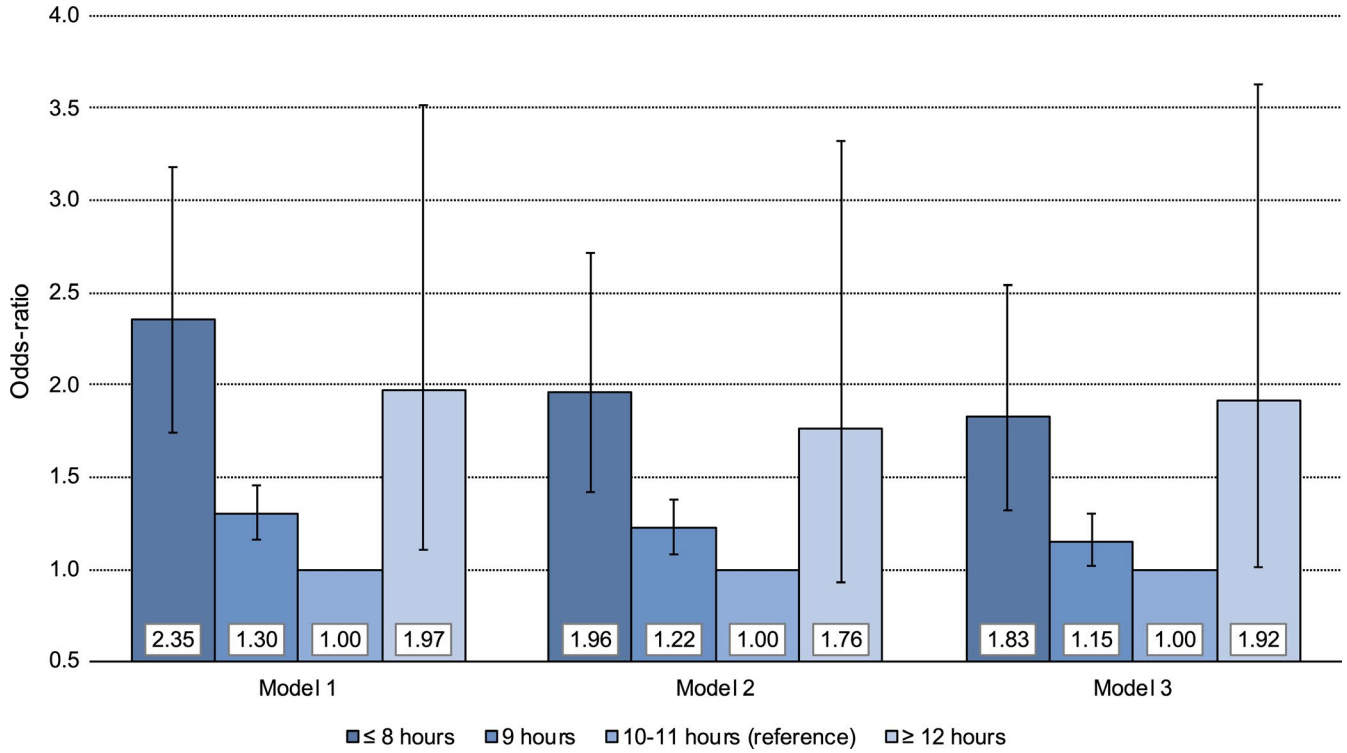

FIGURE 3 Longitudinal associations between internalizing problems at 18 months and subsequent short sleep duration at 8 years (reference 10–11 hr). Bars represent odds ratios, whereas error bars represent 95% confidence intervals. Model 1: unadjusted model. Model 2: adjusted for maternal age and education, maternal psychopathology, duration of pregnancy, parity, birth weight and gender. Model 3: additional adjustment for sleep duration at 18 months

depressive and internalizing problems over time in the present study underscores the importance of including assessment of both internalizing problems and sleep problems in the follow-up of toddlers presenting with one of these problems. A joint focus may also be beneficial in preventive intervention, but should be addressed in future studies.

The results of this study need to be interpreted in light of some limitations. First, the MoBa questionnaires rely solely on mother-reported sleep and mental health problems in their children and thus we cannot disregard the possibility of mono-informant bias. Second, the bidirectionality was not assessed using identical instruments at both time-points. This, however, is a limitation that is difficult to avoid, given that emotional problems are expressed quite differentially over the developmental period in this study. At the 18-month assessment point, a composite instrument measuring internalizing problems was used, which included symptoms of both depression and anxiety. Third, the sleep assessment was based on only two items at 18 months (sleep duration and nocturnal awakening) and one item (sleep duration) at 8 years. In addition, the response options for both the sleep duration and nocturnal awakening variables were quite broad. Hence, we cannot provide exact estimates of these sleep parameters. Future studies should implement more complete and detailed assessment of sleep problems, in order to capture better the relation between the variables. Along the same lines, it would be interesting to explore to what extent maternal sleep problems are related to their perception of their children's internalizing problems and depressive symptoms. Fourth, the results may be affected by a selection bias due to attrition in the MoBa study (Magnus et al., 2016). When comparing data on the MoBa participants with data from the Medical Birth Registry in Norway on key factors, a lower rate on some predictor variables was observed, including higher maternal age, fewer health-related risks, and children who had received better neonatal health care relative to children of mothers not participating in MoBa. However, the associations between predictor variables and outcomes were not biased (Nilsen et al., 2009). If the same pattern holds true for the variables in the present study, the prevalence of sleep problems and depressive symptoms may even be underestimated. Finally, we did not have data on some potential confounders, such as prescribed psychotropic medications.

There are several strengths of the current study. First, this is the largest investigation of the reciprocal associations between sleep and depressive symptoms, allowing us to assess smaller categories of interest. For example, the associations between sleep duration and later depressive symptoms were strongest for those children sleeping 10 hr or less, which only comprised 2% ($n = 568$) of the children. This would have been difficult to examine in smaller studies. Still, care should be taken in terms of making strong public health recommendations given the findings were strongest for these extreme response categories. A final strength is that the 8-year questionnaire included a validated instrument for depression (the SMFQ), which also expands on previous studies using more general

screening instruments, especially the CBCL. As a final note related to the SMFQ, the average total score on this instrument was quite low (mean: 1.9 on a range from 0 to 26), indicating that the overall level of depressive symptoms in this sample was low.

5 | CONCLUSION

To the best of our knowledge, this study is the first to demonstrate a bidirectional relationship between sleep and mental health problems from early toddlerhood to later in childhood. As the individual stability of these problems is high and increasing from childhood to adolescence (Sivertsen, Harvey, Pallesen, & Hysing, 2017), future studies should investigate if the reciprocal associations hold from the transition to adolescence. Following the children into early adolescence will also give the opportunity for self-reported sleep patterns and mental health problems that will further strengthen the findings. Future prospective studies should also seek to explore the bidirectional link between sleep and other mental health issues beyond internalizing problems/depressive symptoms, such as externalizing behaviour and symptoms of inattention and hyperactivity.

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CONFLICT OF INTEREST

None of the authors report any financial interests or potential conflicts of interest.

AUTHOR CONTRIBUTIONS

Study design: BS, AGH and MH. Data collection: BS and TRK. Data analysis and interpretation: BS, MH and EY. All authors were involved in writing the paper and had final approval of the submitted and published versions.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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