Prenatal Psychosocial Stress and Children's Sleep Problems: Evidence from the ELSPAC-CZ Study

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Abstract

Prenatal exposure to maternal stress may increase the risk of developing sleep problems in childhood. This study examined the association between prenatal stressful life events (PSLE) and children's sleep problems, taking into consideration their trajectory over time. Data were obtained from the Czech portion of the European Longitudinal Cohort Study of Pregnancy and Childhood (ELSPAC-CZ; $N = 4{,}371$ children). Mothers reported PSLE using an inventory of 42 life events and child sleep problems at five time points (1.5, 3, 5, 7, and 11 years). The association was tested by a Poisson latent growth model, controlling for maternal and family demographics, birth characteristics, maternal depression, and alcohol use in pregnancy. The average rate of sleep problems was 2.06 ($p < 0.001$) at 1.5 years and the rate of sleep problems decreased in a linear fashion over time (estimate = -0.118; $p < 0.001$). A higher number of PSLE was associated with a higher rate of sleep problems at 1.5 years (incidence rate ratio [IRR] per interquartile range = 1.08, 95% confidence interval [CI] = 1.05-1.12, $p < 0.001$) and with a reduced rate of decrease in sleep problems between 1.5 and 11 years ($p < 0.001$). Thus, PSLE were associated with chronicity of sleep problems in addition to their amount during early childhood. Prenatal exposure to stress may predispose individuals to the development of sleep problems in later life.

Keywords. prenatal stressful life events, childhood sleep problems, latent growth modeling

Prenatal Psychosocial Stress and Children's Sleep Problems: Evidence from the ELSPAC-CZ Study

Sleep is pivotal in the development of the brain and nervous system during childhood and adolescence. Its quality and quantity have important implications for neurological, emotional, cognitive, and behavioral functioning. Children’s sleep problems have been associated with adjustment difficulties, including poor grades in school, low impulse control, hyperactivity and inattention, conduct problems, and emotional difficulties (Astill et al., 2012; Carvalho Bos et al., 2009; McLaughlin Crabtree & Witcher, 2008). Additionally, childhood sleep problems, particularly if persistent, predict health outcomes well beyond childhood. Poor sleep in children has been linked to behavioral and emotional problems during adolescence (Gregory & O’Connor, 2002; Sadeh et al., 2014), and insomnia, anxiety, and depression in adulthood (Gregory et al., 2005; Philip & Guilleminault, 1996; Young et al., 2019).

Given the implications of poor sleep for concurrent and subsequent health, there has been growing interest in identifying early origins of sleep problems (Chatterjee et al., 2018; Morales-Muñoz et al., 2018; Palagini et al., 2015). The model of prenatal and early life programming of neuropsychiatric disorders (Kim et al., 2015) suggests that exposure to excessive or chronic stress during pregnancy leads to stress-response system dysregulation and predisposes the child for mental health problems. Stress hormones cross the placenta, influencing the stress-response system during the fetal stage. Stress-related maternal inflammation, changes in placental function, and epigenetic mechanisms have also been noted as adverse influences on fetal neurodevelopment, including sleep (Babenko et al., 2015; Koehl et al., 1999; Krontira et al., 2020; McEwen, 2019; Palagini et al., 2015; Scher et al., 2010; Figure 1).

<INSERT FIGURE 1 ABOUT HERE>

In addition to the physiological pathway, maternal health behaviors during pregnancy and postpartum may also play a role in child sleep disturbances since maternal sleep, diet, and exercise have important implications for fetal and infant neurodevelopment (De Weerth, 2018). Stress in pregnancy has been associated with health impairing behaviors (e.g., smoking, and unhealthy eating), and mental health problems, such as depression and anxiety, known adverse factors in a range of child developmental outcomes, including sleep (Field, 2011; Morales-Muñoz et al., 2018). Auerbach and colleagues (2014) suggested that health-promoting behaviors during pregnancy require sustained efforts dependent upon stable intra and interpersonal resources that may not be available to expectant mothers dealing with difficult life situations or mental health problems.

Several studies tested the hypothesis that exposure to stress during pregnancy is prospectively associated with sleep problems in childhood. Simcock and colleagues (2019) examined the link between prenatal stress and children’s sleep in a sample of 153 women who were pregnant during a major flood in Australia in 2011. They found a significant association between more severe objective flood-related hardship and higher children’s sleep problem scores at 2.5 years assessed by Child Behavior Checklist (CBCL). Similarly, higher maternal prenatal stress was related to increased sleep concerns at age three (N=64) and with actigraphy sleep metrics at age five (N=25) in addition to decreased fetal cerebellar-insular connectivity (van den Heuvel et al., 2021). Lastly, Schmid and colleagues (2011) found an association between prenatal psychosocial stress and multiple regulatory problems (i.e., a combination of crying, eating, and sleeping problems) in five months old infants (N=5,093). In contrast, two studies testing the association between prenatal stress and child sleep reported null findings. First, Chatterjee and colleagues (2018) did not find a significant link between stress in pregnancy and sleep duration and efficiency measured via accelerometry in a sample of 594 five to six years old children. Second, using data from a population-based birth cohort study (*N*=1,221), Morales-Muñoz and colleagues (2018) did not find threatening experiences during pregnancy to be associated with sleep characteristics at the age of three months.

Sleep problems are relatively common in young children but typically recede over time as the sleep architecture matures (Friedman et al., 2009; Gregory & O'Connor, 2002; Wang et al., 2016). Infant sleep is characterized by fragmentation, with relatively short sleep and wake periods throughout day and night (Carter et al., 2014). Despite individual variations, "sleeping through the night" defined as at least 6 hours of uninterrupted nighttime sleep is evident in most children by the age of 6 to 9 months (Carter et al., 2014; Pennestri et al., 2018) and is accompanied by a reduction in daytime sleep (Thiedke, 2001). Bedtime struggles and night wakings are typical for toddlers and pre-school children but are considered problematic if they persist over time (Thiedke, 2001). Arguably, such persistence may more commonly manifest among children exposed to stress *in utero* as these children might experience a delay in the normative development in sleep patterns.

Extending the model of prenatal programming to child sleep functioning as an outcome, we set out to test the following hypotheses: first, children's sleep problems increase with higher exposure to psychosocial stress during pregnancy (hypothesis 1), and second, exposure to psychosocial stress during pregnancy is associated with the persistence of children's sleep problems over time (hypothesis 2).

Methods

Participants

Data were obtained from the European Longitudinal Cohort Study of Pregnancy and Childhood–Czech Republic (ELSPAC-CZ). The study was initiated by the World Health Organization to investigate maternal and child health in Europe. The Czech portion of the study targeted the entire population of births that occurred in two metropolitan areas between March 1, 1991 and June 30, 1992 (Piler et al., 2017). Compliance with ethical standards was approved by the Scientific Council of Masaryk University. All participating women provided written informed consent. Pregnant women were recruited at a 20-week check-up (i.e., mid-pregnancy); 4,811 of the women completed a survey questionnaire at the baseline (93% response rate). Follow-up assessments were performed at 13 time points from mid-pregnancy (baseline) until 19 years of age. Depending on the time point, assessments included medical examinations as well as surveys completed by mothers, their partners, children themselves, and their teachers.

In this study, we used mother-reported data collected at six time points (mid-pregnancy, delivery, and 1.5, 3, 5, 7, and 11 years). Mothers filled paper-and-pencil questionnaires that were mailed to their home addresses. We retained only participants who completed the child sleep problems assessment scale at least at one time point during the period from 1.5 to 11 years (N=4,371). Approximately 50% of children remained in the study until age 11 and about 20% until age 19. Compared to women participating at the baseline, participants that remained in the study for its entirety were less commonly single (6.2 vs 8.9%) and younger than 20 years at the time of delivery (6.5 vs 9.9%) and more often held a college degree (19.1 vs 7.1%; Piler et al. 2017).

Measures

Sleep problems, the outcome of interest, were measured at five time points (1.5, 3, 5, 7, and 11 years) by a Czech translation of the scale originally developed for the Avon Longitudinal

Study of Parents and Children (ALSPAC; Humphreys et al., 2014). Mothers reported seven common sleep problems, such as “In the last year, your child had difficulties falling asleep” (Appendix) on a four-point Likert-type scale ranging from *did not happen* (0) to *yes, and I was very worried about it* (3). As the response scale captured mothers’ concerns about the child’s sleep rather than the objective occurrence of the problems, we dichotomized the response scale of each question into *any sleep problem* (1) versus *no sleep problem* (0), consistently with previous studies utilizing the scale (Barazzetta & Ghislandi, 2016; Lereya et al., 2016). The count of sleep problems was then created as a sum of the endorsed sleep problems (range 0-7) at each time point.

Prenatal stressful life events (PSLE), the main predictor, were assessed using the Social Readjustment Scale (Holmes & Rahe, 1967) adapted for Avon Longitudinal Study of Pregnancy and Childhood. The questionnaire is tailored specifically for pregnancy and is suitable for use in population-based studies (Dorrington et al., 2014; Hibbeln et al., 2007). The measure covers 41 events (see Appendix for the list of the events). Mothers reported whether the event *occurred* (1) or *not* (0) at mid-pregnancy, reflecting the first half of the pregnancy, and at the delivery, reflecting the second half of the pregnancy. We calculated the number of PSLE reported for each period first; second, we summed the counts of PSLE for the first and second half of pregnancy to obtain the total number of PSLE that occurred between conception and delivery.

Prenatal maternal depressive symptoms were measured by the Edinburg Postnatal Depression Scale (EPDS; Cox, Holden, and Sagovsky 1987), an instrument validated for pregnancy and postpartum. Mothers rated 10 items (e.g., “I have felt sad or miserable”) on a four-point Likert-type scale ranging from *never* (0) to *most of the time* (3).

Alcohol use in early to mid-pregnancy was assessed by two items asking about frequency of drinking in the *first three months of pregnancy* and *around the time of baby's first movements* (four-point scale ranging from *never = 0* to *more than 1 – 2 servings per day = 3*) reported at mid-pregnancy. As the items were highly correlated (r = .61), we used their mean average in the analyses. *Alcohol use in late pregnancy* was assessed by an item asking about frequency of drinking *during the last two months of pregnancy*, reported on a four-point scale ranging from *never* (0) to *more than 1 – 2 servings per day* (3) at the delivery.

Demographic background included maternal *age at delivery* (years) and *family structure (two biological parents = 1; other = 0)*. Socioeconomic position (SEP) was represented by *maternal education* (years) at delivery and a mother-reported *financial hardship* at 6 months assessing how difficult it was to provide items for the family including food, clothing, heating, rent/mortgage payments, and things for the child. Each item was rated on a four-point scale (*not difficult* = 0; *very difficult* = 3). Delivery characteristics were obtained from medical documentation, including child sex (*male* = 1; *female* = 0) and birth weight (grams). To proxy parity, we used women's reports collected in mid-pregnancy on whether they already had children (*nulliparous* = 1; *multiparous* = 0).

Statistical Analysis

First, descriptive statistics of the analytical variables were obtained. Second, study hypotheses were tested via latent growth modeling (LGM). In the first step, we estimated an unconditional linear LGM model to evaluate whether there was a statistically significant change in the rate of sleep problems from 1.5 to 11 years. Next, we regressed PSLE on the intercept and slope of the sleep problems trajectory to test their associations with the rate of sleep problems at 1.5 years (hypothesis 1) and the change in the rate of sleep problems from 1.5 to 11 years (hypothesis 2). Lastly, we added covariates into the model to test whether they influenced the association between PSLE and the intercept and slope of the sleep problems trajectory. The covariates were selected based on theoretical considerations and previous studies focused on the prenatal origins of child sleep problems (Pesonen et al., 2009). See Figure 2 for the conceptual diagram of the predictive LGM model.

<INSERT FIGURE 2 ABOUT HERE>

The effect of PSLE on sleep trajectory was examined per interquartile range (IQR) of the PSLE (IQR = 6 life events). Lastly, we estimated the trajectory of sleep problems separately per tercile group of the PSLE to facilitate interpretation of PSLE as a low, medium, and high, consistent with prior research (Teixeira et al., 2012; Zhang et al., 2021) and to enable graphical representation of the results. As the outcome variable was a count of sleep problems, Poisson models represented the functional form for both unconditional and predictive LGM. Missing data were handled by multiple imputation with 50 imputed datasets. The analysis was conducted in Mplus 8 statistical software (Muthén & Muthén, 2017).

Results

Participants were chiefly young women (median age at delivery = 24.0 years) with secondary education (median years of education = 12.0 years). A large majority of children had normal birth weight (95.5%). Most families had two biological parents (91.0%) and reported low levels of financial hardship (median = 0.4 on a 0-3 scale). There was a slight majority of boys (51.8%) and first-born children in the sample (50.4%). Women reported having experienced a median of 5.0 PSLE. The median of depression symptoms indicated by EPDS was 6.0 on a 0-30 scale during pregnancy. The majority of women reported never drinking alcohol in early to mid-pregnancy (68.4%) as well as in late pregnancy (84.5%; Table 1). Mothers reported more sleep problems at child ages 1.5 and 3 years (median = 3.0 on a 0-7 scale) compared to later years. At age 11, sleep problems declined to a median of 1.0 (Table 1). These results were corroborated with the unconditional LGM model, which indicated a statistically significant, linear, decrease in sleep problems between ages 1.5 and 11 years (estimate = -0.070; $p < .001$).

<INSERT TABLE 1 ABOUT HERE>

More PSLE were associated with a higher rate of sleep problems at 1.5 years (incidence rate ratio [IRR] per interquartile range [IQR] = 1.143, 95% confidence interval [CI] = 1.111-1.176), supporting hypothesis 1. Moreover, PSLE were associated with a reduced rate of decrease in sleep problems from 1.5 to 11 years (IRR per IQR = 1.011, CI = 1.006-1.017), supporting hypothesis 2.

After including the covariates into the model, the association between PSLE and the rate of sleep problems at 1.5 years remained positive and statistically significant (IRR per IQR = 1.083, CI = 1.049-1.117). Similarly, the link between PSLE and the rate of decrease in sleep problems remained significant (IRR per IQR = 1.011, CI = 1.005-1.017). Among covariates, nulliparous women (IRR = 1.115, CI = 1.059-1.171) and those who had male infants (IRR = 1.052, CI = 1.012-1.093) reported a higher rate of sleep problems at 1.5 years. Depressive symptoms during pregnancy (IRR = 1.020, CI = 1.014-1.025) and alcohol use in early to mid-pregnancy (IRR = 1.046, CI = 1.019-1.072) were also associated with a higher rate of sleep problems at 1.5 years. Lastly, higher maternal education was associated with a reduced rate of decrease in sleep problems from 1.5 to 11 years of age (IRR = 1.002, CI=1.001-1.004, Table 2).

<INSERT TABLE 2 ABOUT HERE>

Figure 3 displays predicted over-time trajectories of sleep problems for children exposed to low, medium, and high PSLE. The covariate-adjusted mean rate of sleep problems at age 1.5

years was 2.303 ($p < .001$) in the low PSLE group, 2.492 ($p < .001$) in the medium PSLE group, and 2.588 ($p < .001$) in the high PSLE group. The steepest over-time decrease in the rate of sleep problems was observed in the low PSLE group (estimate = -0.106; $p < .001$); the slope of decrease was flatter in the medium (estimate = -0.100; $p < .001$) and high PSLE (estimate = -0.091; $p < .001$) groups.

<INSERT FIGURE 3 ABOUT HERE>

The estimates from the covariate-adjusted model were similar in size and significance to the estimates obtained from an unadjusted model: the mean rate of sleep problems at age 1.5 years was 2.798 ($p < .001$) in the low PSLE group, 3.133 ($p < .001$) in the medium PSLE group, and 3.401 ($p < .001$) in the high PSLE group. The steepest over-time decrease in the rate of sleep problems was, again, observed in the low PSLE group (estimate = -0.071; $p < .001$), while the slope of decrease was flatter in the medium (estimate = -0.065; $p < .001$) and high PSLE (estimate = -0.055; $p < .001$) groups. These findings suggest that the results have not been confounded by the covariates.

Discussion

The aim of the current study was to test the association between prenatal stress exposure and subsequent sleep problems in children. The number of stressful events reported in pregnancy was prospectively associated not only with a higher rate of sleep problems in early childhood but also with their persistence over time. The rate of sleep problems decreased, on average, in all PSLE exposure groups (i.e., low, medium, and high); however, the rate of decrease was lower with an increasing number of PSLE, and the rate of sleep problems remained higher in the medium and high PSLE groups compared to low PSLE group throughout the entire observed time period. Thus, exposure to stress during pregnancy may trigger a variety of unfavorable developmental sequelae, including development and persistence of sleep problems, and consequently increase the risk for associated conditions, such as emotional and conduct problems in the offspring.

Only a few studies have examined the prospective association between prenatal stress and children's sleep problems in a population-based cohort study, and the previous research produced mixed findings. Morales-Muñoz and colleagues (2018) did not find a statistically significant association between threatening experiences during pregnancy and sleep characteristics in three months old infants. Similarly, negative stressful events in pregnancy were not significantly linked to sleep duration and efficiency in five to six years old children in a study by Chatterjee and colleagues (2018). Both studies suggest that exposure to prenatal stress may not affect sleep characteristics in children. However, the null findings may have been related to the operationalization and measurement of the sleep. The authors of both studies did not assess sleep difficulties as a checklist of sleep problems and used sleep characteristics not necessarily reflective of sleep problems (e.g., sleep quantity or co-sleeping with parents) as their outcomes.

Contrary to the previous research, a study examining the link between disaster-related stress in pregnancy during a 2011 flood in Australia and subsequent adjustment in children, did find a significant association between more severe objective flood-related hardship and higher sleep problem scores at 2.5 years (Simcock et al., 2019). As this association remained significant even after controlling for maternal depression during pregnancy, the authors concluded that the effect of prenatal stress on sleep problems was not solely due to depression and that objective disaster-related stress may have programming influences on fetal development (Simcock et al., 2019). The results of our study were consistent with this finding. We found a modest but statistically significant association between PSLE and child sleep even after adjusting for the depression symptoms. This serves as additional evidence that prenatal stress may affect the developing fetus independently of maternal emotional response and that depression and stress during pregnancy constitute distinct constructs (Palagini et al., 2015; Štěpáníková et al., 2020).

Our results highlight the meaningfulness of screening for PSLE during pregnancy and offering counseling to women experiencing PSLE. Prenatal stress is a malleable factor that can be successfully targeted by intervention strategies. Alleviating stress during pregnancy may improve the health and well-being of the mothers and could also decrease the risk of emotional and regulatory problems in their offspring.

The main strength of the paper is the use of a large longitudinal population-based study that allowed us to test the hypothesized associations prospectively. Due to the longitudinal nature of the data, we were able to model the developmental trajectory of children's sleep problems and show that PSLE were associated with chronicity of sleep problems in addition to their amount during early childhood. To the best of our knowledge, this is a novel contribution since links between prenatal stress exposure and the developmental course of sleep problems have not been previously examined.

The study has several limitations that need to be discussed. First, both exposure (PSLE) and outcome (child sleep problems) variables were reported by mothers; therefore, the association between the constructs may be inflated due to shared method variance. We addressed this issue by conceptualizing PSLE and sleep problems as counts of the respective events or problems that occurred in a given time period, rather than as an individual interpretation of stress or the severity of sleep problems. However, despite our attempt to operationalize both constructs objectively, we cannot entirely rule out the potential impact of maternal factors (e.g., anxiety) on the reporting of PSLE and sleep problems. Objective measurement of sleep characteristics, for example by actigraphy, or by utilizing multiple informants of child sleep problems, would improve the validity of sleep measurement.

Second, the ELSPAC-CZ data collection commenced in 1991 – 1992. Based on data from Czech Statistical Office (2020), mothers in 2019 were, on average, older, more educated, and less likely to be married than those in 1991 – 1992. At the same time, Czechoslovakia, and later the Czech Republic, was undergoing a societal transition after the fall of the communist regime. We cannot rule out the possibility that these demographic and political changes affected the variables examined in our study. However, maternal stress and child sleep difficulties are universally occurring problems and it is unlikely that their association would be affected by the historical period as it is at least to some extent driven by biological pathways.

Third, there has been an attrition of the sample throughout the follow-up period. Given that children of younger and less educated mothers were more likely to drop out from the study, the results need to be generalized with caution. Lastly, due to the observational nature of the study, we cannot rule out a potential confounding effect of unmeasured variables. Thus, the association between PSLE and children's sleep problems cannot be interpreted as causal.

In conclusion, exposure to prenatal stress may serve as a risk factor for the development and persistence of sleep problems in childhood. However, due to the mixed findings of the previous research, the association should be examined further. Future studies may benefit from a more comprehensive assessment of stress as stress is a complex concept and every single instrument for its measurement has limitations. Self-reports of life events represent an improvement in the measurement of prenatal stress compared to measures capturing psychological symptoms only; yet, measures of biomarkers are needed for a more objective understanding of physiological stress response (Štěpáníková et al, 2019). Similarly, mother-reported sleep problems in children may be supplemented with other methods of sleep assessment, including accelerometry. Building on the model of prenatal and early life programming of neuropsychiatric disorders (Kim et al., 2015), we suggested that prenatal stress translated into child sleep problems via stress-induced physiological changes in the fetus as described by Kim and colleagues (2015) and via maternal health behaviors during pregnancy (De Weerth, 2018). Nevertheless, we did not directly test these mechanisms. It would be fruitful to examine whether maternal health behaviors mediate the link between prenatal stress and child sleep problems or whether there are measurable biomarkers of stress that could explain the link.

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Appendix

Child sleep problems

In the last year, your child:

1. Refused to go to bed

2. Woke up very early

3. Had difficulties falling asleep

4. Had nightmares

5. Kept getting up after he/she was put in bed

6. Woke up during the night

7. Woke up after only few hours of sleep

Prenatal stressful life events

1. Your partner died

2. One of your children died

3. A friend or relative died

4. One of your children was ill

5. Your partner was ill

6. A friend or relative was ill

7. You were admitted to hospital

8. You were in trouble with the law

9. You were divorced

10. You found that your partner didn't want your child

11. You were very ill

12. Your partner lost his job

13. Your partner had problems at work

14. You had problems at work

15. You lost your job

16. Your partner went away

17. Your partner was in trouble with the law

18. You and your partner separated

19. Your income was reduced

20. You argued with your partner

21. You had arguments with your family or friends

22. You moved

23. Your partner hurt you physically

24. You became homeless

25. You had a major financial problem

26. You got married

27. Your partner hurt your children physically

28. You attempted suicide

29. You were convicted of an offence

30. You were bleeding and thought you might miscarry

31. You started a new job

32. You had a test to see if your baby was abnormal

33. You had a result on a test that suggested your baby might not be healthy

34. You were told that you were going to have twins

35. You heard that something that had happened might be harmful to the baby

36. You tried to have an abortion

37. You took an examination

38. Your partner was emotionally cruel to you

39. Your partner was emotionally cruel to your children

40. Your house or car was burgled

41. You had an accident

42. Something else happened

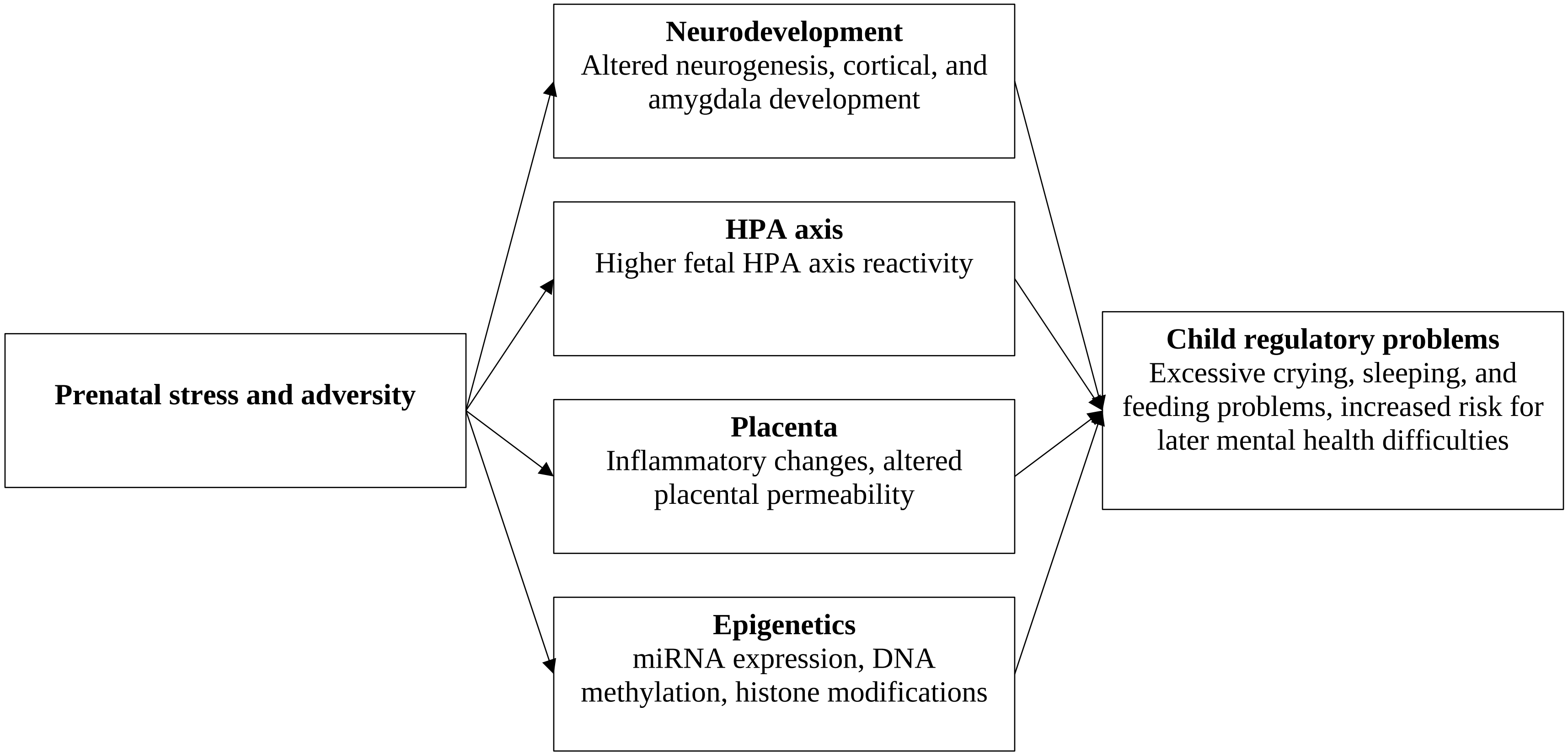

Figure 1. Conceptual model of the hypothesized physiological mechanisms linking prenatal stress and adversity to child regulatory and sleep problems.

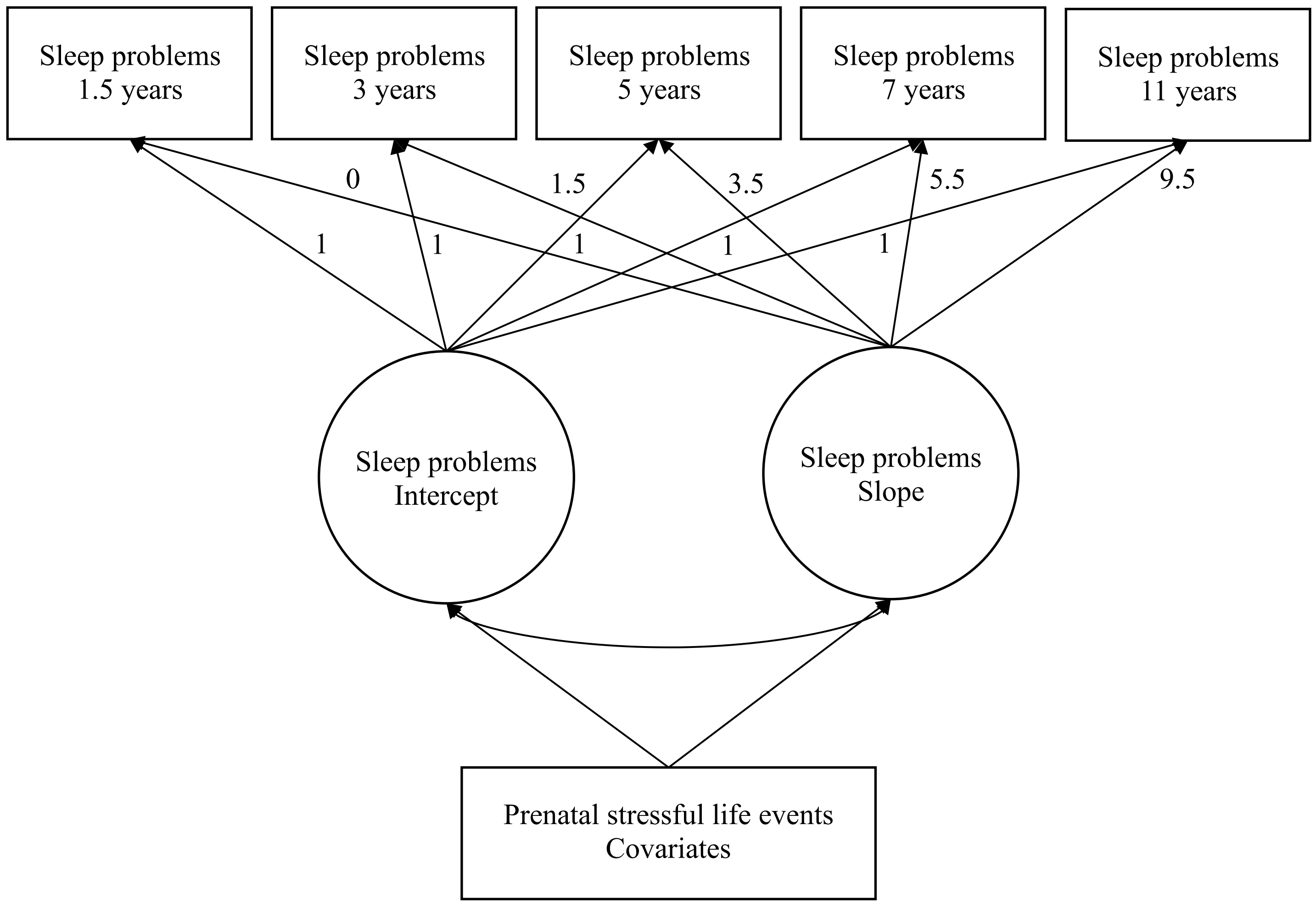

Figure 2. Conceptual diagram of the predictive latent growth model.

Note. Paths from the slope term to the observed scores were fixed to values reflecting the time intervals between each assessment.

Table 1

Descriptive statistics of study variables

Variable	*N*	*Median / %*	*IQR*	*Min*	*Max*
Prenatal stressful life events (PSLE)	3,272	5.0	6.0	0	47
Low PSLE	1,247	38.1 %			
Medium PSLE	887	27.1 %			
High PSLE	1,138	34.8 %			
Sleep problems 1.5 yrs	3,623	3.0	3.0	0	7
Sleep problems 3 yrs	3,660	3.0	3.0	0	7
Sleep problems 5 yrs	3,591	2.0	3.0	0	7
Sleep problems 7 yrs	3,291	2.0	2.0	0	7
Sleep problems 11 yrs	2,524	1.0	3.0	0	7
Child sex^{male}	4,370	51.8 %			
Birth weight (grams)	4,263	3,300.0	600.0	600.0	5,350.0
Parity^{nulliparous}	3,451	50.4 %			
Maternal age at delivery (years)	4,352	24.0	7.0	15	48
Maternal education	3,486	12.0	2.0	8	18
Primary (8 yrs of education)	214	6.1 %			
Lower secondary 1 (10 yrs of education)	1,030	29.5 %			
Upper secondary (12 yrs of education)	1,381	39.6 %			
Post-secondary (14 yrs of education)	181	5.2 %			
Tertiary – college 1 (16 yrs of education)	602	17.3 %			
Tertiary – Postgradual (18 yrs of education)	78	2.2 %			
Family structure$^{two\text{-}parent}$	3,483	91.0 %			
Financial hardship	4,038	0.4	0.8	0	3
Prenatal depression	3,470	6.0	6.0	0	29
Alcohol use in early to mid-pregnancy	4,490	0.0	0.0	0	3
Never	3,071	68.4 %			
Less than 1 serving per week	824	18.4 %			
About 1 serving per week	456	10.2 %			
More than 1 – 2 servings per day	139	3.1%			
Alcohol use in late pregnancy	5,056	0.0	1.0	0	3
Never	4,274	84.5 %			
Less than 1 serving per week	602	11.9 %			
About 1 serving per week	81	1.6 %			
More than 1 – 2 servings per day	99	2.0%			

Note. IQR = interquartile range.

Table 2

Results of the Poisson latent growth model predicting intercept and slope of the sleep problems trajectory, adjusted for delivery characteristics, demographic background and prenatal depression

	Sleep problems – intercept				**Sleep problems – Slope**			
Variable	**IRR (95% CI)**	**S.E.**	**z-value**	***p***	**IRR (95% CI)**	**S.E.**	**z-value**	***p***
Prenatal stressful LEs (per IQR)	1.083 (1.049 - 1.117)	0.016	4.961	<0.001	1.011 (1.005 - 1.017)	0.003	3.743	<0.001
Child sex^{male}	1.052 (1.012 - 1.093)	0.019	2.621	0.009	0.993 (0.986 - 1.000)	0.004	-1.869	0.062
Birth weight (per 1,000 grams)	0.993 (0.953 - 1.033)	0.021	-0.350	0.726	1.002 (0.995 - 1.009)	0.004	0.510	0.610
Parity^{nulliparous}	1.115 (1.059 - 1.171)	0.026	4.248	<0.001	0.998 (0.989 - 1.007)	0.005	-0.370	0.712
Maternal age at delivery (per 1 year)	0.998 (0.993 - 1.003)	0.003	-0.668	0.504	1.000 (0.999 - 1.001)	<0.001	0.138	0.891
Maternal education (per 1 year)	1.004 (0.994 - 1.013)	0.005	0.736	0.462	1.002 (1.001 - 1.004)	0.001	2.855	0.004
Family structure$^{two\text{-}parent}$	1.032 (0.959 - 1.105)	0.036	0.866	0.386	1.004 (0.990 - 1.018)	0.007	0.559	0.576
Financial hardship (per 1 unit)	1.025 (0.994 - 1.057)	0.016	1.591	0.112	0.998 (0.993 - 1.004)	0.003	-0.549	0.583
Prenatal depression (per 1 unit)	1.020 (1.014 - 1.025)	0.003	7.378	<0.001	1.000 (0.999 - 1.001)	<0.001	-0.116	0.908
Alco use in early to mid-pregnancy	1.046 (1.019 - 1.072)	0.013	3.475	0.001	1.002 (0.997 - 1.007)	0.002	0.676	0.499
Alco use in late pregnancy	1.012 (0.978 - 1.046)	0.017	0.677	0.498	1.004 (0.998 - 1.011)	0.003	1.359	0.174

Note. IQR = interquartile range (IQR = 6 life events). IRR = incidence rate ratio. CI = confidence interval. S.E. = standard error. *N* = 4,371 children.

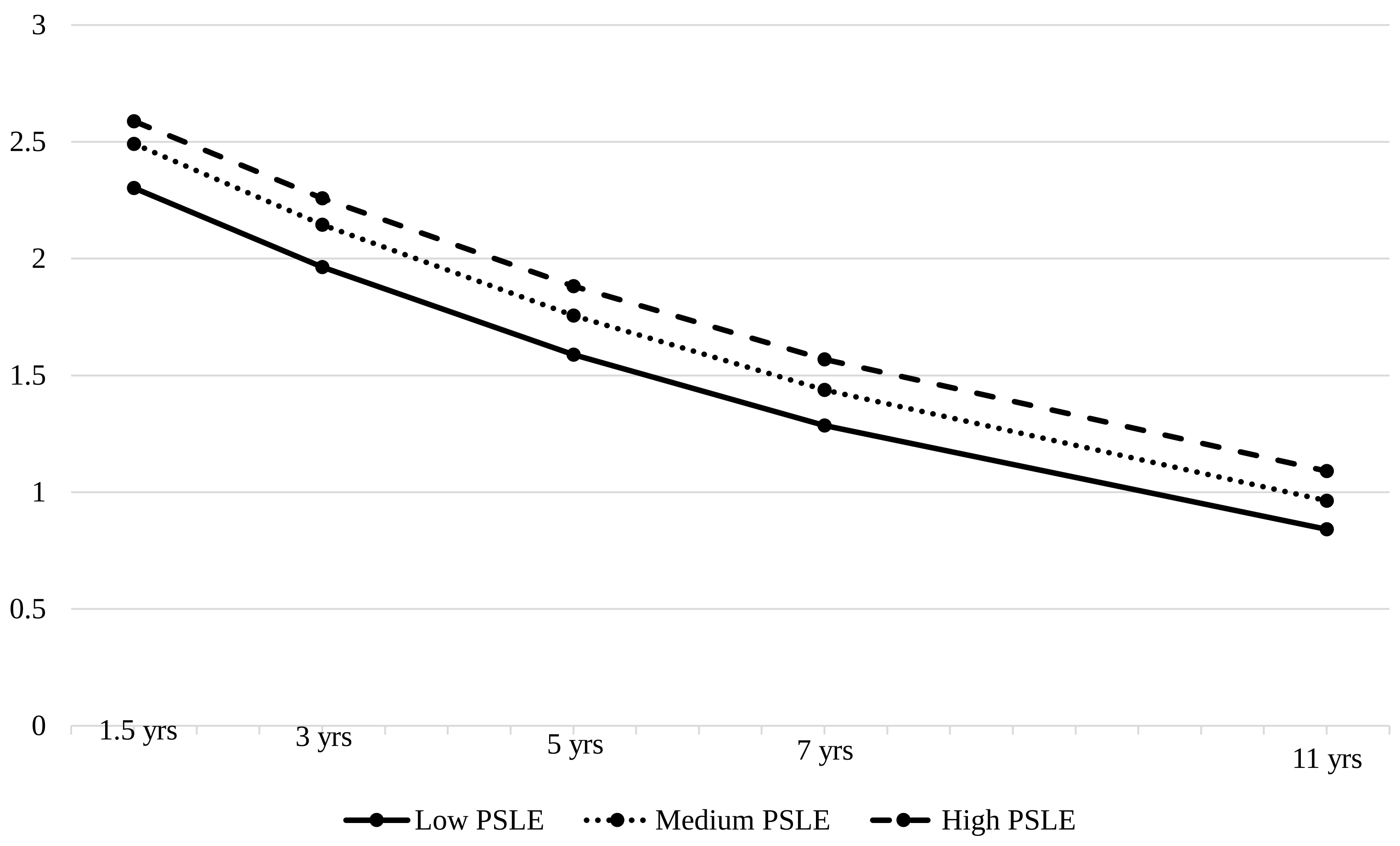

Figure 3. Mean trajectories of the sleep problems rate by tercile group of prenatal stressful life events (PSLE) after adjustment for child sex, low birth weight, parity, maternal education and age at delivery, family structure, financial hardship, prenatal depression, and alcohol use in pregnancy.

Note. Total N = 4,371 children.