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Sleep Problem Trajectories and Cumulative Socio-Ecological Risks: Birth to School-Age

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Abstract

Objectives—To evaluate whether there are distinct childhood sleep problem trajectories from birth to 10–11 years and to assess associations with cumulative socio-ecological risks (child, family, context).

Study design—Participants were 5,107 children from the Longitudinal Study of Australian Children—Birth Cohort. At birth, cumulative risk indexes were generated for birth, parenting, family, socioeconomic, and neighborhood risks. Parent-reported child sleep problems were assessed biennially from ages 0–1 to 10–11 years. Sleep problem trajectories were derived using latent class analysis. Multivariable logistic regression was used to examine associations with risk indexes.

Results—Five distinct trajectories emerged: persistent sleep problems through middle childhood (7.7%), limited infant/preschool sleep problems (9.0%), increased middle childhood sleep problems (17.0%), mild sleep problems over time (14.4%), and no sleep problems (51.9%). Cumulative mother- and father-reported family risks (distress; marital/relational hostility) were

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linked to nearly all of the trajectories, whereas father- and mother-reported parenting risks were associated with fewer trajectories. Birth risks were associated with increased middle childhood sleep problems. Neighborhood risks were not associated with any trajectories. Socioeconomic risks were linked to mild and persistent sleep problem trajectories. Cumulative risk indexes were most associated with increased middle childhood sleep problems.

Conclusions—This study identified distinct longitudinal sleep problem trajectories, suggesting the need for continuous sleep screening over development. Cumulative risks assessed at birth—primarily maternal and paternal family risks—predicted these trajectories, especially for the sleep problems in middle childhood trajectory. Preventive interventions targeting modifiable factors, especially caregiver distress and marital/relational hostility, could benefit child sleep.

Identifying children at-risk for persistent sleep problems through childhood is critical, as sleep difficulties are associated with subsequent deficits in social-emotional and behavioral skills (1, 2), neurocognitive functioning (3, 4), and brain morphology(5). Sleep problems in infancy have been found to persist through early childhood (6–10), but few studies have examined the developmental course of sleep problems beyond ages 5–6 years. One study identified children with persistent sleep problems (10.6% of the sample) and their corresponding behavioral issues, from ages 5 to 14 years (11). Another study examined longitudinal patterns of insomnia symptoms over seven years, from middle childhood to adolescence (12).. Understanding the trajectories of sleep problems can lead to anticipatory guidance for families This research can also provide a basis for future work that identifies children on distinct sleep problem trajectories that should be differentially targeted for preventive intervention.

To further inform targeted screening and prevention efforts, as well as natural pathways to target during intervention delivery, cumulative risk factors across socio-ecological (13) domains that are associated with persistent childhood sleep problems and those that remit over time should be identified. Bronfenbrenner socio-ecological model (13), recently applied to understand factors linked to adult sleep duration (14), consists of multiple, interacting systems that vary in proximity to the individual and impact development and functioning. These systems include the individual microsystem (eg, biological and psychological factors), the mesosystem (e.g., parenting and other family factors; the school context); and the macrosystem (e.g., the broader physical environment; public policy). Many studies have separately identified risk factors for sleep problems at various socio-ecological levels (13). These include individual child factors such as prematurity (15) and temperament (16, 17), parent and family factors such as maternal depression (18, 19), parenting practices (20–22), inter-parental conflict (23) and household chaos (24, 25), and contextual factors, such as family socioeconomic status (26, 27) and neighborhood disadvantage (28, 29).

Studies using cumulative risk models, which combine multiple and highly intercorrelated risk factors into a risk exposure index (30, 31), to predict other aspects of child development have shown that increased exposure to cumulative socio-ecological risks robustly predicts adverse outcomes such as behavioral health diagnoses, school dropout, substance use, and physical illnesses (32–34). Some emerging research suggests that cumulative exposure to risks related to family adversity is linked to decreased sleep duration (35) and increased

sleep problems (36) in childhood. However, linkages with exposure to familial and other cumulative risks on child sleep have not been examined longitudinally or in relation to sleep problem trajectories.

To address these gaps, the primary aim of this study was to identify distinct trajectories of child sleep problems from infancy to middle childhood. The second aim was to examine whether indexes of cumulative risks at multiple socio-ecological levels assessed at birth at the individual child, parent and family, and neighborhood levels were associated with sleep problem trajectories.

METHODS

Data were drawn from the first 6 waves of the prospective Growing up in Australia: The Longitudinal Study of Australian Children (LSAC)—Birth Cohort (B-cohort). Technical details about the study design and methods have been described elsewhere (37). In 2004, LSAC employed a two-stage cluster sampling design to enroll the cohort. In the first stage, Australian postcodes were sampled after stratifying by state and urban/rural status to ensure proportional geographic representation. Within each postcode, children registered on the Australian Medicare database (which includes 98% of all children) were randomly selected to participate. Children not registered on the Medicare database are those who do not have Australian citizenship or whose family members have not applied for a permanent residency (38). Follow-up waves have occurred biennially. The B-cohort includes 5,107 infants aged 0–1 years who were enrolled in 2004 (Wave 1), of whom 3,764 (73.7%) remained in the study at Wave 6 (age 10 to 11 years). The final analytic sample for this study was 4,517 participants. Retention was marginally lower for children with less highly educated parents and from non-English speaking backgrounds (39). Written informed consent for study participation was obtained from children’s primary parent/legal guardian. The study was approved by the Australian Institute of Family Studies Ethics Committee.

Procedure

At each data collection wave researchers administered a face-to-face interview with the primary parent (usually the mother) in the family home (37). When possible, both parents reported on study outcomes.

Measures

Sleep problems.—At each time point, child sleep problems were defined using the parent-reported question, *How much is your child’s sleeping pattern or habits a problem for you?*(40) The primary parent indicated whether their child’s sleep was a *large problem*, a *moderate problem*, a *small problem*, *no problem at all*, or *not sure/don’t know*. Responses were dichotomized according to previous longitudinal and intervention research (41–43), with a sleep problem defined as those who had a moderate or large problem, and no sleep problem defined as no problem or a small problem. *Not sure/don’t know* responses were coded as missing. This dichotomous approach has shown high correspondence with other measures of caregiver-identified problematic sleep behaviors (44, 45).

Cumulative socio-ecological risk indexes (measured during infancy).—Five separate cumulative risk indexes were theoretically derived and constructed according to Bronfenbrenner socio-ecological framework (13), previous LSAC studies examining socio-ecological risks (31, 46), and previous research on socio-ecological predictors of pediatric sleep problems. Indexes included: a birth risk index (46, 47) to reflect the individual child socio-ecological level; a family risk index and a parenting risk index (31) to reflect aspects of the family socio-ecological level; and a socioeconomic risk index and a neighborhood risk index (48–51) to reflect the broader socio-cultural context. Table I shows the variables in each index. Within each index, each risk variable was dichotomously coded as 1 for high risk and 0 for low risk, and then averaged to generate a total risk index score (between 0 to 1) where more than half the risk variables were available, consistent with cumulative risk coding procedures (30) (see Table 2 and Table 3 (available at www.jpeds.com) for coding of cumulative risk variables and for correlations among risk indexes). Higher index scores indicate higher risk levels. When both maternal and paternal reports were available, we generated a separate risk index by reporter, (family risk and parenting indexes; Table 1 shows included variables by reporter). Of note, the maternal family risk index contained a depressed mood variable and the maternal parenting risk index contained a co-parenting, whereas the corresponding paternal indexes did not as these variables were not included in the LSAC data collection for paternal participants. For single parent families, where a score was not available for the partner, the partner index was treated as missing data.

This cumulative risk approach indexes the number of risk factor exposures. Although some risk factors may be strongly intercorrelated, others are not (30, 31); this approach maximizes the likelihood of capturing diverse risk exposures linked with child sleep problems in previous research. Tables 4–8 (available at www.jpeds.com) show the correlations among variables in the risk indexes, which ranged from small to moderate across indexes, with the exception of the birth risk index. In that index, some variables such as maternal prenatal use of teratogenic substances and intensive postnatal care were not associated. This index was created on the basis of previous pediatric sleep and LSAC research (47), and theoretically represents a spectrum of risky birth complications. Reliability and validity for the continuous variables, such as the parenting scales, are strong ($\alpha > .70$) and are described in detail elsewhere (52).

Confounders.—Child sex was entered as confounder in all statistical analyses. We also included three primary caregiver-reported child sleep behaviors in all statistical analyses as confounders: *difficulty getting off to sleep at night*, *not happy to sleep alone*, and *waking during the night*. Caregivers rated whether these items occurred 4 or more nights per week (yes/no).

Statistical Analyses

We used survey methods in all analyses to account for the unequal probability of participant selection into the sample and sample attrition, and the multi-stage, clustered sampling design (53, 54). To identify whether there were distinct trajectories of child sleep problems over time, we conducted latent class analysis in Mplus version 8 (55). Children were grouped based on the repeatedly measured parent-reported child sleep problem across the 6 study

waves. The number of trajectories classified was determined on the basis of the minimum Bayesian Information Criterion (=7870.9) and a significant Lo-Mendell-Rubin Likelihood Ratio Test (<0.05). This technique estimates the number of groups that best represent the data, and whether extracting additional groups would significantly improve model fit. Estimation was by maximum likelihood with robust standard errors, which handles missing data by inferring on the basis of available measures.

We then used Stata version 15 (56) to examine whether cumulative socio-ecological risk indexes measured at birth were differentially predictive of the latent sleep problem trajectories. Associations between the risk indexes and derived sleep trajectories were determined using multinomial logistic regression to estimate the unadjusted and adjusted odds ratios between groups with the “no sleep problems” group (see below) as the reference. Only adjusted models are presented as the estimates attenuated only slightly on including the *a priori* confounders. Finally, we conducted multivariable logistic regression for each trajectory, with only indexes with a $P < .05$ in the multinomial logistic regressions included as predictors in the multivariable models.

RESULTS

Table 9 shows the birth cohort demographic information. There were similar proportions of girls and boys (51.1% male). The mother served as the primary reporter for the majority of children (96.1%). Most families were two-parent families (90.6%), spoke English as the primary language at home (85.6%) and had parents who had completed at least high school (68.3% of mothers; 59.8% of fathers). Mean cumulative risk scores for each index are also presented in Table 9. The correlations between risk indexes are available in Table 3.

Sleep problem trajectories

The Figure depicts the results of latent class analysis, in which 5 distinct sleep problem trajectories emerged across the 6 time points. Spanning ages 0–1 to 10–11 years, 51.9% of children were classified as having “no sleep problems” over time. Seventeen percent of children showed minimal sleep problems in early childhood with increased sleep problems through middle childhood (“increased middle childhood sleep problems”). Another 9.0% of children showed increased sleep problems during the infancy and preschool periods, with substantial decreases around ages 4–5 years and continued decreases during middle childhood (“limited infant/preschool sleep problems”). A total of 14.4% showed mild sleep problems with minor increases in middle childhood (“mild sleep problems over time”), and 7.7% of children were categorized as having a persistently high level of sleep problems from infancy through middle childhood (“persistent sleep problems through middle childhood”).

Cumulative risk indexes at birth and sleep problem trajectories

Table 10 provides results of multinomial models examining associations between each cumulative risk index assessed at birth and each sleep problem trajectory. The birth risk index was associated with “increased middle childhood sleep problems” and the “limited infant/preschool sleep problems” trajectories. Both the mother-reported family risk index and parenting risk index were associated with nearly all of the trajectories; only the

association between the mother-reported parenting risk index and the “mild sleep problems over time” trajectory was non-significant. Father-reported family risk was also associated with all of the trajectories, but father-reported parenting risks were only linked to the “increased middle childhood sleep problems” and “persistent sleep problems” trajectories. Whereas neighborhood risks were only associated with “mild sleep problems over time,” socioeconomic risks were linked to all sleep problem trajectories.

In multivariable logistic regressions, which only included the risk indexes in multinomial models with a $p < .05$ (Table 10), all of the associations were attenuated and some were no longer significant. Birth risks continued to be associated with “increased middle childhood sleep problems.” Mother-reported family risks also continued to be associated with all of the trajectories, as in the multinomial models, and father-reported family risks were associated with all trajectories except “persistent sleep problems through middle childhood.” Mother-reported parenting risks were only associated with “increased middle childhood sleep problems.” Father-reported parenting risks were not associated with any sleep problem trajectories. Neighborhood risks similarly were not associated with any of the trajectories. The socioeconomic risk index, however, continued to be associated with the “mild sleep problems over time” and the “persistent sleep problems through middle childhood” trajectories.

Overall, the “increased middle childhood sleep problems” trajectory had the greatest number of associated cumulative socio-ecological risk indexes. As shown in Table 10, in the multivariable models, this trajectory had four associated cumulative risk indexes, whereas other trajectories were associated with a maximum of three risk indexes. Indexes associated with the “increased middle childhood sleep problems” trajectory were the cumulative birth risk, mother-reported and father-reported family risk, and mother-reported parenting risk indexes.

DISCUSSION

This study identifies distinct sleep problem trajectories from birth to middle childhood and examines associations with cumulative socio-ecological risks assessed at birth. In line with previous studies (6, 11, 57) about one-half of children showed no sleep problems, and 9% showed only early childhood sleep problems and 14% exhibited mild increases in sleep problems through ages 10–11 years. Three of the five trajectories included sleep problems in the first year of life. Interestingly, 17% of the sample had minimal sleep problems in early childhood but developed sleep problems in middle childhood. These trajectories correspond with and extend research showing that 12–20% of infants with sleep problems have continued early childhood difficulties (6, 8) and with research indicating a sleep problem persistence of 4–10% in middle childhood (11, 58). A recent study of sleep problems from ages 10–14 years found evidence for only 2 trajectories—troubled (10.6%) and normal sleepers (11), compared with the 5 found here. A proportion of the “normal” sleepers may have had early sleep problems that resolved or mild middle childhood sleep problems, consistent with the “limited infant/preschool sleep problems” and the “mild increases over time” trajectories that we found (Figure). Studies that do not include the early years likely miss identifying children with early sleep problems.

Mother-reported family risk variables, which included marital/relational hostility, stress exposure, psychological distress, and depression, were consistently associated with sleep problem trajectories. The more limited associations among sleep problem trajectories and father-reported family and especially parenting risk variables may be due to differences in parental practices and the division of childcare. Mothers may have more exposure to infant sleep problems due to longer postpartum family leave, which could lead to continued maternal management of sleep problems in later development. Indeed, mothers are more involved than fathers in nighttime caregiving during both early infancy (59) and toddlerhood (60). A study of 9- to 10-year-olds found that maternal, but not paternal, sleep was linked to child sleep duration and quality (61), suggesting greater maternal involvement in sleep regulation.

In the present study father-reported family risks at birth were associated with all trajectories except “persistent sleep problems through middle childhood,” but father-reported parenting risks were not. Other research (60) has found that paternal family risks and parenting practices are more strongly linked to concurrent or at least less distal sleep problems. Father-reported parenting risks may also have an indirect as opposed to a direct influence on persistent child sleep problems, as found in a longitudinal study showing that maternal marital hostility in infancy directly influenced later sleep problems, whereas paternal marital hostility had an indirect effect (62). Marital/relational hostility, which was a risk factor included in the maternal and paternal family risk indexes, may interact with child emotional and behavioral factors to influence sleep problems over time (63).

It is noteworthy that both mother and father-reported family risks in a child’s first year of life are linked with proximal sleep problems in infancy and early childhood *and* with more distal sleep problems that extend through or emerge in middle childhood. It could be that caregivers struggling with family risks such as marital/relational hostility or psychological distress during their child’s infancy are more likely to experience a recurrence of these concerns over time, leading to continued difficulty with child sleep problems (64). At the same time, persistent child sleep problems may also cause continued parental depressive symptoms and marital/relational stress. A recent study found such bidirectional effects, with child sleep problems robustly impacting maternal depression longitudinally (19); additional research is needed with fathers.

Child birth risks and mother-reported parenting risks were associated only with the “increased sleep problems in middle childhood” trajectory. This is surprising as early birth risks have been linked to sleep problems (43) and poor parenting has been found to impact early childhood sleep via bedtime limit setting difficulties, low parental self-efficacy, and negative parent-child interactions (21, 22, 62). The effects of birth risks and maternal parenting practices in the first year of life may accumulate over time and be exacerbated by other child factors, resulting in a greater impact on sleep in later development. Unmeasured child factors such as temperament and behavioral concerns can also interact with parent behavior and impact the etiology and persistence of child sleep difficulties (16, 23, 62, 63). Future research should examine child temperament, mood, and behavior concerns, which have been linked to poor sleep in middle childhood (11, 58, 65). Research is also needed on

how maternal and paternal family and parenting processes unfold over time to influence child sleep and related outcomes (19, 23).

Collectively, these findings support a personalized and developmentally-tailored approach to child sleep problem screening, prevention, and intervention. The high number of cumulative risk indexes associated with the “increased middle childhood sleep problems” trajectory suggests that anticipatory guidance about the development of later sleep problems may be necessary for families contending with child birth risks, maternal and paternal family risks, and maternal parenting risks in a child’s first year of life. It could be that children with this combination of cumulative risk factors at multiple socio-ecological levels at birth show later sleep problems that are comorbid with behavioral health conditions, given that internalizing and externalizing disorders tend to co-occur with pediatric sleep problems (58, 66).

Screening for caregiver psychological distress, stress exposure, and marital/relational conflict during infancy may also identify children at-risk for early and persistent sleep problems. Although neighborhood-level risks such as safety and noise were not associated with sleep problem trajectories, family-level socioeconomic risks were linked to both mild and persistent sleep problems, consistent with previous research linking socioeconomic disadvantage and poor sleep (26, 27). The American Academy of Pediatrics recommends that pediatricians screen for parent and child adverse experiences, including caregiver mental health and stress exposure, to identify children at-risk for poor developmental outcomes (67, 68).

Aspects of the caregiver family and parenting risks are modifiable intervention targets that could be leveraged to prevent child sleep problems. With an increased postpartum depression prevalence (69), maternal mood screening is recommended as a part of maternity and infant care in Australia and other Western contexts (70, 71). Unfortunately, few mothers who screen positively for postpartum depression receive treatment (70), despite accessing medical care for themselves and for their children (72). Given these service delivery gaps, treatment for maternal mood concerns could be integrated into child behavioral sleep programs. Such programs have had ancillary benefits on maternal mood (41, 73) and marital satisfaction (74), and children with a depressed caregiver show diminished sleep intervention outcomes (75). Integrated services should also be extended to paternal postpartum mood concerns, which impact 10% of fathers and are correlated with maternal mood (76). Incorporating evidence-based strategies to improve caregiver distress, marital/relational hostility, and enhance parenting practices could further augment sleep intervention effects, benefit families who may not respond to sleep intervention, or reduce the risk of sleep problem recurrence (8, 65) One study found that combining behavioral parent training with sleep intervention increased pre-to-posttreatment child behavior effect sizes (77).

Study limitations include the use of subjective reports of child sleep as well as a single item used to assess problematic sleep, which may not fully capture the range, nuances, or presence of a diagnosed child sleep disorder such as insomnia. In addition, this item does not capture objective aspects of child sleep including sleep timing and duration. Future research using objective measures would reduce the potential in the present study for significant linkages between caregiver-reported, and especially maternally-reported, cumulative risks as

well as child sleep problems. In particular, caregiver mood concerns could impact caregiver-reported child sleep, although it is noteworthy that father-reported family risks were still linked to mostly maternally-reported child sleep problems in this study. This study used a large, representative Australian sample, but findings may not generalize to other racial/ethnic backgrounds, cultures, parenting and marital/romantic partnership arrangements, and socio-ecological contexts, especially given cross-cultural variation in parent-defined sleep problems (57). The study design precludes any assessment of causality, however, findings may inform future causal research examining cumulative risk indexes and child sleep. Research should also assess cumulative risk indexes at multiple time points in relation to child sleep, with consistent reporting of mother-versus father-reported risk variables and expansion of caregiver report to families with other parenting arrangements (i.e., relatives; maternal primary and secondary caregivers; etc). Genetic factors may also confer increased risk for or resilience to sleep problems.

Additional research should examine the interplay of socio-ecological risks, sleep problems, and child factors longitudinally, as well as the direct and indirect effects of maternal and paternal risk factors. Screening for maternal and paternal family risks, particularly in socio-economically disadvantaged families, can help to identify risk for persistent sleep problems. Screening can also elucidate modifiable intervention targets, such as caregiver distress or marital/relational concerns that could be delivered to caregivers or incorporated into child sleep treatment. These efforts could buffer against the development or persistence of pediatric sleep problems, augment the effects of behavioral sleep intervention, and potentially mitigate the negative effects of familial and environmental risk factors on broad child and family functioning.

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Abbreviations:

LSAC	Longitudinal Study of Australian Children
OR	odds ratio

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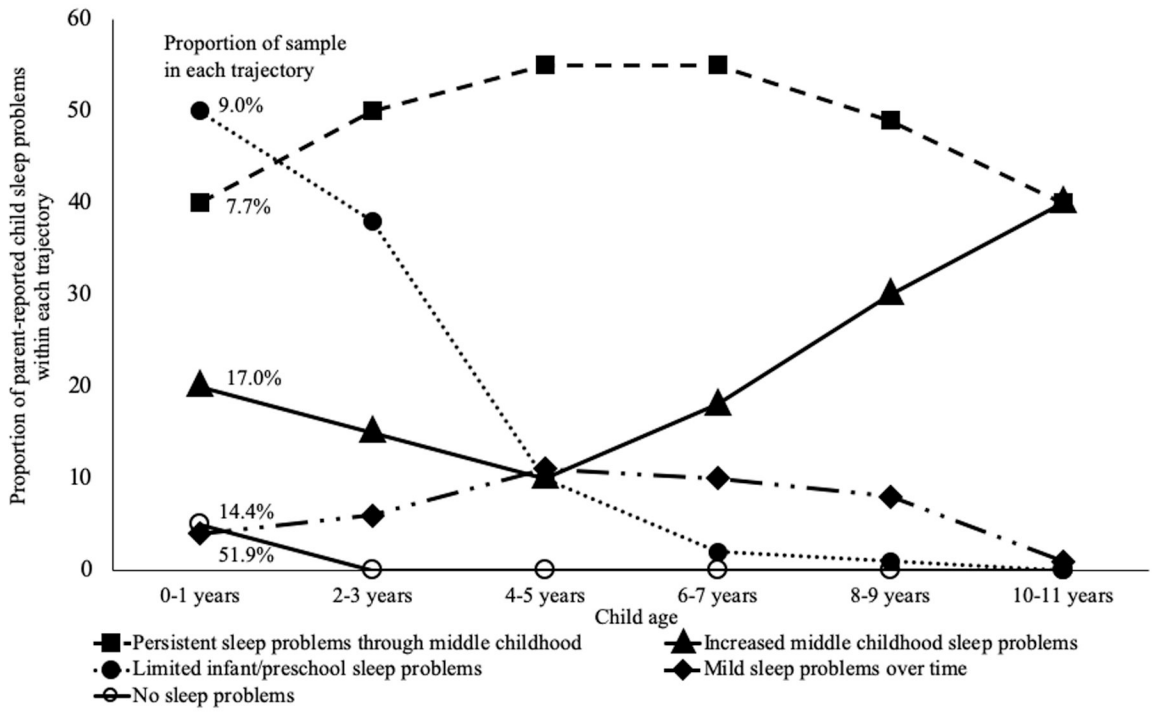


Figure 1.
Sleep problem trajectories from birth to age 10–11 years

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Table 1.

Variables included in cumulative risk indexes

Cumulative risk index and relevant citations	Variables
Birth risks (43, 46, 47)	Prenatal maternal antidepressant use
	Prenatal maternal alcohol use
	Prenatal cigarette use
	Prematurity (<37 weeks gestation)
	Low birth weight (<2500g)
	Postnatal intensive care
	Child special health care needs (78)
Family risks (18, 23, 31, 64) *	Marital hostility
	Parental psychological distress (Kessler K-6 scale (79))
	Parental depression ⁺
	Parental exposure to stressful life events
Parenting risks (21, 22, 31) *	Low parental warmth
	Hostile parenting
	Low parenting self-efficacy
	Poor co-parenting ⁺
Socioeconomic risks (26, 48, 49)	Financial hardship
	Low socioeconomic position (SEP) composite (parental income, education, and occupational prestige)
Neighborhood risks (28, 50, 51)	Poor neighborhood facilities
	Poor neighborhood livability (safety; cleanliness; traffic noise)
	Low neighborhood level socio-economic status composite

* Indicates separate mother- and father-reported indexes were generated when available.

⁺ Indicates that father-reported index does not include this variable.

Table 2.

Coding information for risk indexes (online only)

Index	Variable	Reporter	Procedure/question	Coding	
Birth	Prenatal antidepressant use	Mother	Retrospective report of whether mother had taken any antidepressants during their pregnancy with the child participating in the study, on a yes/no scale.	“Yes” = 1; “no” = 0.	
	Prenatal alcohol use	Mother	Retrospective response to the question, “During the pregnancy with the study child, did you drink alcohol?” on a 3-point scale: “yes, most days”; “yes, occasionally”; “no.”	Any “yes” = 1; “no” = 0.	
	Prenatal cigarette use	Mother	Retrospective response to the question, “During the pregnancy with the study child, did you smoke cigarettes?” on a 3-point scale: “yes, most days”; “yes, occasionally”; “no.”	Any “yes” = 1; “no” = 0.	
	Prematurity	Mother	Retrospective report of number of weeks at which child was born.	<37 weeks = 1; 37 weeks or greater = 0.	
	Low birth weight	Mother	Retrospective report of child birth weight.	Very low (<1500g) and low (1500g - 2500g) birth weight = 1; 2500g or greater = 1(47).	
	Postnatal intensive care	Mother	Retrospective report of whether there was intensive care at birth, rated on a 3-point scale (“yes”; “no”; “I don’t know”).	“Yes” = 1; “no” and “I don’t know” = 0.	
	Child special health care needs	Mother	Response on Children with Special Health Care Needs screener—Short Form; response to whether children had a medical, behavioral, or other health condition that has lasted at least 1 year or who required (1) additional medical, mental health, or educational services or (2) prescription medication as a result of their condition.	Any “yes” = 1; “no” = 0	
	Family (separate for mothers and fathers)	Marital hostility	Mother; father	Response to 5 items on a 5-point Likert scale ranging from “never” (1) to “always” (5). Items included the frequency of disagreements between partners about child-rearing, stressful or awkward conversations, anger or hostility, or arguments that ended in an individual pushing, hitting, kicking, or shoving.	Items were averaged to generate a total score; 20% of the sample with the highest levels of marital hostility = 1; rest of sample = 0; based on Hancock et al. (31).
		Psychological distress	Mother; father	Response to 6-item Kessler K6 scale (79) on a 5-point Likert scale ranging “all of the time” (0) to “none of the time” (4). Items asked how often reported had felt the following over the past 4 weeks: nervous; hopeless; restless or fidgety; that everything was an effort; so sad that nothing would cheer you up; worthless.	Items were reversed coded as needed and summed to generate a total score; 20% of the sample with the highest scores = 1; rest of sample = 0.
		Depression	Mother	Response to one item on a dichotomous yes/no scale asking whether reporter had felt depressed for 2 weeks.	Yes = 1; no = 0.
Stressful life events		Mother; father	Response to one item asking reporter the extent to which they were having difficulties with life stress on a 4-point Likert scale ranging from “no stressors” (0) to “many stressors” (3).	Some or many stressors = 1; no or few stressors = 0; based on Giallo et al. (46).	
Parenting (separate for mothers and fathers)	Parental warmth	Mother; father	Response to 6 items on a 5-point Likert scale ranging from “never/almost never” (1) to “always/almost always” (5). Items asked parents the frequency with which they expressed affection by: hugging, kissing, and holding the child; hugging or holding the child for no particular reason; telling the child how happy he/she makes you; having warm, close times together with the child; feeling close to the child when they are happy and upset.	Items were summed to generate a total score; 20% of the sample with the lowest scores = 1; rest of sample = 0.	
	Hostile parenting	Mother; father	Response to 5 items on a 10-point Likert scale ranging from “not at all” (1) to “all the time” (10). Items asked parents how often in the previous 4 weeks they: had been angry with the study child; had raised their voice or shouted at the study child; felt the study child got on their nerves when	Items were summed to generate a total score; 20% of the sample with the highest scores = 1; rest of sample = 0.	

Index	Variable	Reporter	Procedure/question	Coding
	Parenting self-efficacy	Mother; father	the child cried; had lost their temper with the study child; has left the study child alone in his/her bedroom when they were irritable or upset. Response to four items rated on a 5-point Likert scale ranging from “never/almost never” (1) to “always/almost always” (5). Items asked how good parents felt they were at: performing routine caregiving tasks; keeping the study child amused; calming the study child; keeping the study child busy.	Items were summed to generate a total score; 20% of the sample with the lowest scores = 1; rest of sample = 0.
	Co-parenting	Mother	Response to 3 items on a 5-point Likert scale ranging from “never” (1) to “always” (5). Parents rated how often their partner is a resource or support to them in raising their children; how often they are a resource or support to their partner; and how often they feel their partner understands and is supportive of their needs. Items were summed to generate an overall score	Items were summed to generate a total score; 20% of the sample with the lowest scores = 1; rest of sample = 0.
	Financial hardship	Mother	Report of financial hardship in the previous 12 months using a 6-item measure that asked about the family’s ability to pay their bills and mortgage on time, and whether the family had gone without meals, had been unable to heat or cool their home, had pawned or sold something, or sought out welfare or community-based assistance.	20% of the sample with the highest financial hardship scores = 1; rest of sample = 0.
Socioeconomic	Socioeconomic Position (SEP)	Mother	Composite variable consisting of parent-reported parental income, education, and occupational prestige. Blakemore et al. generated the SEP was generated using the following steps (48). Annual income for each caregiver (maternal and paternal) were summed and log-transformed. Each parent reported on their number of years of education attainment, which ranged from those who had no formal schooling (0 years) to those who had completed a post-graduate degree (20 years). Parents reported on their most recent occupational status, which was then rated using the ANU4, an index of occupational skill level and type. The income, educational attainment, and occupational prestige variables were then standardized, summed, and divided by the number of caregivers in the home. The resulting score was restandardized with a mean of 0 and a standard deviation of 1. The SEP was further categorized into low, medium, and high SEP categories reflecting low, medium, and high SEP.	Low SEP category = 1; middle and high SEP = 0.
	Neighborhood facilities	Mother	Response to six statements on a 4-point Likert scale ranging from “strongly agree” (1) to “strongly disagree” (4). Statements asked parents the extent to which they agreed that the following existed in their neighborhood: good parks, playgrounds, and play spaces in their neighborhood; good street lighting; good footpaths and roads’ access to close, affordable, regular public transport; access to basic shopping facilities; access to basic services such as banks, medical clinics, etc.	Lowest 20% of scores = 1; rest of sample = 0.
Neighborhood	Neighborhood livability	Mother	Response to three statements on a 4-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (4). The ask parents about the livability of their neighborhood, being “This is a safe neighborhood”, “This is a clean neighborhood” and “There is heavy traffic on my street or road”.	Lowest 20% of scores = 1; rest of sample = 0.
	Neighborhood-level socioeconomic status	Administrative data	Socioeconomic Indices for Areas (SEIFA) Index of Advantage/Disadvantage; the SEIFA has been validated by the Australian Bureau of Statistics, and consists of 31 variables drawn from administrative data, including neighborhood-level rates of income, unemployment, occupation, and education (50, 51). Scores range from disadvantaged (1) to advantaged (10).	Lowest 20% of scores = 1; rest of sample = 0.

Table 3.

Correlations between cumulative risk indexes (online only)

Risk indexes	Birth	Family (mother)	Family (father)	Parenting (mother)	Parenting (father)	Socioeconomic
Family (mother)	0.13	.				
Family (father)	0.06	0.28	.			
Parenting (mother)	0.02	0.18	0.04	.		
Parenting (father)	0.03	0.12	0.38	0.12	.	
Socioeconomic	0.07	0.11	0.08	0.01	0.08	.
Neighborhood	0.01	0.01	0.04	0.03	0.04	0.19

Note. Mother = mother-reported; father = father-reported.

Table 4.

Correlations among variables in birth risk index (online only)

Risk variables	Prenatal antidepressant use	Prenatal alcohol use	Prenatal cigarette use	Prematurity	Low birthweight	Postnatal intensive care
Prenatal alcohol use	0.00					
Prenatal cigarette use	0.03	0.01				
Prematurity (<37 weeks gestation)	0.02	-0.02	0.05			
Low birthweight (<2500g)	0.01	-0.05	0.07	0.54		
Postnatal intensive care	-0.01	-0.03	0.02	0.41	0.37	
Child special healthcare needs	0.03	-0.03	0.01	0.08	0.07	0.10

Table 5.

Correlations among variables in family risk indexes (online only)

Mother-reported risk variables	Marital hostility	Psychological distress	Depression
Psychological distress (Kessler-6)	0.25	.	
Depression	0.20	0.37	.
Stress exposure	0.25	0.37	0.26
Father-reported risk variables	Marital hostility	Psychological distress	
Psychological distress (Kessler-6)	0.23	.	
Stress exposure	0.24	0.37	.

Note. Father-reported family risk index did not include depression variable as this item was not measured for fathers.

Table 6.

Correlations among variables in parenting risk indexes (online only)

Mother-reported risk variables	Self-efficacy	Warmth	Hostile parenting
Warmth	0.24	.	
Hostile parenting	0.21	0.11	.
Co-parenting	0.21	0.25	0.12
Father-reported risk variables	Self-efficacy	Warmth	
Warmth	0.21	.	
Hostile parenting	0.17	0.22	.

Note. Father-reported family risk index did not include hostile parenting variable as this item was not measured for fathers.

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Table 7.

Correlations among variables included in the socioeconomic risk index (online only)

Risk variables	Socioeconomic position
Financial hardship	0.24

Note. The socioeconomic position (SEP) variable is a standardized index consisting of family income, education, and occupational prestige. The variable was created by the LSAC study team.

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Table 8.

Correlations among variables included in the neighborhood risk index (online only)

	Neighborhood socioeconomic status	Poor neighborhood livability
Poor neighborhood livability	0.21	.
Poor neighborhood facilities	0.14	0.26

Note. The neighborhood socioeconomic status variable is a standardized index created by the LSAC study team.

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Table 9.

Participant demographic characteristics and mean risk index scores

B cohort	
N = 5107	
Child (baseline)	
Male, %	51.1
Age (months), mean (SD); range	8.8 (2.5); 3 – 19
Primary parent (baseline)	
Female, %	96.1
Age (years), mean (SD); range	31.0 (5.5); 15–63
Born in Australia/New Zealand, %	81.4
English main language spoken at home, %	85.6
Education status, %	
Did not complete high school	31.7
Completed high school only	35.5
Completed tertiary/postgraduate degree	32.9
Married/de facto, %	90.6
Secondary parent (baseline)	
N = 4629	
Male, %	98.3
Age (years), mean (SD); range	33.7 (6.0); 16–65
Born in Australia/New Zealand, %	79.4
Education status, %	
Did not complete high school	40.2
Completed high school only	23.1
Completed tertiary/postgraduate degree	36.7
Cumulative risk index score, mean (SD)	
Birth risks	0.14 (0.15)
Family risks	
Mother-reported	0.27 (0.31)
Father-reported	0.28 (0.33)
Parenting risks	
Mother-reported	0.38 (0.19)
Father-reported	0.10 (0.15)
Socioeconomic risks	0.37 (0.36)
Neighborhood risks	0.19 (0.25)

Table 10.
Associations among cumulative socio-ecological risk indexes and child sleep problem trajectories

Multinomial regression models								
Risk Indexes	Mild sleep problems over time		Increased middle childhood sleep problems		Limited infant/preschool sleep problems		Persistent sleep problems through middle childhood	
	OR	p-value	OR	p-value	OR	p-value	OR	p-value
Birth risks	1.35 (0.67, 2.71)	0.394	2.44 (1.41, 4.25)	0.002	1.99 (1.01, 3.92)	0.046	1.74 (0.77, 3.93)	0.18
Family risks								
Mother-reported	2.27 (1.64, 3.12)	<0.001	3.03 (2.21, 4.14)	<0.001	3.07 (2.16, 4.36)	<0.001	5.85 (4.01, 8.52)	<0.001
Father-reported	1.76 (1.29, 2.39)	<0.001	1.99 (1.49, 2.67)	<0.001	2.13 (1.49, 3.05)	<0.001	2.62 (1.72, 3.99)	<0.001
Parenting risks								
Mother-reported	0.79 (0.49, 1.29)	0.362	2.36 (1.61, 3.44)	<0.001	1.92 (1.22, 3.04)	0.005	1.80 (1.04, 3.11)	0.034
Father-reported	1.15 (0.58, 2.27)	0.677	2.56 (1.45, 4.50)	0.001	0.69 (0.32, 1.47)	0.341	2.73 (1.17, 6.40)	0.020
Socioeconomic risks	2.33 (1.82, 2.99)	<0.001	1.40 (1.10, 1.78)	0.006	1.42 (1.05, 1.93)	0.022	3.09 (2.21, 4.32)	<0.001
Neighborhood risks	1.47 (1.04, 2.06)	0.026	1.11 (0.81, 1.53)	0.482	1.15 (0.75, 1.76)	0.497	1.30 (0.82, 2.08)	0.257
Multivariate logistic regression models								
Risk Indexes	Mild sleep problems over time		Increased middle childhood sleep problems		Limited infant/preschool sleep problems		Persistent sleep problems through middle childhood	
	OR	p-value	OR	p-value	OR	p-value	OR	p-value
Birth risks	-	-	2.15 (1.07, 4.32)	0.031	1.32 (0.56, 3.08)	0.515	-	-
Family risks								
Mother-reported	1.84 (1.24, 2.72)	0.002	2.38 (1.60, 3.54)	<0.001	2.47 (1.64, 3.72)	<0.001	4.41 (2.69, 7.24)	<0.001
Father-reported	1.45 (1.03, 2.05)	0.032	1.41 (1.00, 1.96)	0.045	1.56 (1.06, 2.29)	0.022	1.49 (0.90, 2.46)	0.113
Parenting risks								
Mother-reported	-	-	1.93 (1.08, 3.46)	0.026	1.25 (0.66, 2.33)	0.486	1.05 (0.51, 2.15)	0.889
Father-reported	-	-	1.56 (0.844, 2.87)	0.155	-	-	1.55 (0.59, 4.09)	0.368
Socioeconomic risks	2.06 (1.50, 2.83)	<0.001	1.22 (0.92, 1.62)	0.158	1.30 (0.93, 1.83)	0.121	2.14 (1.41, 3.28)	<0.001
Neighborhood risks	1.03 (0.66, 1.61)	0.882	-	-	-	-	-	-

Note. OR = odds ratio. Multivariate logistic regressions include only those risk indexes associated with trajectories at $p < .05$ in multinomial analyses.