Longitudinal sleep problem trajectories are associated with multiple impairments in child well-being

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**Background:** This study examined whether distinct sleep problem trajectories from infancy through middle childhood were associated with multiple aspects of child well-being at ages 10-11 years. **Methods:** Data were from the first six waves of the Longitudinal Study of Australian Children – Birth Cohort (5,107 children recruited at birth). Caregivers reported on child sleep problems at each time point. A combination of caregiver-reported, teacher-reported, and child-completed tasks were used to index child well-being outcomes at ages 10-11 years including emotional/behavioral functioning (internalizing and externalizing symptoms; self-control), health-related quality of life, cognitive skills and academic achievement. **Results:** Latent class analysis identified five distinct sleep problem trajectories over time: persistent sleep problems through middle childhood (7.7% of the sample), 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%). Compared to those with no sleep problems, children with persistent sleep problems had the greatest impairments across all outcomes except cognitive skills (perceptual reasoning), with moderate to large effect sizes. Children with increased middle childhood sleep problems similarly experienced greater internalizing and externalizing symptoms and worse quality of life, but few academic impairments. Both the limited infant/preschool sleep problems and mild increases over time trajectories also showed internalizing concerns and worse caregiver-reported quality of life, although effects were smaller than the other sleep trajectories. **Conclusions:** The linkages between sleep problems and negative child outcomes across domains underscore the importance of early identification and targeted intervention to address sleep problems and promote child well-being. **Keywords:** Academic; cognitive; longitudinal studies; sleep; quality of life; well-being.

**Introduction**

Up to 40% of children will experience symptoms of behavioral sleep problems, such as difficulty falling or staying asleep (Mindell, Kuhn, Lewin, Meltzer, & Sadeh, 2006; Sadeh, Mindell, Luedtke, & Wiegand, 2009). Behavioral sleep problems often co-occur with behavioral health and neurodevelopmental conditions (Tietze et al., 2012; Van Dyk, Becker, & Byars, 2019) and are associated with diminished child well-being (e.g., psychological, social, cognitive/academic, and physical health functioning) (Moore et al., 2011). Specifically, behavioral sleep problems have been linked to increased emotional and behavioral concerns (Gregory & O'Connor, 2002; Wang et al., 2016; Williams, Berthelsen, Walker, & Nicholson, 2017), impaired cognitive and...
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academic performance (Bub, Buckhalt, & El-Sheikh, 2011; Hoyniak et al., 2019; Williams, Nicholson, Walker, & Berthelsen, 2016), and poor health-related quality of life (Combs et al., 2016).

Although there are a number of previous longitudinal studies examining child sleep and well-being, there are several salient gaps in this research. For example, few studies have examined the continuity of sleep concerns and their association with developmental outcomes from infancy, when behavioral sleep problems are the most prevalent (Mindell et al., 2006; Williamson, Mindell, Hiscock, & Quach, 2019a), through the middle childhood. One study found that caregiver-reported child behavioral sleep problems at age 4 years predicted emotional and behavioral concerns at age 15 years (Gregory & O’Connor, 2002), but sleep problems in infancy and toddlerhood were not assessed. Other studies have examined problematic early childhood sleep patterns, such as actigraphy-derived delayed sleep timing (Hoyniak et al., 2019) or caregiver-reported child night awakenings and sleep duration (Kocevska et al., 2016; Touchette et al., 2007), with subsequent cognitive development, but outcome assessments did not extend beyond age 7 years. More research is needed that assesses the impact of sleep problems from infancy through middle childhood, particularly as the first 10-11 years of life is a period of important child development, with the acquisition of foundational psychosocial and cognitive/academic skills and the transition to a formal school setting.

In addition, few previous longitudinal studies have examined whether distinct profiles, or classes, of sleep problems are differentially linked to child outcomes. An increasing number of studies have used latent growth curve modeling to identify individual trajectories of caregiver-reported child sleep problems (Bub et al., 2011; Friedman, Corley, Hewitt, & Wright Jr, 2009) or actigraphy-derived sleep patterns (El-Sheikh, Bub, Kelly, & Buckhalt, 2013; Hoyniak et al., 2019) and their association with child outcomes longitudinally. Whereas latent growth curve models can robustly model within- and between-person change trajectories (Tasca & Gallop, 2009), latent profile (continuous data) or class (categorical data) analysis can identify whether these longitudinal change trajectories can be categorized into sub-groups (Lanza & Cooper, 2016). Very few pediatric sleep studies have applied this analytic approach, and those that do have focused primarily on problematic sleep patterns, such as quantified caregiver-reported child short sleep duration or night awakenings, instead of broad caregiver-identified child sleep problems. For instance, in a sample of preschoolers followed from ages 2 to 6 years, five
different caregiver-reported child nighttime sleep trajectories (Plancoulaine et al., 2018) and two
different night awakening trajectories emerged (Reynaud et al., 2016). Children belonging to the
frequent awakenings trajectory had increased emotional and behavioral concerns (Reynaud et al.,
2018). Another study of young children found four sleep duration profiles, with those in the short
sleeping profile showing diminished neurodevelopment at age 2 years (Smithson et al., 2018).

While examining problematic sleep patterns is important, it is also necessary to examine
caregiver-identified behavioral child sleep problems, particularly as caregivers are typically
responsible for seeking associated sleep treatment. Furthermore, some children with behavioral
sleep concerns may not view their sleep behaviors as being problematic (e.g., child difficulty
sleeping independently may be concerning to the caregiver but not the child). Only two previous
studies have examined profiles of caregiver-identified behavioral sleep problems. A study of
nearly 2,000 children followed longitudinally from ages 5 to 17 years found a profile of “normal
sleepers” (89.4% of the sample) without any sleep concerns over time and “troubled sleepers”
(10.6%) with persistent caregiver-reported sleep problems, who also demonstrated poorer
emotional and behavioral functioning at age 17 years. In our study using latent class analysis
(LCA) to identify caregiver-reported behavioral sleep problems from ages 0-1 years through ages
10-11 years, we found five distinct trajectories (Figure 1): (1) persistent sleep problems through
middle childhood (2) limited infant/preschool sleep problems, (3) increased middle childhood
sleep problems, (4) mild sleep problems over time, and (5) no sleep problems (Williamson,
Mindell, Hiscock, & Quach, 2019b). However, we have not yet examined whether these
trajectories are differentially associated with child well-being outcomes.

Building on this research, the present study aimed to examine whether these five
previously identified, distinct behavioral sleep problem trajectories are associated with domains
of child well-being at 10-11 years: emotional/behavioral functioning (internalizing and
externalizing symptoms; self-control), health-related quality of life, cognitive skills and
academic achievement. This study extends noted gaps in previous longitudinal research in
several ways. First, we assessed child sleep problems from infancy through middle childhood,
which captures a key period of development and the first major school transition. Second, we
identified specific sub-groups of sleep problem trajectories using LCA. Third, we focused on
caregiver-reported sleep problems, given the importance of caregiver report for behavioral sleep
disorder diagnosis (American Academy of Sleep Medicine, 2014) and treatment seeking in
childhood. Finally, whereas previous studies have examined only one or two domains of child well-being, we assessed multiple aspects of child well-being (Moore et al., 2011), which allows for the comparison of sleep problem impacts across outcomes and can inform targeted sleep and behavior interventions. We hypothesized that children belonging to the persistent sleep problems trajectory would exhibit the poorest child well-being outcomes. We also hypothesized that children belonging to the increased middle childhood sleep problems trajectory also showing impairments in child well-being, given that children in this trajectory showed an increase in sleep problems around the same time as the ages 10-11 year outcomes assessment occurred.

**Method**

*Study design and participants*

Data were drawn from the first 6 waves of the Growing up in Australia: The Longitudinal Study of Australian Children (LSAC)–Birth Cohort (B-cohort). Detailed information about the study design and methods has been provided elsewhere (Soloff, Lawrence, & Johnstone, 2005). The B-cohort includes 5,107 infants aged 0-1 years who were enrolled in 2004 (Wave 1; Table 1). Follow-up waves occurred biennially. A total of 3,764 (73.7%) child participants remained in the study at Wave 6 (age 10-11 years). The final analytic sample for this study was 4,517 participants (including those children for whom complete data were collected at least four time points). Children with less highly educated caregivers and children from non-English speaking backgrounds had marginally increased study attrition (Norton & Monahan, 2015).

*Ethical considerations*

Written informed consent for study participation was obtained from the child’s primary caregiver/legal guardian. The study was approved by the Australian Institute of Family Studies Ethics Committee and funded by the Australian federal government. No financial compensation was provided to participants.

*Procedure*

At each data collection wave a face-to-face interview was conducted with the primary caregiver (usually the mother) in the family home (Australian Government Department of Families, 2011).

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Teachers of participating children were also asked to complete a survey sent by mail.

**Measures**

*Sleep problem trajectories (birth to ages 10-11 years).* In a previous paper, we used latent class analysis in Mplus to derive five sleep problem trajectories based on a caregiver-reported child sleep problem item at each time point (Williamson et al., 2019b). Caregivers rated *How much is your child’s sleeping pattern or habits a problem for you?* as a large problem, a moderate problem, a small problem, no problem at all, or not sure/don’t know. Responses were dichotomized according to extensive previous research cross-cultural and intervention research (Hiscock et al., 2019; Mindell et al., 2011; Quach, Hiscock, Ukoumunne, & Wake, 2011; Quach, Nguyen, O’Connor, & Wake, 2017; Sadeh, Mindell, & Rivera, 2011; Sadeh et al., 2009), with a sleep problem defined as those who had a moderate or large problem. Not sure/don’t know responses were coded as missing. In identifying these trajectories, we covaried for child sleep behaviors reported at each time point by the primary caregiver (difficulty getting off to sleep at night; not happy to sleep alone; and waking during the night). Although the prevalence of these child sleep behaviors varied over development, each behavior was strongly associated with the presence of a caregiver-reported child sleep problem at each age in this sample (odds ratios ranging from 3.10 to 17.78, p<.001) (Williamson et al., 2019a).

Figure 1 shows the proportion of the sample at each age (x-axis) in each trajectory (y-axis), with the distribution of the sample for each trajectory. Spanning ages 0-1 to 10-11 years, 51.9% of children were in the “no sleep problems” trajectory. Another 14.4% showed “mild sleep problems over time,” reflecting lower levels of sleep problems consistently across all timepoints. Nine percent (9.0%) had “limited infant/preschool sleep problems.” Seventeen percent had “increased middle childhood sleep problems” trajectory, with sleep problems increasing steadily from ages 4-5 to 10-11 years. A “persistent sleep problems through middle childhood” trajectory captured children whose caregivers endorsed high levels of sleep problems over time (7.7%).

*Child internalizing and externalizing concerns at ages 10-11 years.* The primary caregiver and teacher reported on child internalizing and externalizing concerns using the Strengths and Difficulties Questionnaire (SDQ). Internalizing symptoms were represented by the 5-item SDQ.
emotional problems subscale (e.g., many worries, often seems worried; often unhappy, 
downhearted, or tearful), with possible scores ranging from 0 to 10. Externalizing symptoms 
were represented by 10 items from the SDQ conduct and hyperactivity/inattention subscales 
(e.g., often loses temper; often fights with other children or bullies them; restless, overactive, 
cannot sit still for long), with possible scores ranging from 0 to 20. Higher scores on these 
measures indicate greater emotional and behavioral concerns. The SDQ is a widely used measure 
for children aged 4-16 years with strong psychometric properties, including good internal 
consistency (caregiver-report $\alpha = .63-.77$ and teacher-report $\alpha = .74-.88$ for the subscales used 
in this study), strong stability, an established underlying factor structure, and correspondence 
with child psychiatric diagnoses (Goodman, 2001; Stone, Otten, Engels, Vermulst, & Janssens, 
2010). Caregiver and teacher interrater agreement correlations are .23-.41 for the emotional 
symptoms subscale, .27-.65 for the conduct problems subscale, and .44-.61 for the hyperactivity/ 
inattention subscale, supporting the multi-informant use of the SDQ (Stone et al., 2010).

Self-control at ages 10-11 years. The primary caregiver reported on child self-control using 7 
items from the Social Skills Improvement Rating System (Gresham, Elliott, & Kettler, 2010). 
Higher scores indicate increased child self-control. Psychometric research shows strong internal 
consistency ($\alpha = .84$) for this subscale and convergence with similar measures of prosocial 
behaviors (Gresham et al., 2010; Gresham, Elliott, Vance, & Cook, 2011).

Quality of life at ages 10-11 years. The primary caregiver reported on child quality of life using 
the Pediatric Quality of Life Inventory (PedsQL) Version 4.0, which is a 23-item questionnaire 
for children aged 2 to 18 years (Varni, Limbers, & Burwinkle, 2007). Fifteen items are summed 
to yield a Psychosocial Health summary score that reflects child quality of life with regard to 
emotional, social, and school functioning, while the remaining 8 items are summed to generate a 
Physical Health summary score. Summary scores are transformed to a 0-100 scale with increased 
scores representing better quality of life. In samples of both children with chronic illnesses and 
healthy controls (Varni, Burwinkle, Seid, & Skarr, 2003; Varni et al., 2007), the PedsQL has 
shown good psychometric properties, including strong internal consistency ($\alpha = .88$ for the 
caregiver-reported Psychosocial Health and Physical Health scores) and construct validity.

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Cognitive and academic skills at ages 10-11 years. Four aspects of child cognitive and academic skills were assessed. First, non-verbal (perceptual reasoning) skills were assessed via performance the Wechsler Intelligence Scale for Children (WISC-IV) matrix reasoning subtest, which is a reliable ($\alpha = .89$), valid, and norm-referenced measure of child perceptual reasoning (Wechsler, 2003). The matrix reasoning subtest has a mean score of 10 with a standard deviation of 3. Additional psychometric information is available elsewhere (Wechsler, 2003).

Second, academic competencies in language/literacy and mathematics were indexed using two subscales from the teacher-reported Academic Rating Scale (ARS), which is a 20-item measure drawn from the Early Childhood Longitudinal Study (ECLS; Rock & Pollack, 2002). The Language and Literacy scale contains 11 items, while the Mathematical Thinking subscale contains 9 items. Each subscale has a possible range of 1 to 5, with higher scores reflecting higher levels of academic competency. Rasch models were applied to estimate ARS scores in the original measurement development and validation study (Rock & Pollack, 2002), which provided evidence of very strong person reliability for the Rasch-based scores (.91 for Language and Literacy and .94 for Mathematical Thinking).

Third, academic achievement was defined using children’s scores from the Australian National Assessment Program—Literacy and Numeracy (NAPLAN) exam (Australian Curriculum, 2018). NAPLAN tests are designed each year by the Australian Curriculum, Assessment and Reporting Authority to measure academic progress according to the Australian Curriculum (Australian Curriculum, 2018). Students complete this standardized assessment in Years 3, 5, 7, and 9. Academic scores for Year 5 (ages 10-11 years) were available in the domains of mathematics, reading, sentence comprehension, writing and spelling. We computed a mean score across domains to reflect broad academic achievement, with higher scores indicating higher achievement. In a technical report, which contains details about this standardized assessment, the NAPLAN showed moderate correspondence ($r = .41 - .64$) with teacher-rated ARS scores in the LSAC study (Daraganova, Edwards, & Sipthorp, 2013).

Finally, classroom learning was defined by 6 teacher-reported items from the Approach to Learning Social Rating Scale, which was developed by the ECLS-K (Rock & Pollack, 2002). Items were designed to assess various aspects of a child’s approach to learning, such as organization, working independently, and task completion. The possible score range was 1 to 6, with higher scores indicating better learning-related behaviors. Split half reliability in the
validation study for this measure was high (.89), with evidence of good validity through moderate convergence with other teacher-rated child behavior measures (Rock & Pollack, 2002).

Confounders. Confounders included Wave 1 child age and Wave 6 family socioeconomic position (SEP). Family SEP is a composite LSAC measure derived from standardized scores of combined annual household income, parental education, and parental occupation (Blakemore, Strazdins, & Gibbings, 2009). SEP is divided into quintiles. As proportions of children in each trajectory varied only marginally by SEP quintile, we elected to adjust, rather than stratify, for SEP quintile to account for any residual confounding.

We additionally covaried for maternally- and paternally-reported family risk index scores, as our previous research demonstrated that these indexes, which were assessed at child age 0-1 years, predicted the sleep trajectories used in this study (Williamson et al., 2019b). These family risk scores were generated separately by reporter, with each risk item dichotomized and averaged to generate a risk index (range 0 to 1, with 1 being positive for all items). Each family risk index contained a caregiver rating of marital hostility, clinically significant psychological distress as measured by the Kessler-6 (Kessler et al., 2002), and exposure to stressful life events. The mother-reported risk index also contained a dichotomous (yes/no) item on whether she had felt depressed over the last 2 weeks. Higher risk scores indicate greater family-level risk at child age 0-1 years. Details about the psychometric properties of these variables and the index scores are provided elsewhere (Hancock, Christensen, & Zubrick, 2017; Williamson et al., 2019b).

Statistical analysis

We used survey methods in all analyses to account for the unequal probability related to participant selection and attrition and the multi-stage, clustered sampling design. All analyses were conducted in Stata version 15.0. Psychosocial outcomes at ages 10-11 years were converted to z-scores to facilitate comparison across sleep problem trajectories and for presentation as effect sizes relative to the whole sample’s standard deviation. Associations between the sleep trajectories and child well-being were determined using unadjusted and adjusted linear regression to estimate the mean differences between trajectories, with the “no sleep problems” sleep trajectory as the reference group. Only adjusted regressions are presented because estimates attenuated minimally on including the a priori confounders.

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Results

Demographic information
Table 1 shows the demographic information when the birth cohort sample was recruited at child ages 0-1 years. There were similar proportions of girls and boys (51.1% boys). Most of the primary caregivers were mothers (96.1%). The majority of children were from two-caregiver families (90.6%) and spoke English as the primary language at home (85.6%). Over half had a caregiver who had completed at least high school (68.3% of mothers; 59.8% of fathers).

Associations between sleep problem trajectories and well-being
The associations between the sleep problem trajectories and child well-being are shown in Figures 2 and 3 and Table S1, expressed as effect sizes (ES) indicating the adjusted mean difference between each sleep problem trajectory and the “no sleep problem” trajectory used as the reference group. Across outcomes, with the exception of child non-verbal reasoning, children in the “persistent sleep problems through middle childhood” trajectory showed the poorest functioning, with effect sizes for the mean differences compared to the no sleep problem group in the moderate to large range.

Child internalizing and externalizing concerns. Children in the “persistent sleep problems” trajectory showed moderate teacher-reported internalizing (ES = -0.65, 95% CI -0.87 to -0.43, p <.001) and externalizing concerns (ES = -0.40, 95% CI -0.58 to -0.21, p <.001) and large caregiver-reported internalizing (ES = -0.75, 95% CI -0.92 to -0.57, p < .001) and externalizing concerns (ES = -0.70, 95% CI -0.86 to -0.53, p < .001) relative to those with no sleep problems. Children in the “increased middle childhood sleep problems” trajectory similarly showed greater caregiver- and teacher-rated internalizing and externalizing symptoms, with small to moderate effect sizes (caregiver ES for both = -0.61, 95% CI -0.76 to -0.46, p <.001; teacher ES range = -0.29 to -0.39, 95% CI -0.53 to -0.15, p <.001). Children with “limited infant/preschool sleep problems” only showed small impairments in teacher-rated internalizing symptoms (ES = -0.12, 95% CI -0.23 to -0.01, p <.05), whereas children in the “mild sleep problems over time” trajectory showed small impairments in caregiver-rated internalizing symptoms (ES = -0.19, 95%
**Self-control.** Children following the “persistent sleep problems” and “increased middle childhood sleep problems” trajectories showed moderate impairments in caregiver-reported self-control compared to children without sleep problems (ES for both = -0.37, 95% CI -0.52 to -0.21, \( p < .001 \)). Neither the “limited infant/preschool sleep problems” nor the “mild sleep problems over time” trajectories evidenced significant impairments in self-control.

**Quality of life.** Children in all of the trajectories showed significantly worse caregiver-reported psychosocial and health-related quality of life compared to those in the “no sleep problems” group. Effect sizes were largest for those in the “persistent sleep problems group” (ES range = -0.78 to -0.90, 95% CI -1.06 to -0.56, \( p < .001 \)), followed by those in the “increased middle childhood sleep problems” trajectory (ES range = -0.33 to -0.75, 95% CI -0.88 to -0.19, \( p < .001 \)). Children in the “limited infant/preschool sleep problems” (ES range = -0.12 to -0.13, 95% CI -0.23 to -0.02, \( p < .05 \)) and “mild sleep problems over time” (ES range = -0.17 to -0.20, 95% CI -0.32 to -0.05, \( p < .01 \)) trajectories showed small quality of life impairments.

**Cognitive and academic skills.** No trajectories showed significant impairments in non-verbal reasoning compared to children without sleep problems. However, children with persistent sleep problems evidenced moderate teacher-rated language/literacy and mathematical thinking impairments (ES = -0.41 for both outcomes, 95% CI -0.60 to -0.23, \( p < .001 \)). Whereas children in the “increased middle childhood sleep problems” and “limited infant/preschool sleep problems” showed no significant differences in academic competencies, those in the “mild sleep problems” trajectory evidenced small impairments in these outcomes (ES range = -0.14 to -0.17, 95% CI -0.31 to -0.004, \( p < .05 \)).

Findings for academic achievement on standardized national testing followed a similar pattern, with children who had “persistent sleep problems” showing lower achievement scores, with a small effect size (ES = -0.29, 95% CI -0.46 to -0.12, \( p < .001 \)). No significant differences were found for children in the “increased middle childhood sleep problems” and “limited infant/preschool sleep problems” trajectories. Those with mild sleep problems did show very small, yet significant, impairments (ES = -0.14, 95% CI -0.27 to -0.02, \( p = .03 \)).
Teacher-rated approach to learning also varied by sleep trajectory. The “persistent sleep problems” group showed moderate impairments in learning-related behaviors ($ES = -0.42$, 95% CI -0.59 to -0.25, $p < .001$), while the “increased middle childhood sleep problems” showed small impairments ($ES = -0.26$, 95% CI -0.41 to -0.12, $p < .001$). No differences emerged for children with “limited infant/preschool sleep problems” or for those with “mild sleep problems.”

**Discussion**

Overall, this study found that caregiver-perceived behavioral sleep problems at any age, from birth to age 10-11 years, were associated with impairments in multiple domains of child well-being in middle childhood. These findings extend previous longitudinal research linking sleep and child outcomes. Previous studies were limited by a lack of attention to the important period between infancy and middle childhood and a focus on problematic sleep patterns (e.g., quantified sleep duration or awakenings) rather than caregiver-identified child sleep problems, which are important given the role of caregivers in diagnosing and seeking treatment for these concerns. Additionally, few studies have identified latent classes, or sub-groups, of sleep problems and examined these groups in relation to domains of child well-being. Children with persistent sleep problems evidenced the greatest impairments relative to those without sleep problems, with the mean difference effect sizes in the moderate to large range. These impairments included greater caregiver- and teacher-reported internalizing and externalizing psychopathology symptoms, the poorest quality of life, the worst self-control, and the most impaired language/literacy and mathematics competencies, academic achievement, and classroom behaviors. Children with increased sleep problems in middle childhood had moderate impairments in psychosocial domains that were similar to those with persistent sleep problems (psychopathology; quality of life; self-control), but this group had few academic and cognitive impairments. Children with limited infant/preschool sleep problems similarly had few academic and cognitive impairments, but did evidence teacher-reported internalizing symptoms and poorer caregiver-reported quality of life. Interestingly, children who had “mild sleep problems over time” also showed impairments across many domains, albeit with smaller effect sizes.

While these findings are consistent with many studies showing associations between childhood sleep problems and poor outcomes (Combs et al., 2016; Dewald, Meijer, Oort,
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Kerkhof, & Bogels, 2010; Gregory & O’Connor, 2002; Wang et al., 2016), the findings of this study extend the literature by demonstrating how persistent child sleep problems measured in two-year increments longitudinally, rather than sleep problems at one or two age points, may be linked to child outcomes. In addition, study findings extend the literature by allowing for the comparison of the impact of sleep problems across different child outcomes. These study findings suggest that some aspects of child well-being may be more closely linked to sleep problems than others. Across sleep problem trajectories, effect sizes were the largest for associations between sleep problems and child emotional/behavioral concerns (internalizing and externalizing symptoms, self-control) and health-related quality of life. Although this finding warrants replication, it could be that child sleep problems are more proximally and/or strongly linked to emotional/behavioral concerns and other aspects of psychosocial functioning, including health-related quality of life, than to cognitive and academic outcomes. Indeed, neurobiological research indicates that sleep may play a causal role in emotional regulation and processing (Goldstein & Walker, 2014), both of which are critical for psychosocial development. In addition, intervention research has demonstrated that addressing behavioral sleep problems can yield concurrent emotional/behavioral, but not academic, improvements (Quach et al., 2011).

Specific to the children in the persistent sleep problems trajectory, poor sleep in the first 10 years of life may be particularly detrimental for both the acquisition and advancement of emotional and behavioral regulation skills. Diary studies (Kouros & El-Sheikh, 2015; Van Dyk, Thompson, & Nelson, 2016) and experimental sleep restriction research (Baum et al., 2014; Miller, Seifer, Crossin, & Lebourgeois, 2015) show that poor sleep is linked to short-term emotional and behavioral dysregulation, while longitudinal research shows that early sleep problems are associated with longer-term emotional and behavioral consequences (Gregory & O’Connor, 2002; Sivertsen et al., 2015). Persistent sleep problems resulting in both short- and longer-term impacts on child emotional/behavioral functioning could explain the larger mean difference effect sizes for impairments in these domains relative to those found in the other sleep problem trajectories. Bidirectional associations between sleep problems and emotional/behavioral concerns occurring daily (Kouros & El-Sheikh, 2015) and longitudinally (Quach, Nguyen, Williams, & Sciberras, 2018; Wang et al., 2016; Williams et al., 2017) could also explain these greater impairments compared to those with shorter-term concurrent sleep issues, such as those seen in the increased middle childhood sleep problems trajectory.
In addition, impairments in both sleep and emotional/behavioral functioning may cumulatively impact subsequent child classroom behaviors and, in turn, academic achievement (Williams et al., 2017; Williams et al., 2016). For example, despite having a pattern of increased middle childhood sleep problems, children on this trajectory did not show concurrent impairments cognitive and academic performance (standardized testing and teacher-rated academic achievement). The only impaired academic outcome for this group was teacher-rated approach to learning, which captures classroom learning-related behaviors such as attention and organization. Given the relatively recent onset and worsening of sleep problems for children belonging to this trajectory relative to the assessment of child outcomes, it is possible that sleep concerns have not yet begun to erode or even possibly do not affect academic achievement, but do impact classroom behaviors (e.g., organization, attention) and thus teacher perceptions of student behavior, including emotional/behavioral concerns. Academic performance at age 10-11 years may be more dependent on child functioning longitudinally, including prior academic skill acquisition, and perhaps reflects the cumulative impact of sleep on performance, whereas classroom behaviors could represent the next-day impacts of poor sleep. This idea is in line with experimental sleep restriction research, which shows impaired attention in sleep-deprived youth (Beebe, Rose, & Amin, 2010). It could be that only children with persistent sleep problems experience impairments in standardized academic testing and teacher-rated achievement because their poor sleep has impacted classroom behavior over a longer period of time, resulting in impaired learning and poor academic skills acquisition. Of note, however, studies have not examined whether caregiver-perceived child sleep problems such as difficulty falling or staying asleep are linked to next-day child functioning, which is an important future research direction.

It is also notable that no trajectories were associated with non-verbal perceptual reasoning. Cognitive functioning and performance on a particular task at one timepoint may be more attributable to other, perhaps less malleable factors, such as genetic heritability for perceptual skills. Sleep problems may also be differentially associated with cognitive skills. For instance, short sleep duration has been linked to perceptual reasoning deficits across studies (Astill, Van der Heijden, Van Ijzendoorn, & Van Someren, 2012; Gruber et al., 2010), but as previously noted research is limited on the extent to which other behavioral sleep problems such as pediatric insomnia symptoms are linked to cognitive functioning.

More research that identifies the sequence by which behavioral sleep problems impact
different domains of child functioning is needed to better understand these findings as well as those related to children in the other sleep trajectories examined in this study. Given that child sleep problems are known to co-occur at a high rate with behavioral health and neurodevelopmental conditions (Tietze et al., 2012; Van Dyk et al., 2019), both of which impair multiple aspects of child functioning, children with sleep problems at any age in this study may represent those with diagnosed or subclinical psychopathology or neurodevelopmental differences. Especially in light of results suggesting middle childhood internalizing concerns for those in the limited infant/preschool and mild sleep problem trajectories, sleep problems could serve as a sign of subsequent anxiety or other internalizing disorders. Future research should examine whether sleep problems longitudinally predict child impairment over and above existing behavioral health and neurodevelopmental diagnoses. As noted earlier, it is also quite possible that psychosocial impairments predict sleep problems, with bidirectional linkages that should examined in additional research (Quach et al., 2018; Wang et al., 2016).

Study findings have important implications for more comprehensively addressing child sleep problems. Sleep problems are highly prevalent in early childhood, impacting 20-30% of infants, toddlers, and preschoolers (Mindell et al., 2006). In this study, children on the trajectory characterized by early sleep problems that remitted after preschool still showed small impairments in aspects of child well-being, particularly caregiver-reported child quality of life and teacher-reported internalizing symptoms. These findings underscore the importance of identifying and treating child sleep problems early in development, particularly to avoid having these sleep concerns persist into middle childhood, when they are associated with more deleterious impacts on child well-being.

In addition, the persistence of child sleep problems and the significant and cross-domain impairments seen in middle childhood indicate that screening for sleep problems consistently over development is necessary, especially to target children who experience persistent sleep problems longitudinally. Additional research is needed on the child and family characteristics of those who evidence persistent sleep problems, as this could help to direct screening efforts. However, even children whose caregivers reported “mild sleep problems” over time appear to be at-risk for poor outcomes, as children following this trajectory evidenced small psychosocial and academic impairments. Although this study cannot answer whether minor, early, or persistent sleep problems represent a marker for the onset of behavioral health or neurodevelopmental
conditions, findings support consistently integrating questions about sleep into routine
developmental screenings in school and primary care contexts. As screening for social-emotional
and behavioral health concerns increasingly occurs in these settings (Dowdy et al., 2015; Essex
et al., 2009; Wissow et al., 2013), better incorporating sleep problems in these screenings could
help to identify children who are at-risk for later impairments in other domains.

Interventions targeting symptoms of both sleep problems and psychopathology are
needed to identify whether addressing these often comorbid concerns can prevent their
progression and impact on child well-being. Some intervention research has targeted both sleep
and anxiety disorders, with mixed findings (Alfano, 2018). A recent pilot trial found that an
integrated sleep and anxiety treatment was feasible and acceptable for anxious youth, with
similar sleep benefits for children randomized to the combined treatment or a standard cognitive
behavioral therapy condition (Clementi & Alfano, 2020). Concurrently treating insomnia and
depressed mood in adolescents has also yielded positive results (Clarke et al., 2015).
Additionally, an open trial of caregiver training enhanced with behavioral sleep strategies was
associated with large improvements in disruptive behaviors (Nelson, Van Dyk, McGinnis,
Nguyen, & Long, 2016). Future research should examine whether these approaches are feasible
for children with different severities of sleep problems and comorbid conditions, and on methods
for sequencing these treatment components.

Limitations of this study include an Australian sample that may not be generalizable to
children of different racial/ethnic backgrounds or living in different cultural contexts. We
covaried for child age, family socioeconomic factors, and family-level risks assessed at birth,
including caregiver stress exposure and mood, but there are many other factors that may
contribute to or account for the associations found between sleep problems and child well-being.
Factors that are more proximally associated with child sleep and functioning in middle
childhood, such as caregiver-child interactions (Kelly & El-Sheikh, 2013) and teacher-student
relationships (Holdaway & Becker, 2018), as well as underlying factors including child
temperament (Cremone et al., 2018) and genetic predispositions, should also be examined in
subsequent research studies. As some of the outcomes for the persistent sleep problems group
had 95% confidence intervals that overlapped with other groups, it is possible that those with
persistent sleep problems may not necessary have the poorest outcomes. However, the findings
do indicate that persistent sleep problems are associated with the poorest outcomes compared to
those without sleep problems, even if they are similar to other sleep problem trajectories.

This study did not utilize objective measures of child sleep, such as actigraphy, and did not assess child sleep duration or sleep time regularity or child-report of behavioral sleep problems, which can also influence outcomes. Dichotomizing sleep problems is common in population-based pediatric sleep research (Quach et al., 2011; Sadeh et al., 2011) and has been highly correlated with caregiver-reported problematic sleep behaviors (Williamson et al., 2019a). Nonetheless, this approach may miss nuanced differences in the nature of childhood sleep disturbances and does not substitute for sleep disorder diagnosis. Studies examining distinct profiles of pediatric sleep disorders, such as different subtypes of pediatric insomnia, should also assess whether such profiles differentially predict child outcomes. The reliance on caregiver-reported child sleep problems and some of the outcomes may contribute to greater associations between these variables. However, we did utilize a multi-informant approach, with several teacher-rated outcomes and objective ratings of child performance on tasks (non-verbal reasoning and academic achievement), which also showed significant associations with some sleep problem trajectories. Replicating and extending the examination of sleep problem trajectories into adolescence is necessary, particularly given evidence of sleep problem persistence and psychopathology symptoms in teenagers (Quach et al., 2018; Wang et al., 2016).

Conclusions
Sleep problem trajectories from infancy to 10-11 years were associated with impairments in multiple domains of child well-being. Children with persistent sleep problems had the poorest outcomes, with the strongest associations and largest mean effect sizes in the areas of child internalizing and externalizing symptoms and quality of life. Notably, impairments in child well-being were found across all sleep problems trajectories. The differences in outcomes based on the five distinct sleep trajectories provides evidence that future studies should focus on methods to consistently screen for child sleep concerns throughout development and implement interventions that can target child sleep problems and benefit broad child well-being.
Supporting information
Additional supporting information may be found online in the Supporting Information section at the end of the article:

Table S1. Sleep problem trajectories and child well-being at ages 10-11 years.

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Key points
- Behaviorally-based pediatric sleep problems are associated with poor outcomes.
- This study examined whether distinct sleep problem trajectories from infancy to middle childhood were linked to multiple aspects of child well-being.
- While all sleep problem trajectories were associated with increased internalizing and
externalizing symptoms and worse quality of life, children with persistent sleep problems from infancy to school age had the worst middle childhood outcomes across well-being domains.

- Findings underscore the importance of early intervention for sleep problems and the need to integrate behavioral sleep treatment with other behavioral health services.
References


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Table 1. Participant demographic characteristics at Wave 1 (ages 0-1 years)

<table>
<thead>
<tr>
<th></th>
<th>N = 5,107</th>
<th></th>
<th>N = 4,629</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Child</strong></td>
<td></td>
<td><strong>Primary caregiver</strong></td>
<td></td>
</tr>
<tr>
<td>Male, %</td>
<td>51.1</td>
<td>Female, %</td>
<td>96.1</td>
</tr>
<tr>
<td>Age (months), mean (SD); range</td>
<td>8.8 (2.5); 3 - 19</td>
<td>Age (years), mean (SD); range</td>
<td>31.0 (5.5); 15-63</td>
</tr>
<tr>
<td>Born in Australia/New Zealand, %</td>
<td>81.4</td>
<td>Born in Australia/New Zealand, %</td>
<td>79.4</td>
</tr>
<tr>
<td>English main language spoken at home, %</td>
<td>85.6</td>
<td>English main language spoken at home, %</td>
<td>85.7</td>
</tr>
<tr>
<td>Education status, %</td>
<td></td>
<td>Education status, %</td>
<td></td>
</tr>
<tr>
<td>Did not complete high school</td>
<td>31.7</td>
<td>Did not complete high school</td>
<td>40.2</td>
</tr>
<tr>
<td>Completed high school only</td>
<td>35.5</td>
<td>Completed high school only</td>
<td>23.1</td>
</tr>
<tr>
<td>Completed tertiary/postgraduate degree</td>
<td>32.9</td>
<td>Completed tertiary/postgraduate degree</td>
<td>36.7</td>
</tr>
<tr>
<td>Married/de facto, %</td>
<td>90.6</td>
<td>Married/de facto, %</td>
<td>91.0</td>
</tr>
<tr>
<td>Family risk index, mean (SD)</td>
<td>0.27 (0.31)</td>
<td>Family risk index, mean (SD)</td>
<td>0.28 (0.33)</td>
</tr>
</tbody>
</table>
Figure 1. Sleep problem trajectories from ages 0-1 to 10-11 years (Williamson et al., in press), reprinted with permission from Elsevier Inc.
Figure 2. Longitudinal sleep problem trajectories and psychosocial outcomes at ages 10-11 years.
Note. PedsQL = Pediatric Quality of Life; SDQ = Strengths and Difficulties Questionnaire; SSIS = Social Skills Improvement System.
Figure 3. Longitudinal sleep problem trajectories and cognitive and academic outcomes at ages 10-11 years.

Note. ARS = Academic Rating Scale; NAPLAN = National Assessment Program—Literacy and Numeracy.
Author/s:  
Williamson, AA; Mindell, JA; Hiscock, H; Quach, J  

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