



ORIGINAL ARTICLE

Sleep problems, internalizing and externalizing symptoms, and domains of health-related quality of life: bidirectional associations from early childhood to early adolescence

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Abstract

Study Objectives: To examine longitudinal, bidirectional associations among behavioral sleep problems, internalizing and externalizing symptoms, and domains of health-related quality of life (HRQoL) from early childhood to adolescence in a population sample of Australian children.

Method: Data were drawn from the Longitudinal Study of Australian Children, a national prospective cohort study with 4983 children participating in the Kindergarten cohort. Data were collected when children were aged 4–5, 6–7, 8–9, 10–11, and 12–13 years. At each study wave, the primary parent (97% mothers) reported on behavioral child sleep problems, internalizing and externalizing symptoms, and HRQoL domains (psychosocial and physical). Cross-lagged structural equation models were used to evaluate bidirectional associations.

Results: At nearly every age, behavioral sleep problems were associated with worse subsequent psychosocial and physical HRQoL. Despite bidirectional associations between mental health and HRQoL at many waves, HRQoL domains more strongly predicted later internalizing symptoms, while externalizing symptoms more strongly predicted later HRQoL. Many of the bidirectional associations among sleep, mental health, and HRQoL were found earlier in childhood.

Conclusions: Behavioral sleep problems may forecast later HRQoL psychosocial and physical impairments. Attending to both sleep problems and HRQoL could prevent the progression of internalizing conditions, while a focus on externalizing concerns could prevent the worsening of these symptoms, sleep problems, and HRQoL, particularly during the transition to school.

Statement of Significance

Behavioral sleep problems are common in children, often coexist with internalizing and externalizing symptoms, and are associated with children's psychosocial and physical health-related quality of life (HRQoL). Treating behavioral sleep problems may help to improve child functioning; however, clinicians need more information on the complex interrelationship between these functional domains to inform and prioritize treatment. Study findings suggest that addressing both early behavioral sleep problems and externalizing concerns may benefit later psychosocial and physical HRQoL, while targeting sleep problems and HRQoL domains may buffer against the development of internalizing symptoms. Overall, findings highlight the importance of routinely assessing for and targeting HRQoL improvements in sleep and mental health interventions.

Key words: behavioral; longitudinal; mental health; physical; psychosocial; quality of life; sleep

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Introduction

Healthy sleep plays a vital role in daily functioning and long-term childhood outcomes, including cognitive development [1, 2], academic achievement [3], and social-emotional functioning [4, 5]. Behavioral sleep disturbances, including difficulty falling and staying asleep, are quite common in childhood, with an estimated prevalence of 25%–40% [6, 7]. Children with internalizing mental health conditions, such as anxiety [8], and externalizing mental health conditions, such as attention deficit hyperactivity disorder (ADHD) [9, 10], are at particularly high risk for poor sleep. However, the direction of the associations among behavioral sleep problems, mental health symptoms, and other related childhood outcomes longitudinally remains largely unexplored.

The few pediatric studies examining bidirectional associations have primarily focused on sleep and mental health symptoms. Objectively measured short sleep duration at ages 6 and 8 years predicted symptoms of anxiety and mood disorders in boys and girls and symptoms of disruptive behavior disorders in boys 2 years later, but early mental health symptoms did not predict subsequent sleep duration [11]. Insufficient sleep and poor sleep quality have also been found to predict worse daily mental health symptoms in a sample of children with diagnosed mental health conditions [12]. While sleep duration is a critical aspect of overall sleep health, understanding the interplay of behavioral sleep problems and mental health symptoms is necessary to better inform preventive and targeted treatment [13], particularly given high levels of comorbidity [14, 15]. In a twin study, behavioral sleep problems at age 8 years predicted depressive symptoms at age 10 years, but the converse was not found [16]. In a prospective study of children with ADHD, there was a weak reciprocal association between sleep problems and internalizing symptoms over 1 year but not between sleep and externalizing symptoms [17]. In one of the only studies to examine a longer period of time, from ages 4 to 13 years, there was evidence of a longitudinal, bidirectional association between behavioral sleep problems and externalizing concerns (e.g., inattention and conduct problems), but sleep problems were only associated with subsequent internalizing symptoms without a bidirectional association [18].

In addition to limited prior research on bidirectional associations between sleep and child mental health symptoms, there is surprisingly little research on interrelationships among behavioral sleep problems, mental health symptoms, and health-related quality of life (HRQoL). HRQoL is a multidimensional construct that reflects broad child health and psychosocial well-being and is often a treatment target for children with mental health conditions [19], who show greater HRQoL impairments compared to controls [20]. Sleep problems have also been linked to diminished HRQoL in early childhood [21] and adolescence [22]. Longitudinally, children with disrupted and poor quality sleep [23] and those with insomnia [24] have worse HRQoL. Previous studies have also found associations between sleep problems and HRQoL in children with ADHD and those with chronic illnesses (e.g., cerebral palsy, renal failure, and fatigue) [25–27]. However, no studies to date have examined bidirectional associations among sleep, mental health symptoms, and HRQoL. Furthermore, previous studies have focused on sleep and overall HRQoL [23] without examining whether these associations vary according to the physical and psychosocial

subdomains that comprise the multidimensional HRQoL construct. Behavioral sleep problems and mental health symptoms may be differentially linked with physical and psychosocial functioning. For example, children with symptoms of anxiety and sleep deficits may manifest greater somatic complaints [28], potentially resulting in more physical than psychosocial HRQoL impairments.

More research on the potential bidirectional associations among behavioral sleep problems, internalizing and externalizing symptoms, and domains of HRQoL is needed in large samples of children longitudinally. Of particular interest is to understand relationships among these important constructs across key developmental stages, including school entry, middle childhood, and the transition to adolescence. Information about associations at these time points could support specific targets of sleep or mental health interventions and inform the sequencing or integration of sleep-focused versus mental health symptom or HRQoL domain-focused intervention components. This study builds on a previous investigation of bidirectional associations between behavioral sleep problems and internalizing and externalizing mental health symptoms from early childhood to early adolescence in a population sample of Australian children [18]. The aim of this study was to extend this existing research by identifying whether there were additional bidirectional associations among these constructs and the psychosocial and physical HRQoL domains over time in the same sample. We hypothesized that there would be longitudinal, bidirectional relationships between sleep and HRQoL domains and between mental health symptoms and HRQoL domains over time. However, based on previous research showing high levels of comorbidity between sleep and mental health symptoms [14, 15], and the impacts of these concerns on later HRQoL [20, 23, 24, 29], we also hypothesized that, overall, sleep problems and mental health symptoms could contribute more strongly to later psychosocial and physical HRQoL than these HRQoL domains would contribute to sleep and mental health concerns.

Method

Participants and study design

Data for this study were drawn from the Longitudinal Study of Australian Children (LSAC), which recruited a large representative sample of Australian children. LSAC commenced in 2004 and included the birth cohort of 5107 infants and the kindergarten cohort (K cohort) of 4983 children aged 4 years. Participating families were randomly selected in a two-stage cluster sampling design selecting first Australian postcodes and then children residing in those postcodes enrolled in the Medicare universal health care database. Detailed information about LSAC sampling, recruitment, and data collection methods are provided elsewhere [30].

The current study uses data from the K cohort. Data were collected when children were aged 4–5, 6–7, 8–9, 10–11, and 12–13 years, of which 73.9% ($n = 3,682$) of the original cohort (wave 1) were retained at 12–13 years (wave 5). Retention was slightly higher for children with more educated parents and from English-speaking backgrounds [31]. Data were collected on aspects of child development and family and community characteristics using multiple information sources at each of the five waves. The Australian Institute of Family Studies Ethics

Committee provided ethical approval and parents provided informed written consent for participation.

Procedures

Families participated in data collection every 2 years from 2004 to 2012. The primary parent (97% biological mothers) reported on child behavioral sleep problems, internalizing and externalizing symptoms, and HRQoL domains at each wave.

Measures

Behavioral sleep problems

As in the previous bidirectional study using this cohort [18], we created a latent variable to reflect behavioral sleep problems at each wave using five parent-reported items. On four of these items, parents responded whether or not (yes/no) their child usually had “a problem on 4 or more nights a week, or more than half the time,” with regard to (1) “getting off to sleep at night,” (2) “not happy to sleep alone,” (3) “waking during the night,” and (4) “seeming tired in the morning.” On the fifth item, parents rated the extent to which their child’s overall sleep patterns were a problem, dichotomized according to prior research [9, 18] into “a small problem or no problem at all” (score 0) and “moderate or large problems” (score 1). Responses of “not sure/don’t know” were treated as missing data.

The resulting latent variable at each study wave reflects the unobserved construct of behavioral sleep problems and represents the shared variance among the five observed (parent-reported) sleep problem items at each wave. The benefits of this latent variable approach include the ability to model the multifaceted behavioral sleep problem construct more parsimoniously and without measurement error, as error is separated from the latent factor, unlike in observed variables [32]. At each wave, each of the sleep items loaded significantly and strongly on the latent factor (0.59–0.90 across items and waves, see [Supplementary Tables 1–4](#)) [32]. Further supporting the validity of the behavior sleep problems latent variable, there were moderate associations in the expected directions with the mental health and HRQoL variables, as shown in [Supplementary Figures 1–4](#) and described further in the Results section. In previous research using the LSAC birth cohort, parent-reported child sleep behaviors were strongly and significantly linked to parent endorsement of a child sleep problem longitudinally [33].

Internalizing and externalizing symptoms

Child internalizing and externalizing symptoms were measured using the parent-reported Strengths and Difficulties Questionnaire (SDQ) [34]. The SDQ is a well-validated 25-item measure used to screen for behavioral and emotional symptoms in youth aged 4–17 years. Parents were asked to rate their child’s behavior over the last 6 months by responding to each item on a three-point Likert scale (“not true,” “somewhat true,” and “certainly true”). Three of the five SDQ subscales capturing internalizing and externalizing symptoms were used in the current study. Scores were generated by summing the items for each subscale, with higher scores reflecting greater symptoms. If two or more subscale items were missing, the subscale was not computed.

The five-item emotional problems SDQ subscale captures internalizing symptoms. Items include somatic complaints (“often complains of headaches, stomachaches, or sickness”) and worries (“many worries, often seems worried”). The externalizing symptoms score was comprised of the five-item conduct problems and five-item hyperactivity/inattention SDQ subscales. The conduct problems subscale includes items about behavioral regulation (“often loses temper”) and rule-breaking behaviors (“steals from home, school, or elsewhere”), while the hyperactivity/inattention subscale items relate to motor activity (“restless, overactive, cannot stay still for long”) and attention functioning (“easily distracted, concentration wanders”). Prior studies examining child mental health symptoms have used the emotional problems SDQ subscale as a measure of internalizing symptoms and the conduct problems and hyperactivity/inattention SDQ subscales to measure externalizing symptoms [35].

HRQoL domains

HRQoL was measured using the parent-reported Pediatric Quality of Life Inventory Scale, which is a widely used and well-validated proxy measure of broad child and adolescent functioning [36]. The current study examined the psychosocial and physical HRQoL subscales. The psychosocial functioning subscale includes 15 items related to emotional (e.g., feeling sad; five items), social (e.g., friendship problems; five items), and school functioning (e.g., missing school due to illness; five items). The physical HRQoL subscale includes eight items about physical functioning (e.g., pain and energy level). Each HRQoL subscale score is generated by calculating a mean item score and linearly transforming it to a 0–100 scale. If more than 50% of the items for each HRQoL score are missing, that subscale score is not computed. Higher scores indicate better HRQoL.

Demographic information

At wave 1, the primary parent reported on child age, sex, Aboriginal or Torres Strait Islander (ATSI) status, the language spoken at home (English/other), and the number of siblings. The primary parent also reported their age, education level, and whether two parents lived in the home. Children with complete data were less likely to be of ATSI background and were more likely to have older mothers, fewer siblings, a mother that completed high school, English as the main language at home, and a two-parent household.

Statistical analysis

We estimated a series of longitudinal structural equation models in Mplus version 8.1 [37] to examine behavioral sleep problems, internalizing and externalizing symptoms, and each HRQoL domain over time. First, as part of the preliminary analyses, four autoregressive models were estimated to examine the stability of these constructs longitudinally, as well as their cross-sectional associations at each wave. To examine whether there were bidirectional associations between these constructs, we then estimated four transactional models, which added potential cross-lagged associations between behavioral sleep problems, internalizing and externalizing symptoms, and each HRQoL domain. Models were generated separately for internalizing and externalizing symptoms and for physical and psychosocial HRQoL domains in both autoregressive and

cross-lagged analyses, to better understand distinct pathways between these constructs and sleep. Model fit across analyses was assessed using the chi-square test (χ^2), the Tucker–Lewis Index (TLI), the Comparative Fit Index (CFI), and root mean square error of approximation (RMSEA). TLI and CFI values of over 0.90 and RMSEA values close to or below 0.05 reflect acceptable model fit [38, 39]. We also reported the R^2 to indicate the variance explained by each of the transactional models in sleep problems, internalizing and externalizing symptoms, and HRQoL domains at 12–13 years. A series of Wald tests were then conducted to sequentially compare pairs of paths of interest to determine the strength of bidirectional associations between behavioral sleep problems, mental health symptoms, and HRQoL domains.

One case was excluded due to missing data on all outcomes of interest. After excluding this case, missing data impacted less than 15% of all variables. All missing data were determined to be missing at random. To address missing data, we performed multiple imputations in Stata using chained equations with linear regression for continuous variables and logistic regression for binary variables, including all demographic covariates predictive of missingness. As findings from data with and without imputations were similar, sample characteristics are reported using nonimputed data, and results are reported using imputed data.

Results

Sample characteristics

Table 1 describes nonimputed sample characteristics across the five study waves. At baseline, there were similar numbers of male and female children (49% female), with less than 4% of children

from ATSI backgrounds. Less than 15% of children lived in a single-parent home. Participating mothers had an average age of about 34 years and most (58.6%) had completed high school. Twenty percent of families spoke a language other than English at home.

Overall, the prevalence of moderate to large sleep problems declined from 12.5% at ages 4–5 years to between 5% and 7% between ages 6 and 13 years. The prevalence of specific sleep behaviors also shifted longitudinally. Whereas difficulty sleeping alone and waking overnight were the most commonly reported sleep behaviors between ages 4 and 7 years, difficulty falling asleep and appearing tired in the morning were most common between ages 8 and 13 years. However, at all waves, each of the five sleep items loaded strongly and significantly onto the latent behavioral sleep problems factor (Supplementary Tables 1–4), suggesting that each item robustly contributed to the underlying behavioral sleep problems construct [32].

Preliminary autoregressive and cross-sectional correlation models

Supplementary Figures 1 (sleep, internalizing, and psychosocial HRQoL model) and 2 (sleep, internalizing, and physical HRQoL) show that there was a high degree of stability in the constructs longitudinally, with path estimates ranging from 0.72 to 0.89. Constructs were also highly stable across time in the externalizing models, as path estimates ranged from 0.57 to 0.89 (Supplementary Figure 3; sleep, externalizing, and psychosocial HRQoL; Supplementary Figure 4; sleep, externalizing, and physical HRQoL).

In the internalizing models, there were moderate to large negative associations cross-sectionally between sleep problems

Table 1. Sample characteristics at each study wave

	Wave 1 (4–5 years) n = 4983	Wave 2 (6–7 years) n = 4464	Wave 3 (8–9 years) n = 4196	Wave 4 (10–11 years) n = 3940	Wave 5 (12–13 years) n = 3682
Mean (SD)					
Child age (years)	4.2 (0.4)	6.3 (0.5)	8.3 (0.4)	10.3 (0.5)	12.4 (0.5)
Maternal age (years)	34.6 (5.3)				
Externalizing symptoms score (range 0–20)	6.0 (3.7)	4.8 (3.3)	4.5 (3.3)	4.5 (3.4)	4.0 (3.3)
Internalizing symptoms score (range 0–10)	1.7 (1.7)	1.6 (1.7)	1.6 (1.7)	1.9 (2.0)	1.9 (2.0)
Psychosocial HRQoL (range 1–100)	77.5 (12.9)	77.4 (13.7)	76.0 (14.8)	77.1 (15.4)	78.9 (15.7)
Physical HRQoL (range 1–100)	82.7 (12.1)	82.6 (14.8)	83.5 (14.6)	79.2 (19.2)	82.9 (16.1)
n (%)					
Female child	2446 (49.1)				
Mother completed high school	2895 (58.6)				
ATSI background	187 (3.8)				
Two-parent household	4286 (86.0)				
Family speaks LOTE at home	1018 (20.4)				
Behavioral sleep problems					
Getting to sleep	617 (12.4)	519 (11.6)	588 (13.6)	634 (15.2)	621 (15.9)
Sleeping alone	1087 (21.8)	619 (13.9)	473 (10.9)	331 (8.0)	143 (3.7)
Waking during the night	887 (17.8)	362 (8.1)	252 (5.8)	205 (4.9)	141 (3.6)
Tired in the morning	444 (8.9)	425 (9.5)	422 (9.7)	442 (10.6)	560 (14.3)
Moderate to large sleep child problem	673 (12.5)	254 (5.7)	241 (5.6)	295 (7.1)	265 (6.8)

Higher internalizing/externalizing scores and HRQoL scores = more symptoms and better quality of life, respectively. Data presented are nonimputed. LOTE, language other than English.

and psychosocial HRQoL (-0.43 to -0.67 ; [Supplementary Figure 1](#)) and small to moderate associations between sleep problems and physical HRQoL (-0.22 to -0.43 ; [Supplementary Figure 2](#)). There were large, negative associations between internalizing symptoms and psychosocial HRQoL (-0.60 to -0.74) and moderate, negative associations between internalizing symptoms and physical HRQoL (-0.33 to -0.45).

Similar to the internalizing models, sleep problems showed moderate to large negative associations with psychosocial HRQoL (-0.43 to -0.69 ; [Supplementary Figure 3](#)) and small to moderate negative associations with physical HRQoL (-0.23 to -0.44 ; [Supplementary Figure 4](#)) at each wave. At each wave, there were also moderate to large negative associations between externalizing symptoms and psychosocial HRQoL (-0.45 to -0.56) and moderate, negative associations between externalizing symptoms and physical HRQoL (-0.31 to -0.36).

Bidirectional models for behavioral sleep problems, internalizing symptoms, and HRQoL

Psychosocial HRQoL model

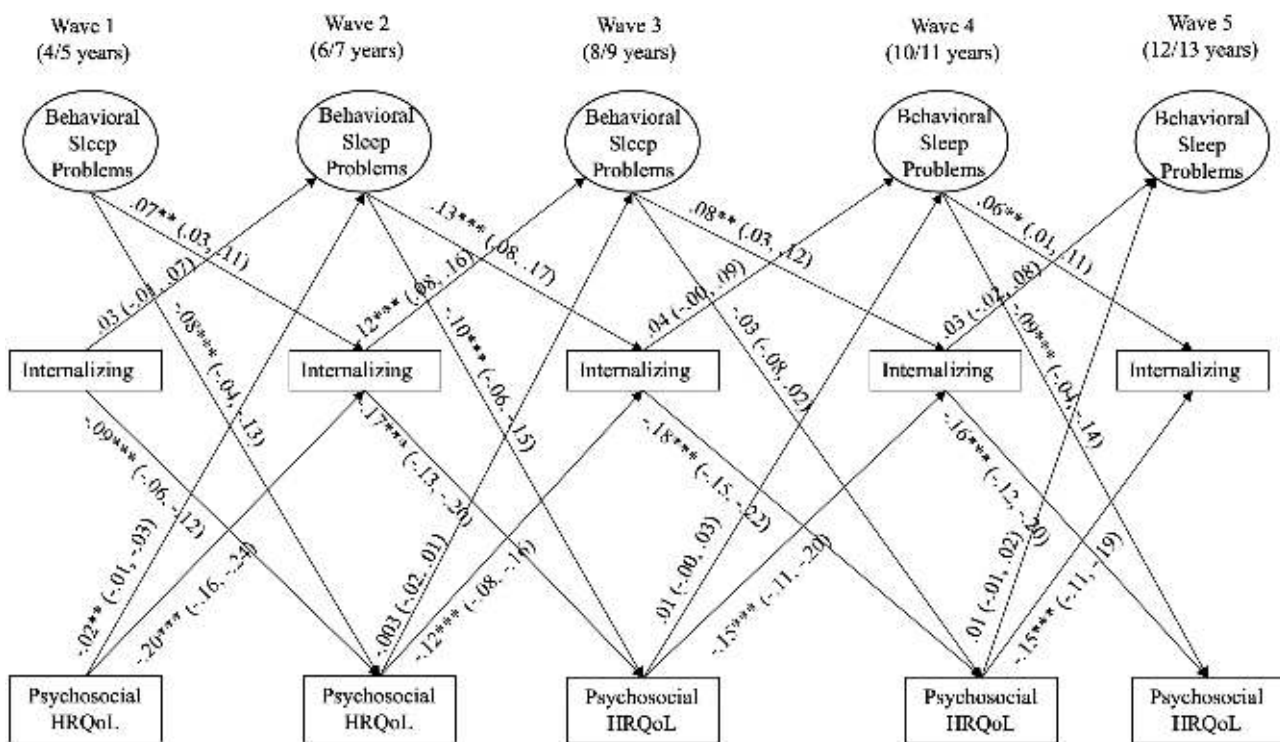
Path estimates for the bidirectional model for behavioral sleep problems, internalizing symptoms, and psychosocial HRQoL are shown in [Figure 1](#). As in a previous study in this cohort, behavioral sleep problems significantly contributed to subsequent internalizing symptoms at each wave, but the reverse association was not consistently found [18]. Sleep problems also contributed to later psychosocial HRQoL impairments at each age except at ages 8–9 years, when sleep problems were not related to psychosocial HRQoL at ages 10–11 years. Conversely, with the exception of an association between psychosocial HRQoL at ages 4–5 years and sleep problems

at ages 6–7 years, psychosocial HRQoL was not associated with later sleep problems. A bidirectional, negative association between internalizing symptoms and psychosocial HRQoL was found consistently across waves. The model accounted for 68.3% of the variance in sleep problems, 50.3% of the variance in internalizing difficulties, and 52.4% of the variance in psychosocial HRQoL at ages 12–13 years.

Pairs of paths were sequentially constrained and Wald tests used to compare the strength of bidirectional relationships between constructs between each time lag. There were stronger associations from sleep problems to psychosocial HRQoL than from psychosocial HRQoL to sleep problems at all time points (p -values <0.01 , Wald test) except for between 8–9 and 10–11 years, when the estimates did not differ in magnitude. The associations from psychosocial HRQoL at one time point to internalizing symptoms 2 years later were stronger than from internalizing symptoms to subsequent psychosocial HRQoL (p -values <0.001 , Wald test), except for from ages 6–7 to 8–9 years when the associations did not differ. Finally, from 8–9 to 10–11 years, there was a stronger association from internalizing to psychosocial HRQoL than from sleep problems to HRQoL (p -value = 0.003, Wald test); across all other time points, the estimates did not differ in magnitude. In summary, early sleep problems were more strongly associated with later psychosocial HRQoL than vice versa. Generally, early psychosocial HRQoL was more strongly associated with later internalizing symptoms than vice versa.

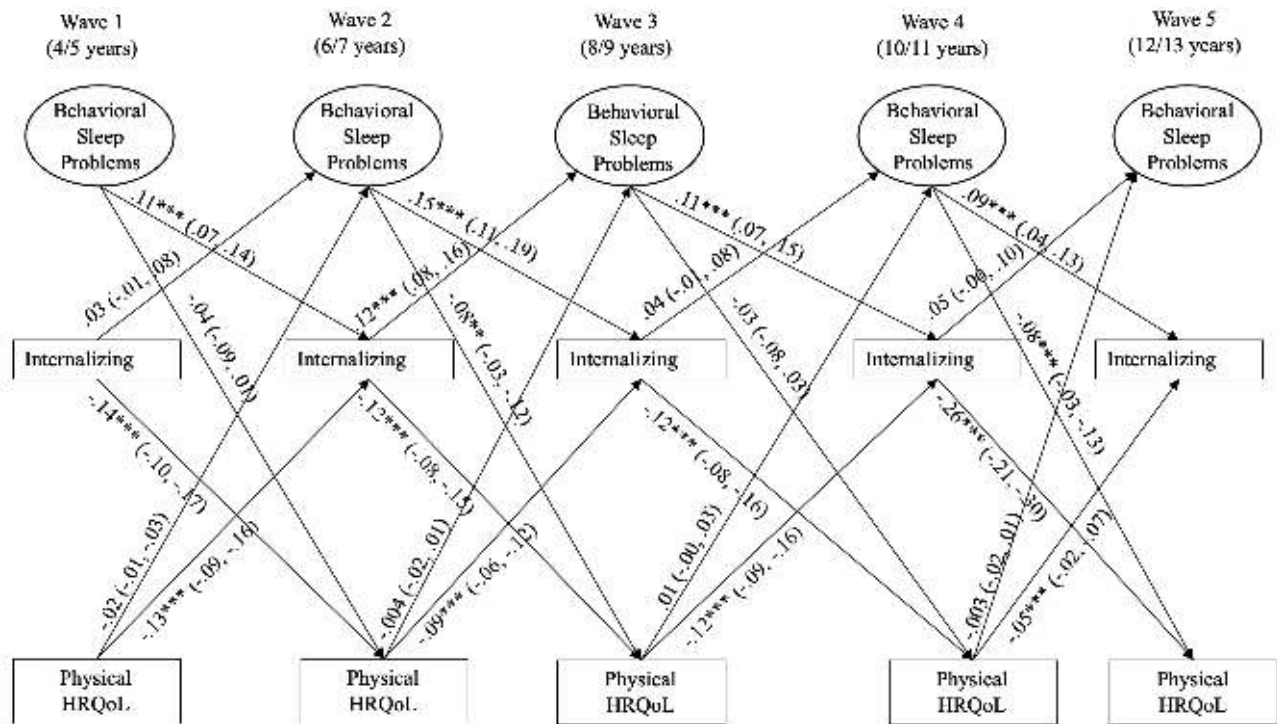
Physical HRQoL model

[Figure 2](#) shows path estimates for the bidirectional model for behavioral sleep problems, internalizing symptoms, and physical HRQoL. Unlike the psychosocial HRQoL model, sleep problems only



Fit indices: $X^2(489)=1943$; RMSEA=.02; CFI=.97; TLI=.96; * $p < .05$, ** $p < .01$, *** $p < .001$

Figure 1. Bidirectional model for sleep problems, internalizing symptoms, and psychosocial HRQoL. χ^2 = chi-square test.



Fit indices: $\chi^2(489) = 2441$; RMSEA = .03; CFI = .95; TLI = .94; * $p < .05$. ** $p < .01$. *** $p < .001$

Figure 2. Bidirectional model for sleep problems, internalizing symptoms, and physical HRQoL. χ^2 = chi-square test.

significantly contributed to physical HRQoL 2 years later at ages 6–7 and 10–11 years. Physical HRQoL did not contribute to later behavioral sleep problems at any wave. However, internalizing symptoms and physical HRQoL were significantly and bidirectionally linked at each wave. The model accounted for 68.2% of the variance in sleep problems, 50.2% of the variance in internalizing difficulties, and 34.5% of the variance in physical HRQoL at ages 12–13 years.

Wald tests for this model revealed stronger associations from sleep problems at ages 6–7 and 10–11 years to physical HRQoL 2 years later than from physical HRQoL to sleep problems at these ages (p -values < .001, Wald test). Estimates did not differ in magnitude at other waves. The associations from physical HRQoL at one time point to internalizing difficulties 2 years later were stronger than the associations from internalizing difficulties to physical HRQoL at all time points (p -values < .001, Wald test), except from ages 10–11 to 12–13 years when the association was stronger from internalizing difficulties to physical HRQoL. There was no difference in the magnitude of estimates from sleep problems to physical HRQoL and from internalizing difficulties to physical HRQoL. Overall, sleep problems were only more strongly associated with later physical HRQoL than vice versa at two waves. Physical HRQoL was generally more strongly linked to internalizing symptoms than vice versa.

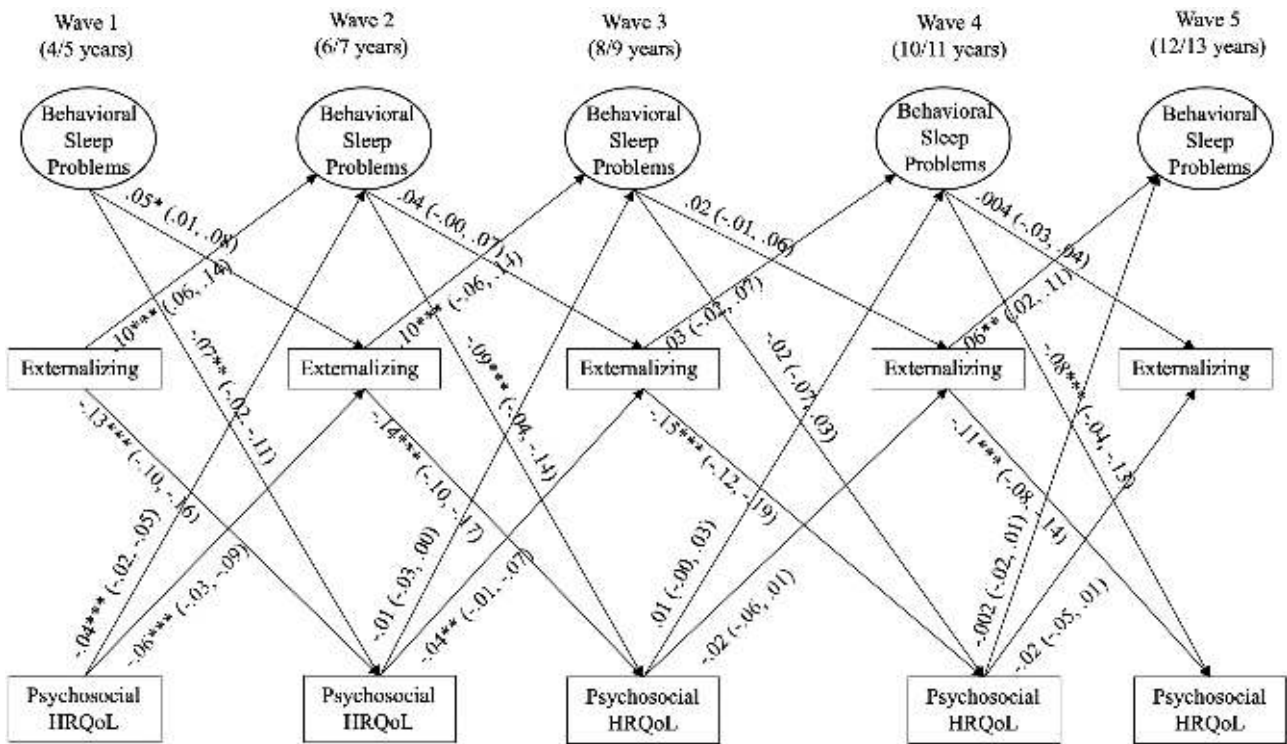
Bidirectional models for behavioral sleep problems, externalizing symptoms, and HRQoL

Psychosocial HRQoL

Figure 3 shows the bidirectional model for sleep problems, externalizing symptoms, and psychosocial HRQoL (Figure 3). In line with previous findings in this cohort [18], whereas sleep problems only significantly contributed to later externalizing

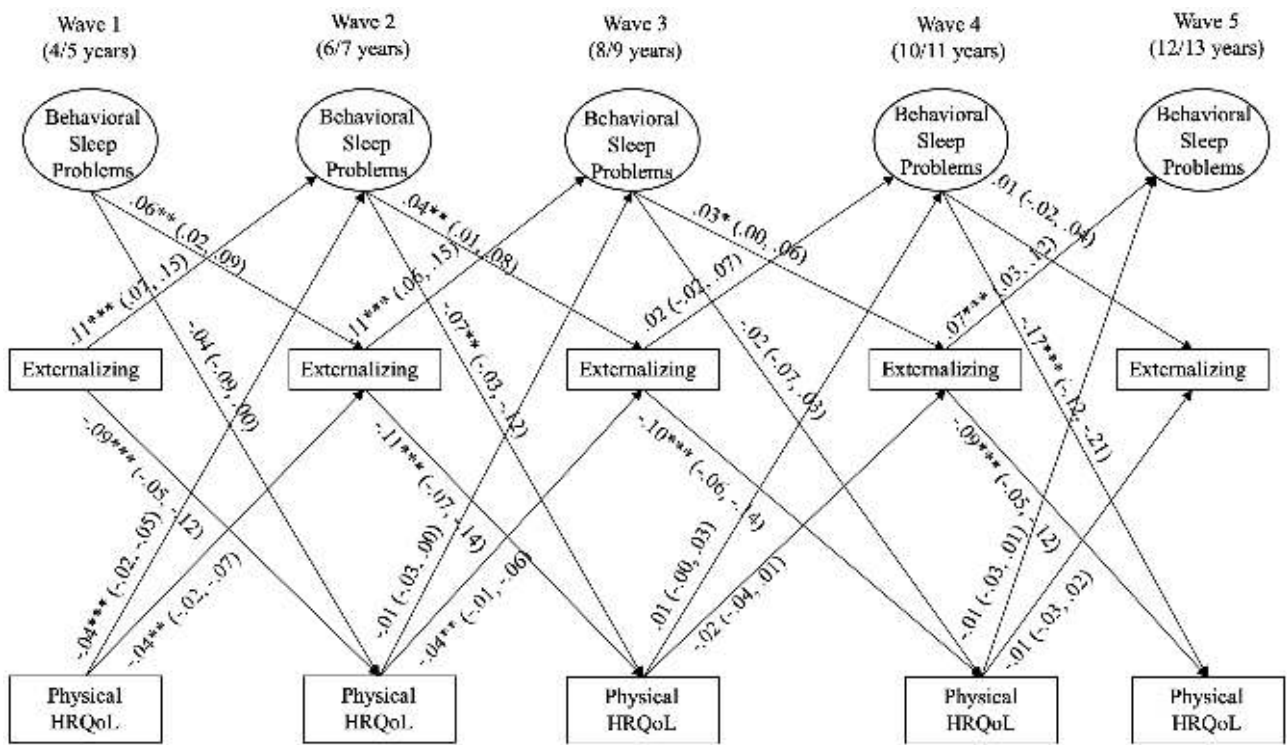
symptoms in younger children, externalizing symptoms contributed to later sleep problems at nearly every wave. Sleep problems significantly contributed to later psychosocial HRQoL at every age except from ages 8–9 to 10–11 years, but psychosocial HRQoL only contributed to sleep problems from ages 4–5 to 6–7 years. Externalizing symptoms at every age consistently predicted subsequent psychosocial HRQoL impairments, but psychosocial HRQoL only predicted subsequent externalizing symptoms from ages 4–5 to 6–7 years and from ages 6–7 to 8–9 years. The model accounted for 68.0% of the variance in sleep problems, 71.3% of the variance in externalizing symptoms, and 53.9% of the variance in psychosocial HRQoL at ages 12–13 years.

Pairs of paths were sequentially constrained and Wald tests used to compare the strength of bidirectional relationships among constructs between each time lag in this model. The association from sleep problems to psychosocial HRQoL 2 years later was significantly stronger than the associations from psychosocial HRQoL to sleep problems at all waves (p -values < .05, Wald test) except from ages 8–9 to 10–11 years, when the magnitude of the associations did not differ. The association from externalizing difficulties to later psychosocial HRQoL was stronger than the reverse paths at each wave (p -values < .001, Wald test). Finally, there was a stronger association from externalizing problems at ages 8–9 years to psychosocial HRQoL at 10–11 years than from sleep problems at 8–9 years to HRQoL at 10–11 years ($p = 0.048$, Wald test), but the estimates did not differ in magnitude at other time points. In summary, both sleep problems and externalizing symptoms were generally more strongly associated with later psychosocial HRQoL than vice versa, but there was no difference in the strength of the associations from sleep problems to subsequent psychosocial HRQoL compared to



Fit indices: $\chi^2(489)=1696$; RMSEA=.02; CFI=.97; TLI=.97; *p<.05, **p<.01, ***p<.001

Figure 3. Bidirectional model for sleep problems, externalizing symptoms, and psychosocial HRQoL. χ^2 = chi-square test.



Fit indices: $\chi^2(489)=2441$; RMSEA=.03; CFI=.96; TLI=.95; *p<.05, **p<.01, ***p<.001

Figure 4. Bidirectional model for sleep problems, externalizing symptoms, and physical HRQoL. χ^2 = chi-square test.

those from externalizing symptoms to subsequent psychosocial HRQoL.

Physical HRQoL

The bidirectional model for sleep problems, externalizing symptoms and physical HRQoL appears in [Figure 4](#). Sleep problems significantly contributed to later physical HRQoL from ages 6–7 to 8–9 years and from ages 10–11 to 12–13 years. Similar to the model with psychosocial HRQoL, physical HRQoL only significantly contributed to later sleep problems from ages 4–5 to 6–7 years. At each wave, externalizing symptoms significantly predicted physical HRQoL 2 years later. However, physical HRQoL only predicted subsequent externalizing symptoms in early childhood (from ages 4–5 to 6–7 years and from ages 6–7 to 8–9 years). The model accounted for 68.6% of the variance in sleep problems, 71.0% of the variance in externalizing symptoms, and 36.5% of the variance in physical HRQoL at ages 12–13 years.

Wald tests showed that the association from sleep problems at ages 6–7 and 10–11 years to physical HRQoL 2 years later was significantly stronger than the associations from HRQoL to sleep problems (p -values <0.01 , Wald test). The estimates did not differ in magnitude from ages 4–5 to 6–7 years or from ages 8–9 to 10–11 years. For physical HRQoL and externalizing difficulties, the association from externalizing difficulties to later physical HRQoL was stronger than the paths from physical HRQoL to later externalizing difficulties at each wave (p -values <0.001 , Wald test). The association from sleep problems at 10–11 years to physical HRQoL at ages 12–13 years was significantly stronger than the association from externalizing problems to physical HRQoL from ages 10–11 to 12–13 years (p -value <0.001 , Wald test). The estimates did not differ in magnitude at other time points. Overall, while the strength of the associations from sleep problems to physical HRQoL were similar to those from externalizing to physical HRQoL, there was variation in other bidirectional associations among these constructs. Whereas externalizing symptoms were consistently more strongly associated with subsequent physical HRQoL than vice versa, the strength of bidirectional linkages between sleep problems and physical HRQoL varied at different waves.

Discussion

This study examined longitudinal, bidirectional associations among behavioral sleep problems, internalizing and externalizing symptoms and psychosocial and physical HRQoL domains in a population sample of Australian children. This builds on a previous study in this cohort [18] and expands the limited previous literature to include HRQoL. There was very limited evidence of bidirectional associations among behavioral sleep problems and HRQoL domains. Instead, behavioral sleep problems emerged as a stronger and more consistent predictor of subsequent HRQoL, and especially psychosocial HRQoL, than vice versa. However, in partial support of study hypotheses, longitudinal, bidirectional associations were evident among mental health symptoms and HRQoL domains at many study waves, although the magnitude and reciprocity of the associations among these symptoms and HRQoL varied according to both the mental health symptom cluster (internalizing versus externalizing) and the HRQoL domain.

Previous research has shown that sleep problems are cross-sectionally [21, 22] and longitudinally linked to overall HRQoL [23, 24], but very few studies have examined causal pathways or specific HRQoL domains. We found a lack of reciprocity between sleep problems and each HRQoL domain, suggesting that behavioral sleep problems forecast both psychosocial and physical HRQoL impairments from early childhood to the transition to adolescence, although this should be tested in study designs that permit causal inferences. Of note, across internalizing and externalizing models, sleep problems consistently predicted subsequent psychosocial HRQoL, but associations with later physical HRQoL were less consistent, occurring across two waves (from ages 6–7 to 8–9 years and from ages 10–11 to 12–13 years). In the context of these findings, it is important to acknowledge that this research was not conducted with children who have chronic medical or diagnosed mental health conditions. It could be that, in the context of a medical condition, HRQoL domains and physical HRQoL, in particular, are bidirectionally linked with sleep in line with evidence of reciprocal associations between symptoms of chronic conditions, such as pain, and sleep disruption [40]. Nonetheless, our findings suggest that both domains of HRQoL should be routinely assessed as an outcome of behavioral child sleep treatment across age groups from early childhood to early adolescence.

A potential mechanism through which behavioral sleep problems impact HRQoL is the emotional, behavioral, and attentional dysregulation that may occur as a result of sleep problems. This dysregulation, in turn, is likely to impact the functional areas of HRQoL, and psychosocial HRQoL in particular (emotional, social, and school). Research indicates that children and adolescents show poorer mood and emotion regulation [41], attention and neurobehavior [42, 43], and teacher-rated academic performance [44] when undergoing experimental sleep restriction. Emotion regulation and executive functioning skills are thought to be particularly vulnerable to sleep loss, potentially due to the impact of insufficient sleep on prefrontal cortex activity [45–47]. Although we did not measure sleep duration, behavioral sleep problems, such as difficulty falling or staying asleep, could cause shortened or poor quality sleep. Research on daily youth reports of mood and actigraphy-derived sleep has also found that daily negative mood (i.e., short-term negative emotional states) mediated the association between prolonged sleep latency and parent-rated child internalizing and externalizing conditions [48]. Such fluctuations in emotional and behavioral regulation should be examined as a potential mechanism linking sleep and HRQoL domains.

In line with previous findings in this cohort [18], behavioral sleep problems were associated with later internalizing symptoms, but the reverse was not found. While we did find evidence of negative, bidirectional associations between each HRQoL domain and internalizing symptoms across waves, psychosocial and physical HRQoL were generally stronger predictors of later internalizing than vice versa. Thus, both behavioral sleep problems and HRQoL impairments could serve as precipitating and maintaining factors in the development of childhood internalizing conditions in line with other studies showing the high prevalence of comorbid sleep and mood concerns [8, 47] and evidence of early sleep problems predicting subsequent internalizing conditions [16]. There could be a developmental cascade in which sleep problems impact emotional-behavioral regulation, in turn causing HRQoL impairments in major functional

domains that predict internalizing symptoms. This progression is similar to research showing cascading effects of sleep, attention, and self-regulation on children's school adjustment [49]. Emerging cognitive distortions and negative attentional biases, which are common in individuals with anxiety and depression, could be exacerbated by poor sleep [8, 47], potentially leading to HRQoL impairments that maintain internalizing symptoms. For example, an individual with anxiety could catastrophize about their health status when confronted with a physical HRQoL concern, resulting in increased anxiety, while an individual with depression could perceive a neutral social interaction as being negative, leading to worsened mood. Sleep deficiencies could heighten these maladaptive cognitive and emotional attributions [47]. Prospective research that explicitly tests these putative mechanisms is needed to better understand these findings.

Consistent with the previous study conducted in this cohort [18], externalizing symptoms were reciprocally related to sleep problems only in early childhood, with externalizing concerns being a stronger predictor of sleep problems than vice versa. Following a similar pattern, externalizing symptoms were only reciprocally related to both psychosocial and physical HRQoL domains in early but not later childhood, with externalizing symptoms being a stronger predictor of later HRQoL domains than vice versa. Different from the worry or low mood characteristic of internalizing concerns, externalizing symptoms include difficulties with impulse control, attention, and behavior regulation. These executive functioning and self-regulation difficulties could more strongly impact HRQoL domains than vice versa. Additionally, these skills are compromised in sleep-restricted youth, suggesting that children with externalizing conditions could be more sensitive to the impacts of poor sleep, as others have suggested [46, 50].

Taken together, findings have implications for the sequencing and tailoring of interventions to address child sleep problems, mental health symptoms, and HRQoL. For children at risk of developing internalizing conditions, sleep and HRQoL may be important targets of treatment. Some preliminary research has examined whether integrating sleep and anxiety treatments yield more robust outcomes for youth with anxiety concerns [8]. However, more research is needed on whether treating behavioral sleep problems in early childhood is linked to a reduced risk of developing anxiety or other internalizing conditions in later childhood. Treatments that have been effective in preventing depression by improving skills aligned with HRQoL domains, such as Interpersonal Psychotherapy—Adolescent Skills Training, which targets social-emotional deficits in youth at risk for depression [51], may also benefit from integrating methods to address co-occurring behavioral sleep problems.

In contrast to internalizing models, study findings suggest that early childhood intervention focused on externalizing concerns may help to prevent subsequent sleep problems, as well as psychosocial and physical HRQoL impairments. There is a growing evidence base for the broad benefits of behavioral sleep treatment in children with externalizing conditions, such as ADHD [52] and other disruptive behavior disorders [53]. However, research on whether treating externalizing disorders early in development prevents the onset of behavioral sleep problems or HRQoL impairments longitudinally is lacking. It is notable that many of the bidirectional associations found in this study between behavioral sleep problems, mental health symptoms, and HRQoL were in the younger age groups (4–5 and 6–7 years). This

could be because the prevalence of sleep problems was higher at these earlier ages, a pattern that is consistent with other studies examining the prevalence of pediatric sleep problems longitudinally [33]. At the same time, this period corresponds with the transition to school, which comes with increased child academic, social, and emotional demands and is thus an especially critical time for promoting healthy sleep and HRQoL. Indeed, early childhood sleep problems impact academic progress [54] and are reciprocally linked to self-regulation [49], which is also rapidly developing during this critical time [55]. Behavioral sleep intervention at the transition to school has been found to benefit child behavior and overall HRQoL [56], but studies have not examined whether this approach produces durable benefits that extend into middle childhood and early adolescence.

In this study, we were able to draw upon data over a 10 year period with key windows for positive child development, including the school entry and the transition from childhood to early adolescence. The use of a large, population sample and longitudinal data to examine associations between study constructs while accounting for changes over time and bidirectional effects, as well as the inclusion of well-validated and widely used outcome measures that can be compared to other samples, are strengths of this study. At the same time, there are several notable limitations. As noted above, this study is not generalizable to children with chronic medical conditions, who may face more significant psychosocial and physical HRQoL impairments. Findings also should be replicated in samples with increased diversity in racial/ethnic background and other sociodemographic factors, as sleep may vary in these subpopulations [57]. Future research should examine measurement invariance across sociodemographic groups.

The brief measure of internalizing and externalizing problems assesses symptoms and not diagnoses; therefore, findings cannot be generalized to clinical populations. Future studies should examine associations among sleep problems, HRQoL domains, and mental health symptoms across different mental health diagnoses, particularly given research showing that such linkages could vary according to internalizing (e.g., anxiety versus depression) [58] or externalizing (ADHD versus conduct problems) [46] diagnoses. It is also possible that child self-report at older ages on each of the domains may have shown different associations. This study relied on parent-reported sleep problems. It could be that parents are more aware of child sleep problems in early childhood, contributing to some of the early childhood associations found in this study. Future studies should include child-reported, as well as objectively measured sleep. Unmeasured variables, including parent-child interactions, parent mental health, and other aspects of the family, school, and environmental context, could contribute to child sleep problems, mental health symptoms, and HRQoL domains and should be considered in future research that aims to understand these complex associations. Additional mechanistic research is also necessary.

Conclusions

This study found that behavioral sleep problems from early childhood to early adolescence are associated with worse psychosocial and physical HRQoL over time. We also found that bidirectional associations between behavioral sleep problems and mental health

symptoms and between these symptoms and HRQoL are especially salient during the transition to school but vary according to mental health symptom cluster. Whereas HRQoL domains consistently predicted subsequent internalizing concerns from ages 4–5 to ages 12–13 years, externalizing concerns more strongly predicted subsequent HRQoL. Collectively, these findings highlight the importance of routine HRQoL assessment in the context of behavioral sleep treatment and the potential for interventions that address sleep problems and mental health symptoms early in development to benefit HRQoL domains and prevent a progression or worsening of these symptoms during key periods of development.

Supplementary Material

Supplementary material is available at *SLEEP* online.

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