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Original Article

# Sleep timing and child and parent outcomes in Australian 4–9-year-olds: a cross-sectional and longitudinal study

Jon Quach [a,b,c,*], Anna M.H. Price [a,b], Michael Bittman [d], Harriet Hiscock [a,b,e]

[a] Murdoch Children's Research Institute, Parkville, Victoria, Australia
[b] Centre for Community Child Health, The Royal Children's Hospital, Parkville, Victoria, Australia
[c] Melbourne Graduate School of Education, The University of Melbourne, Parkville, Victoria, Australia
[d] School of Behavioral, Cognitive and Social Sciences, University of New England, Armidale, NSW, Australia
[e] Department of Paediatrics, The University of Melbourne, Parkville, Victoria, Australia

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ABSTRACT

*Objectives:* The aim of this study is to use national Australian time-diary data to examine both (1) cross-sectionally and (2) longitudinally whether being late versus early to sleep or wake is associated with poorer child behavior, quality of life, learning, cognition and weight status, and parental mental health.
*Methods:* Design/setting: Data from the first three waves of the Longitudinal Study of Australian Children were taken. Participants: A national representative sample of 4983 4–5-year-olds, recruited in 2004 from the Australian Medicare database and followed up biennially, was taken; 3631 had analyzable sleep information and a concurrent measure of health and well-being for at least one wave. Measures: *Exposure:* Parents completed 24-h child time-use diaries for one week and one weekend day at each wave. Using median splits, sleep timing was categorized into early-to-sleep/early-to-wake (EE), early-to-sleep/late-to-wake (EL), late-to-sleep/early-to-wake (LE), and late-to-sleep/late-to-wake (LL) at each wave. *Outcomes:* The outcomes included parent-reported child behavior, health-related quality of life, maternal/paternal mental health, teacher-reported child language, literacy, mathematical thinking, and approach to learning. The study assessed child body mass index and girth.
*Results:* (1) Using EE as the comparator, linear regression analyses revealed that being late-to-sleep was associated with poorer child quality of life from 6 to 9 years and maternal mental health at 6–7 years. There was inconsistent or no evidence for associations between sleep timing and all other outcomes. (2) Using the count of the number of times (waves) at which a child was categorized as late-to-sleep (range 0–3), longitudinal analyses demonstrated that there was a cumulative effect of late-to-sleep profiles on poorer child and maternal outcomes at the child age of 8–9 years.
*Conclusions:* Examined cross-sectionally, sleep timing is a driver of children's quality of life and maternal depression. Examined longitudinally, there appears to be cumulative and adverse relationships between late-to-sleep profiles and poorer child and maternal outcomes at the child age of 8–9 years. Understanding how other parameters – such as scheduling consistency, sleep efficiency and hygiene – are also related to child and parent outcomes will help health professionals better target sleep management advice to families.



## 1. Introduction

Sleep problems affect approximately 40% of school-aged children [1,2]. It is often assumed that sleep duration is the key factor underpinning sleep problems, hence the popularity of guidelines recommending how much children should sleep at different ages [3]. While a range of literature has reported associations between sleep duration and poorer outcomes such as children's learning [4], cognitive function [5], weight [6], and behavior [7], sleep has predominately been assessed using summary recall measures, which are known to be inaccurate [8–10]. In contrast, finer-grained time-use diary data from 3631 Australian 4–9-year-olds showed no clear associations between how much children slept and a wide range

*Abbreviations:* ARS, Academic Rating Scale; BMI-Z, Body Mass Index z-score; CI, Confidence Interval; ECLS, Early Childhood Longitudinal Study-Kindergarten; HRQoL, Health-Related Quality of Life; K6, Kessler-6; PedsQL, Pediatric Quality of Life Inventory; PPTV, Peabody Picture Vocabulary Test; SD, Standard deviation; SDQ, Strengths and Difficulties Questionnaire; WISC, Wechsler Intelligence Scale for Children.

* Corresponding author. Centre for Community Child Health, The Royal Children's Hospital, Flemington Road, Parkville, Victoria 3052, Australia. Fax: +61 3 9345 5900.
*E-mail address:* jon.quach@mcri.edu.au (J. Quach).

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of child and parent outcomes [11]. Therefore, although sleep duration guidelines can be an important clinical tool for helping parents understand the normal range of children's sleep [12], other sleep parameters may be more important for optimizing children's daily functioning.

Sleep timing may be one such parameter. In 1622 children aged 5–10 years, Biggs et al. (2011) found that parent-reported bedtimes that varied by more than 60 min across the week were associated with poorer behavior and mental health [13]. Using data from 11,178 7-year-old children from the UK Millennium Cohort Study, Kelly et al. (2013) also found longitudinally that consistent bedtimes – measured using a general parent report question about regular bedtimes – were associated with better cognitive ability at seven years old [14]. These findings align with other child and adolescent studies examining the importance of consistent bedtimes for a broad range of child learning, health, and well-being outcomes [15–17].

While these studies examined the importance of bedtimes, Olds et al. (2011) found that the overall timing of children's sleep, including the wake time, is relevant to weight-related outcomes [18]. In 2200 Australians aged 9–16 years, the authors found that children and adolescents who were both late to bed and to rise were more likely to be overweight or obese, participate in low levels of moderate-to-vigorous physical activity, and use more screen time than those who were both early to bed and to rise [18]. However, it is unknown whether sleep timings are associated with other outcomes such as child learning, mental and physical health, and parent mental health [19–21]. Understanding the extent to which different sleep timings are associated with child and parent outcomes will inform clinicians on how to best manage different aspects of children's sleep, outside of only sleep duration.

Using the cross-sectional 24-h sleep time-diary data from the Longitudinal Study of Australian Children for 4–9-year-old children, this paper investigates how children's sleep timing is associated with children's and parents' health and well-being. Basing our analyses on Olds' research [22], we created four categories of children's sleep timing: (1) early-to-sleep/early-to-wake (EE), (2) early-to-sleep/late-to-wake (EL), (3) late-to-sleep/early-to-wake (LE), and (4) late-to-sleep/late-to-wake (LL) [22]. Using the EE group as the comparator, we examined cross-sectional differences in children's cognition, learning, quality of life, behavior, body mass index (BMI) and waist circumference, and parents' mental health between the four sleep timing groups (Aim 1). We **hypothesized** that later sleep and wake times would be associated with poorer outcomes and that these associations would exist regardless of the sleep duration. Following this, we conducted post-hoc analysis that at examined whether being late-to-sleep across one or more waves (i.e., at child age 4–5, 6–7, or 8–9) was associated with poorer outcomes at child age 8–9 years than being early-to-sleep across all waves (Aim 2). We **hypothesized** that children who were late-to-sleep at all waves would have poorer outcomes and their parents would have poorer mental health than children who were early-to-sleep at all waves.

## 2. Patients and methods

### 2.1. Design and setting

We used cross-sectional data from the first three waves of the preschool cohort (K-cohort) of the Longitudinal Study of Australian children (described in detail elsewhere [23]). A two-stage cluster sampling design was used to create two cohorts, birth (B cohort: aged 0–1 years in 2004) and preschool (K cohort: aged 4–5 years in 2004), who were assessed every two years. In the first stage, postcodes (except the most remote) were sampled after stratifying based on the state of residence and urban versus rural status to ensure proportional geographic and socio-economic representation. All in-age children registered on the Australian Medicare database (98% of Australian children) were randomly selected within each postcode to participate in the trial. As the child and parent health and well-being measures are not available across all B cohort waves, only K cohort data are included in this paper.

### 2.2. Participants

Of the 8446 families invited to join the K cohort, 4983 (59%) children participated in wave 1. Although differences between participants and non-participants are not available, the final Longitudinal Study of Australian Children sample was proportionally representative of Australian children based on urban versus rural geographical location and according to state, except for an over-representation of mothers who had completed high school and an under-representation of families with low incomes [23]. At wave 3 in 2008, 4332/4983 (87%) K cohort children (aged 8–9 years) were retained. Retention was marginally lower for children with less highly educated parents and from non-English speaking background [24].

### 2.3. Procedures

At all waves, trained researchers visited the child's home to complete a face-to-face interview with the primary caregiver and conduct direct child assessments. They then left two time-use diaries (see the section "Measures") with primary caregivers to complete on one randomly selected (computer-generated) week and one weekend day, using a "designated day" approach where respondents were told on which days to do each diary. Parents returned the diaries by post, and there was roughly equal representation in diary completion between week and weekend days, across the waves [25]. Children's teachers completed written surveys, also returned via post.

### 2.4. Measures

Sleep profiles (exposure) at the first three waves were measured using a "light" time-use diary [25]. Parents (usually the mother) completed the 24-h diaries, beginning at 4:00 a.m. and ending at 4:00 a.m. the following day. A diary could be completed prospectively through the day or all at once at the end of the day. As any of the 26 pre-coded activities occurred, mothers indicated its duration in 15-min time intervals. Sleep was represented by the category "sleep, napping." [26] For the purpose of this paper, sleep onset time was defined as the start of the first sleep episode occurring after 7 p.m. If the child was asleep at 7 p.m., the sleep onset time was defined as the beginning of that sleep episode, providing that episode was at least 90 min in duration. Wake time was distinguished from an interruption of sleep in the morning period (from 4 a.m.) if the child was awake for at least 75 min before the next sleep episode. From wave 4 onwards, K cohort children completed the diary themselves and were only asked to complete one diary instead of two. Given the measurement differences between waves 1–3 and 4 onwards, only time-use diary data from the first three waves were included in the current analyses.

Sleep profiles at each of the first three waves were determined by the analyses conducted by Olds' et al. [18]. Participants were classified into one of the four categories using median splits for sleep and wake times at each wave: (1) EE, (2) EL, (3) LE, and (4) LL.

Outcome measures for child and parent health according to wave, including score ranges and clinical cut-off points, are summarized in Table 1.