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Original Article

Outcomes at six years of age for children with infant sleep problems: Longitudinal community-based study

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ABSTRACT

Objectives: To examine whether infant sleep problems predict (1) sleep problems and (2) poorer outcomes at the age of six years.
Methods: We studied a community-based cohort of 326 six-year-olds recruited to a randomized trial of a behavioral sleep intervention for sleep problems at age seven months. Predictors were parent-reported child sleep problems at ages 4, 12, and 24 months ("yes" vs. "no"). There were a number of parent reported six-year-old outcomes: (1) Child sleep problem ("moderate/large" vs. "none/small") and Child Sleep Habits Questionnaire (CSHQ); (2) child and maternal mental and global health, child health-related quality of life (HRQoL, also child-reported), and child–parent relationship. The analyses were composed of multivariable models, adjusting for potential confounders and six-year sleep problems, examining whether each outcome was predicted by each infant sleep problem entered simultaneously. In a second set of analyses the predictor was the count of the number of waves with a sleep problem.
Results: A total of 225 (69%) families participated at six years. The CSHQ Total increased 0.5 points (95% CI: 0.4 to 2.4, $p = 0.006$) with each additional infant sleep problem, but there was little evidence that sleep problems at one or more time points during early childhood predicted other child, maternal, or child–parent outcomes at six years.
Conclusion: Infant sleep problems, whether transient, recurring, or persistent, do not predict long-term outcomes. Clinicians should focus on reducing child sleep problems and their considerable short-to-medium term impacts as they arise during childhood.

1. Introduction

Throughout their early years, children's sleep problems – reported by approximately 20–40% of parents [1] – are associated with a substantial health burden for families. In infancy (0–2 years), they are associated with poorer maternal wellbeing, including depressive symptoms [2], and poorer general health [3]. Children with early sleep problems are more likely to have sleep problems at school-entry age (5–7 years) [4], by which time they are associated with a raft of negative outcomes including poorer child mental health, health-related quality of life (HRQoL) [5] and physical health [6], and poorer maternal mental and general health [3,7].

It remains unclear whether these important adverse associations around the time of school entry are the outcomes of earlier sleep problems or are simply the immediate impacts of concurrent sleep difficulties. Findings from a randomized controlled trial which suggested that a behavioral sleep intervention delivered in the first six months of school leads to improved child psychosocial HRQoL, prosocial behavior and maternal mental health immediately post-intervention [8], lends some support to the latter view.

This does not eliminate the possibility, however, that a long history of childhood sleep problems extending back as far as infancy also contributes to adverse outcomes. The two studies examining how early childhood sleep problems relate to school-entry child outcomes both reported that infant sleep problems predicted later Attention Deficit Hyperactivity Disorder (ADHD) [9] and hyperactivity symptoms [10], but no studies have investigated whether early childhood sleep problems predict other childhood mental health problems, HRQoL, or general health. Similarly, while infant sleep interventions can improve maternal depression symptoms up to 16 months post-intervention [1,11], it remains unclear whether early childhood sleep problems predict maternal mental and general health in the longer term. Finally, while researchers

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have hypothesized a relationship between childhood sleep problems and impaired child–parent relationships [12], none have investigated associations of both early and concurrent sleep problems with these outcomes. If ongoing (i.e., persistent or recurring) sleep problems throughout early childhood predispose children and their parents to a range of adverse outcomes at school-entry age, there may be a case for more systematically addressing sleep management throughout the early years than is currently the case [1,11,13].

The Kids Sleep Study offers an opportunity to examine the long-term outcomes of sleep problems measured prospectively and repeatedly across the first two years of life. Using a community sample of 326 children, originally recruited from a population-based survey on the basis of parent-reported sleep problems at age seven months, the aim, therefore, was to quantify the extent to which (a) sleep problems at each of 4, 12, and 24 months of age, and (b) frequency of sleep problems across these ages, predicted at child age six years:

1. Child sleep problems (primary outcome), and
2. Secondary outcomes of child mental health, HRQoL and global health; maternal mental health and global health; and child–parent relationships, after adjusting for sleep problem status at six years.

2. Methods

2.1. Design and setting

The current cohort was originally recruited for a cluster randomized trial of a behavioral sleep intervention delivered in infancy (ISRCTN48752250) [11,14]. Following a population survey of mothers attending their infants' scheduled four-month well-child check (conducted by maternal and child health [MCH] nurses across six socioeconomically diverse local government areas in Melbourne, Australia), those who reported an infant sleep problem at seven months ($N = 328$) were recruited to the Infant Sleep Study trial. Maternal and child health nurses excluded infants born <32 weeks gestation and mothers with insufficient English to complete questionnaires.

After randomization, intervention mothers were offered a behavioral sleep intervention at 8–10 months. Control families received usual care from Australian health care services which did not include the behavioral sleep intervention [11,14]. Compared to controls, intervention parents reported fewer sleep problems at infant age 10 months (56% [intervention] vs. 68% [control]; adjusted odds ratio [adj OR] 0.6 [95% CI 0.4 to 0.9]) and 12 months (39% vs. 55%; adj OR 0.5 [0.3 to 0.8]) [14], and a lasting reduction in maternal depression at two years (15% vs. 26%; adj OR 0.4 [0.2 to 0.9]) [11]. At six years there were no differences between trial arms on any child, maternal, or child–parent outcome [15]. Intervention and control groups were therefore combined into a single cohort to examine the novel question of whether early sleep problems predict later child, maternal, or child–parent outcomes at six years, independent of intervention effects from seven months to six years.

2.2. Follow-up participants and procedures

From April to October 2009 the study team re-contacted all families. Two children met pre-specified exclusion criteria (one each with intellectual disability and autism), leaving 326 eligible. Consenting parents were mailed a questionnaire and then telephoned to arrange a home-based assessment as close as practicable to their child's sixth birthday (a uniform time of follow-up that falls soon after the transition to school for virtually all Australian children). At the home visit, trained researchers administered the children's self-reported Pediatric Quality of Life Inventory (PedsQL 4.0 [16] see *Measures*, below).

2.3. Measures (all parent-reported)

2.3.1. Predictor variables (sleep)

At 4, 12 and 24 months, the primary caregiver completed the single "yes"/"no" item "Over the last two weeks, has your child's sleep generally been a problem for you?" In a community survey of 738 Australian parents, this item differentiated infants on sleep patterns including evening bedtime ($p = 0.04$), time to fall asleep, number of disturbed nights per week, number of night awakenings, and length of wake durations (all $p < 0.001$) [2]. A sleep problem frequency was created by counting the number of times a child had a sleep problem at 4, 12 and 24 months, with possible values of 1–4 since all children had a sleep problem at seven months. Although assessed at 10 months, sleep problems at this age were excluded from the count variable to meet the requirements of an ordinal variable, i.e., to assume an equal distance between each pair of consecutive points [17].

2.3.2. Six year outcome variables

2.3.2.1. Child. The single four-point item "How much is your child's sleeping pattern or habits a problem for you?" developed for the Longitudinal Study of Australian Children [7], was the primary outcome. Presence of a sleep problem ("no/small/moderate/large") was dichotomized into "no/small" vs. "moderate/large" problems. This item correlates with blinded teacher ratings of behavior and academic ability [7], and pilot data ($n = 89$ Melbourne 6-year-olds) indicate that this dichotomization corresponds best (92.3%) to the binary predictor sleep variable collected at 4, 12 and 24 months [18]. Severity of a clinical sleep problem was measured using the validated 33-item (all three-point ordinal scales) Child Sleep Habits Questionnaire Short Form (CSHQ) [19]. The Total score sums items (possible range 33–99); a higher score indicates a greater problem. In American community ($n = 460$, mean age [SD] = 7.6 [1.5] years) and sleep disordered ($n = 154$, mean age [SD] = 6.8 [1.7] years) samples, internal reliabilities for the total score were $r = 0.68$ and $r = 0.78$, respectively [19].

Mental health was assessed with the validated 25-item (all three-point ordinal scales) Strengths and Difficulties Questionnaire (SDQ 4–10-year-old version) [20–22]. Twenty items are summed to produce the Total problems score (possible range 0–40); a higher score indicates a greater problem. Australian community data from 1359 students aged 4–9 years showed good internal reliability for the Total score ($\alpha = 0.82$). Health-related quality of life (HRQoL) was assessed with the validated 23-item (all five-point ordinal scales) Pediatric Quality of Life Inventory 4.0 (PedsQL 4.0) [23,24], which yields Psychosocial and Physical Health summary scales (possible range 0–100); higher scores represent better HRQoL. The 5–7-year-old self report version [16] – which produces the same subscales and ranges as the parent version – was also collected and administered by trained researchers at the home visit. Each item of the self report is scored on a three-point scale and children answer by pointing to faces on an A4 piece of card corresponding to the response options. Examples of items include "Is it hard for you to run?" and "Do you feel sad?" The PedsQL has shown strong internal reliabilities for parent-reported psychosocial and physical HRQoL ($\alpha = 0.86$ and $\alpha = 0.87$, respectively; $n = 1111$ American parents of six-year-old children) and child-reported psychosocial and physical HRQoL ($\alpha = 0.82$ and $\alpha = 0.70$, respectively; $n = 914$ American six-year-olds) [16,24]. Children's global health was measured with the single five-point item "In general, would you say your child's health is:" with the possible responses "poor/fair/good/very good/excellent." Drawn from the

general health scale of the 28-item Child Health Questionnaire (CHQ) [25], this item demonstrated the highest correlation with a visual analogue scale of children's health ($r = 0.50$) in school-aged children (mean age = 8.1 years). For the current study, the item was dichotomized into "poor/fair/good" vs. "very good/excellent" health and analyzed as a binary outcome measure.

2.3.2.2. Maternal. Mental health was assessed with the validated 21-item (all four-point ordinal scales) Depression, Anxiety, Stress Scale Short-Form (DASS-21) [26]. A higher score indicates worse mental health. The DASS-21 Total score shows strong internal reliability ($\alpha = 0.93$; $n = 1794$ UK adults) [26]. Global health was measured with the single five-point item "In general, would you say your health is:" with the possible responses "poor/fair/good/very good/excellent." Drawn from the validated Short Form-36 [27], it is identical to child global health item above and was dichotomized and analyzed the same way.

2.3.2.3. Child–parent. The child–parent relationship was assessed with the 15-item (all five-point ordinal scales) Child–Parent Relationship Scale Short-Form (CPRS) [28], which yields Closeness and Conflict subscales; higher scores indicate greater closeness or conflict. In an American sample of 1226 children aged 3–7 years of age, internal consistency was moderate for Closeness ($\alpha = 0.64$) and strong for Conflict ($\alpha = 0.84$) [29]. The global child–parent relationship was assessed with the study-designed five-point item "How would you rate your current relationship with this child?" with the possible responses "poor/fair/good/very good/excellent". The item was dichotomized into a "poor/fair/good" vs. "very good/excellent" relationship and analysed as a binary outcome measure.

2.3.3. Covariates

Five potential confounders were selected *a priori* from the baseline data: [6,30] child gender, difficult temperament, maternal education, depression symptoms (Edinburgh Postnatal Depression Scale) [31,32], and Socio-Economic Indexes for Areas (SEIFA) [33] Index of Relative Disadvantage. SEIFA is a national (quantitative) index derived from census data for all individuals living in a postcode, with higher scores indicating less disadvantage [33]. Additionally, child birth order (1st vs. other) and financial stress (six-point categorical item, "Given your current needs and financial responsibilities, how would you say you and your family are getting on?" with responses "prosperous/very comfortable/reasonably comfortable/just getting along/poor/very poor") were adjusted for in specific models listed in Section 2.4 below.

2.4. Analyses

Unadjusted and adjusted marginal logistic regression models were fitted using Generalized Estimating Equations (GEE) assuming an exchangeable correlation structure with information sandwich ("robust") estimates of standard error for the binary outcomes [34] and random effects linear regression models estimated using maximum likelihood for quantitative outcomes [35]. Both methods allow for correlation between outcomes of participants from the same cluster because the original study sampled and then randomized MCH centers (clusters). Two separate sets of analyses were run for each aim. In the first, the three indicators of infant sleep problems at 4, 12, and 24 months were simultaneously used as separate predictors in the regression models. In the second, the infant sleep problem predictors were quantified as a count of the number of waves at which a sleep problem was reported (ordinal variable with possible scores 1–4, since all children had one sleep problem at seven months). Tests showed little evidence of a deviation from the assumption of a linear relationship between this ordinal variable and the outcome and, therefore, for ease of presentation, results are reported based on the assumption that it should be treated as a quantitative predictor.

The adjusted regression models included the five potential confounders and randomization status (whether the child was assigned to the intervention or control group), except that "moderate/large" child sleep problems and the global child–parent relationship rating analyses were not adjusted, and analysis of child global health was adjusted for randomization status only, because there were too few subjects in the category of interest for these outcomes to obtain stable estimates of the odds ratios once potential confounders were included [36]. The CSHQ Total was further adjusted for child birth order (first-born children are more likely to have "moderate/large" sleep problems at age six years) [7]; the Strengths and Difficulties Questionnaire (SDQ) total was further adjusted for financial stress [37] (associated with a doubling of the risk of behavior problems in 2–7-year-olds in the Longitudinal Study of Australian Children) [38]; and analyses for Aim 2 were further adjusted for six-year sleep problems to examine whether infant sleep problems predicted those outcomes over and above concurrent sleep problems.

Confidence intervals from analyses of quantitative outcomes were validated using the bootstrap method [39]. All data files were analysed using Stata 11.1 (Stata, College Station, TX, USA).

2.5. Ethical approval

The Human Research Ethics Committee of The Royal Children's Hospital, Melbourne, approved both the original trial (EHRC 23067B) and six-year-old follow-up (EHRC 28137F).

3. Results

3.1. Responder characteristics (Table 1)

225/326 children (69%) participated at a mean age of 6.0 years (SD 1.9 months). The study team was unable to contact 49 (15%) families, and 52 (16%) families declined completing the parent questionnaire for reasons including "too busy" ($n = 26$), "not interested" ($n = 6$), "personal reasons" ($n = 6$), "child illness" ($n = 1$), or no reason ($n = 13$). Fifty-seven percent (186/326) of families had a home visit and completed the self-reported PedsQL. The 39 families who completed the questionnaire but declined the home visit did so because they were "too busy" ($n = 17$), "not interested" ($n = 15$), living overseas or interstate ($n = 3$), or did not provide a reason ($n = 4$). Compared with those retained, families lost to follow-up were more likely to speak a language other than English, have less maternal education, and have higher socioeconomic disadvantage.

3.2. Natural history of sleep

Table 2 shows that, of 326 children with sleep problems at seven months (original inclusion criterion), 172 (53%) had sleep problems at four months, which was higher than the 19% recorded for the remaining 411 patients in the population-based sample surveyed at four months but not followed further. Most children continued to have sleep problems at 10 months (190/308, 62%), after which sleep problems were more likely to resolve than persist or recur (see Fig. 1). Thirty percent (81/271) had sleep problems at two years and 32% (73/225) had any sleep problem at six years (i.e., "small/moderate/large") but just 8% reported a "moderate/large" problem (the criterion for a sleep problem) (Table 2). The Fig. 1 shows that few children with sleep problems at 24 months also had sleep problems at six years. Only 2% of children had persistent sleep problems at all time points, whereas 23% had no sleep prob-

Table 1
Early characteristics according to follow-up status at age six years. All values are percentages, except where otherwise stated.

Early characteristics	Total (N = 326)	
	Retained (N = 225)	Lost (N = 101)
Child		
Male	54.7	53.5
Age (months), mean (SD)	4.6 (0.6)	4.6 (0.6)
Difficult temperament	24.4	27.7
Number of times with sleep problem[a]		
1	22.2	29.7
2	39.1	38.6
3	28.4	24.8
4	10.2	6.9
Mother		
Age (years), mean (SD)	33.1 (4.4)	32.9 (4.9)
Depression (EPDS), mean (SD)	8.5 (5.1)	8.2 (5.3)
Depression (EPDS)> 9	39.6	39.6
Education status		
Did not complete high school	15.6	21.8
Completed high school	30.2	35.6
Tertiary degree	54.2	42.6
Family		
Index of social disadvantage		
High disadvantage	15.1	24.8
Medium disadvantage	33.3	26.7
Low disadvantage	51.6	48.5
Language other than English	16.0	26.0

EPDS = Edinburgh Postnatal Depression Scale, where EPDS > 9 is the community cut-point for depression [17,18]; SEIFA = Socioeconomic Indexes for Areas, 2001 Australian census data for socio-economic status by postcode [19,36].

[a] Sleep problem count calculated from four waves: number of sleep problems at 4, 7, 12 and 24 months, with all children reporting a sleep problem at 7 months.

lems after seven months. The majority of children retained at six years (68%) had sleep problems on two or three of the possible four occasions (Table 1).

Table 2 shows that the proportion of children with any night awakenings, the mean number of awakenings per night the and total length of night awakenings fell across childhood, with the few night awakenings reported at age six being very brief (<5 min). In contrast, parent-reported night-time sleep duration remained static from seven months to six years.

3.3. Predicting six-year outcomes

3.3.1. Childhood sleep problems (Aim 1)

There was little evidence that early childhood sleep problems at any one time point predicted six-year-old child sleep problems measured by either the binary sleep problem or continuous CSHQ outcome (Table 3). Only infant sleep problems at 12 months predicted higher CSHQ Total score (adjusted mean difference = 2.4, 95% CI: 0.4 to 4.5, p = 0.02). Table 4 shows that, for each additional timepoint that a sleep problem was reported in early childhood, the six-year-old CSHQ Total score increased by 0.5 points (95% CI: 0.4 to 2.6, p = 0.006), but there was no evidence for an association between frequency of early sleep problems and six year "moderate/large" sleep problems (OR = 1.33, 95% CI: 0.84 to 2.10, p = 0.2).

3.3.2. Secondary outcomes (Aim 2)

Table 3 shows that there was evidence that sleep problems at four months predicted "very good/excellent" maternal health at six years (adjusted odds ratio = 2.12, 95% CI: 1.12 to 4.04, p = 0.02); at 12 months predicted poorer self-reported psychosocial HRQoL (adjusted mean difference = −5.7, 95% CI: −10.7 to −0.6, p = 0.03); and at 24 months predicted improved child–parent relationship (adjusted odds ratio = 0.25, 95% CI: 0.08 to 0.81, p = 0.02). There was very weak evidence that sleep problems at 12 months predicted poorer self-reported physical HRQoL (adjusted mean difference = −3.9, 95% CI: −8.0 to 0.2, p = 0.06); and at 24 months predicted poorer maternal mental health (adjusted mean difference = 3.4, 95% CI: −0.3 to 7.1, p = 0.08). There was, however, no clear predictive pattern across these associations, and no evidence for associations between early sleep problems measured individually and secondary six year outcomes for the other 28 statistical tests (see Table 3).

In contrast, the same models indicated that concurrent sleep problems were strongly associated with child mental health (adjusted mean difference = 5.8, 95% CI: 2.9 to 8.6, p < 0.001), child psychosocial and physical HRQoL (adjusted mean differences = −13.6, 95% CI: −19.6 to −7.6, p < 0.001, and −12.9, 95% CI: −20.9 to −5.0, p = 0.001, respectively), poorer child global health (adjusted odds ratio = 0.17, 95% CI: 0.07 to 0.42, p < 0.0001), and poorer parent mental health (adjusted mean difference = 14.4, 95% CI: 8.1 to 20.7, p < 0.0001). These children also self-reported poorer physical HRQoL (adjusted mean difference = −8.5, 95% CI: −16.2 to −0.7, p = 0.03). There was little evidence for associations between concurrent sleep problems and children's self-reported psychosocial HRQoL, parent global health, or the child–parent relationship.

There was only weak evidence for a relationship between the frequency of early sleep problems and six-year-old outcomes (see Table 4). An increasing count of sleep problems was associated with impaired child, but improved maternal, global health (adjusted odds ratios per additional reported problem = 0.71, 95% CI: 0.49 to 1.03, and 1.33, 95% CI: 0.97 to 1.81, respectively, both p = 0.07), and with impaired global child–parent relationship (odds ratio = 0.60, 95% CI: 0.34 to 1.07, p = 0.08). There was little evidence that the other outcome variables were associated with the sleep problem count. For all outcomes, there was little change in the outcome estimates whether six year sleep problems were, or were not, controlled for. This suggests that, rather than a large effect of concurrent sleep problems dominating the models, frequency of early sleep problems had little effect on later outcomes.

Table 2
Sleep variables for the combined cohort at each wave of data collection.

Age	%		Mean (SD)		
	Sleep problem N = 224–326	Any night wakes N = 198–326	Number of wakes per night N = 221–325	Total waking length (min) N = 221–312	Night time sleep duration (hours)[a] N = 221–321
4 months	52.8	–	–	–	–
7 months	100	97.8	2.5 (1.4)	44.0 (60.3)	10.6 (1.5)
10 months	61.7	85.9	1.8 (1.5)	32.0 (34.0)	10.9 (1.1)
12 months	46.3	78.1	1.5 (1.3)	30.1 (42.4)	11.2 (1.0)
24 months	29.9	–	–	–	–
6 years	32.6[c]/8.0[d]	53.0	0.3 (0.4)[b]	3.3 (5.2)[b]	10.8 (0.6)[b]

[a] Including night wakes.
[b] Summary statistics for 6 years used composites of CSHQ items.
[c] Any sleep problem (mild/moderate/severe).
[d] Moderate/severe sleep problem.

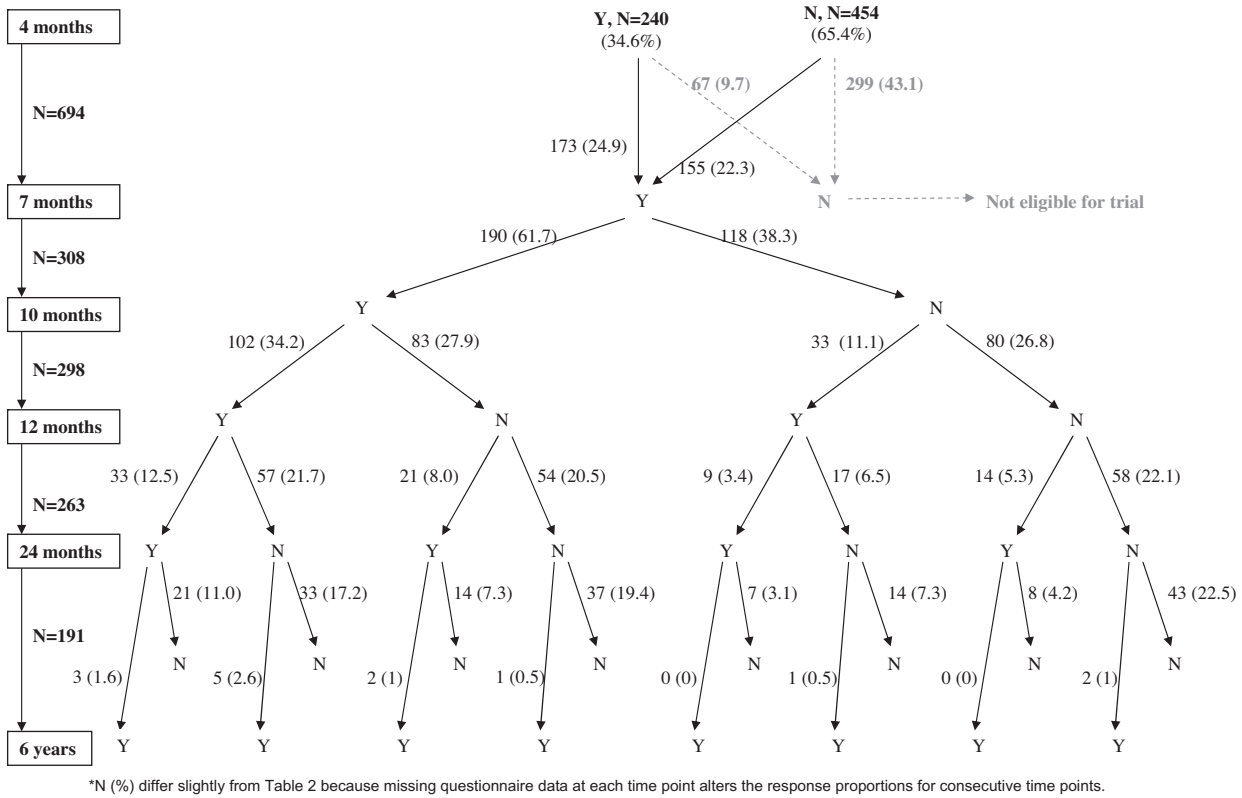

Fig. 1. *N* (%)* of children with or without sleep problems at each follow-up point, according to sleep problem status (Yes [Y] vs. No [N]) at preceding waves.

Table 3
Results of adjusted regression models predicting outcomes at six years from child sleep problems at each of 4, 12 and 24 months.

Six year child outcome	Sleep problem					
	four months		12 months		24 months	
	Adj comparative stat (95% CI)	*p*	Adj comparative stat (95% CI)	*p*	Adj comparative stat (95% CI)	*p*
Child						
Moderate/severe problem (%)	0.93 (0.35 to 2.45)	0.9	1.70 (0.56 to 5.19)	0.4	1.65 (0.64 to 4.25)	0.3
CSHQ Total	1.7 (−0.5 to 3.9)	0.1	2.4 (0.4 to 4.5)	0.02	1.2 (−1.0 to 3.5)	0.3
SDQ Total Problems	−0.04 (−1.7 to 1.6)	1.0	−0.2 (−1.7 to 1.3)	0.8	0.5 (−1.2 to 2.1)	0.6
PedsQL Parent-Proxy						
Psychosocial	−1.2 (−4.8 to 2.3)	0.5	0.5 (−2.8 to 3.8)	0.8	−0.9 (−4.4 to 2.6)	0.6
Physical	−0.5 (−5.2 to 4.1)	0.8	0.6 (−3.7 to 4.9)	0.8	0.2 (−4.5 to 4.8)	0.9
PedsQL Child-Self						
Psychosocial	−2.2 (−7.6 to 3.1)	0.4	−5.7 (−10.7 to −0.6)	0.03	0.7 (−4.7 to 6.1)	0.8
Physical	1.7 (−2.6 to 6.0)	0.4	−3.9 (−8.0 to 0.2)	0.06	−1.0 (−5.4 to 3.3)	0.6
"Very good/excellent" health (%)	0.94 (0.47 to 1.89)	0.9	0.66 (0.27 to 1.57)	0.3	0.91 (0.42 to 1.98)	0.8
Maternal						
DASS Total	1.0 (−2.8 to 4.7)	0.6	−0.7 (−4.2 to 2.8)	0.7	3.4 (−0.3 to 7.1)	0.08
"Very good/excellent" health (%)	2.12 (1.12 to 4.04)	0.02	1.47 (0.78 to 2.78)	0.2	1.04 (0.55 to 1.98)	0.9
Child–parent						
CPRS Closeness	−0.001 (−0.1 to 0.1)	1.0	−0.03 (−0.1 to 0.03)	0.3	−0.01 (−0.1 to 0.1)	0.7
CPRS Conflict	0.1 (−0.1 to 0.4)	0.4	−0.1 (−0.3 to 0.2)	0.6	0.2 (−0.1 to 0.4)	0.2
"Very good/excellent" relationship (%)	1.00 (0.29 to 3.20)	1.0	0.84 (0.26 to 2.70)	0.8	0.25 (0.08 to 0.81)	0.02

Comparative statistic is odds ratio (denoted with %) for binary moderate/severe sleep problem, child and parent global health, and global child–parent relationship outcomes and mean differences for all other outcomes that are continuous. The reference category for "moderate/severe" sleep problem is "none/mild" sleep problem; and for "very good/excellent" child and parent global health and child–parent relationship is "poor/fair/good" child and parent health and child–parent relationship, respectively.

4. Discussion

4.1. Principal findings

While a subgroup of infants appear to be predisposed to a trajectory of poorer sleep throughout childhood, early sleep problems – whether at single or multiple time points – have little lasting effect on child, maternal, or child–parent outcomes to the time of school-entry.

4.2. Strengths of the trial

This is the first prospective longitudinal study to repeatedly measure child sleep problems against long-term outcomes. The

Table 4
Six year outcomes predicted by increasing frequency of early sleep problems when treated as a linear exposure variable. Summary statistics are mean (SD) except moderate/severe problem outcome where percentage is shown.

Six year outcome	Six year summary statistic (N = 212–224)	Comparative statistic for increasing count			p
		Unadjusted	Adjusted	95% CI	
Child					
Moderate/severe problem (%)	8.0	1.33	–	0.84 to 2.10	0.2
CSHQ Total	42.4 (7.1)	1.3	1.5	0.4 to 2.6	0.006
SDQ Total Problems	8.3 (5.8)	0.8	0.4	−0.4 to 1.2	0.4
PedsQL Parent-Proxy					
Psychosocial	78.6 (12.9)	−2.1	−1.1	−2.8 to 0.7	0.2
Physical	82.6 (15.4)	−1.1	−0.4	−2.6 to 1.8	0.7
PedsQL Child-Self					
Psychosocial	68.9 (16.0)	−2.2	−2.1	−4.7 to 0.4	0.1
Physical	76.2 (13.2)	−1.1	−1.0	−3.1 to 1.1	0.4
"Very good/excellent" health (%)	86.2	0.69	0.71	0.49 to 1.03	0.07
Maternal					
DASS Total	17.4 (14.1)	2.6	1.3	−0.6 to 3.1	0.2
"Very good/excellent" health (%)	61.8	1.06	1.33	0.97 to 1.81	0.07
Child–parent					
CPRS Closeness	4.3 (0.3)	−0.02	−0.01	−0.04 to 0.03	0.6
CPRS Conflict	2.3 (0.8)	0.1	0.1	−0.05 to 0.2	0.2
"Very good/excellent" relationship (%)	92.0	0.60	–	0.34 to 1.07	0.08

Comparative statistics are odds ratio (denoted with %) for binary moderate/severe sleep problem, child and parent global health and global child–parent relationship outcomes, and mean difference for all other outcomes, which are continuous; they refer to relative increase in odds or mean increase in outcome for each extra wave at which the participant had a sleep problem. The reference category for "moderate/severe" sleep problem is "none/mild" sleep problem and for "very good/excellent" child and parent global health and child–parent relationship is "poor/fair/good," child and parent health and child–parent relationship, respectively.

prospective nature of the sleep measure limits recall bias and should capture the fluctuating nature of child sleep problems, thus identifying which children suffered prolonged sleep disruption throughout infancy. Families completed (where available) well-validated and reliable parent- and child-reported outcome measures [16,19–24,26,29,40,41], and the population-based sampling should allow these findings to generalize to English-speaking families across a wide demographic range.

4.3. Study limitations

As these analyses were planned secondary to the original study, the choice of time points measured was relatively arbitrary, so the relationships observed will not necessarily replicate if other infant ages are studied. Similarly, conceptually, frequency of sleep problems in early childhood is an ordinal categorical rather than a continuous variable, although there was little statistical evidence against a linear relationship for the variable used. A subjective parent report of child sleep problems rather than a more objective measure like actigraphy or polysomnography was collected. Defining a sleep problem using more objective measures, however, still requires the use of arbitrary (i.e., arguably subjective) cutpoints, and previous studies using the same "no/small/moderate/large" item have shown strong correlations with blinded teacher ratings of behavior and academic ability [5,8]. The 31% loss to follow-up of the original sample, and the original inclusion criteria, can potentially reduce the generalizability of the results. Non-English speaking and disadvantaged families were over-represented in those lost to follow-up, while families without infant sleep problems at seven months were excluded from the original study, so the findings may not generalize to these participant groups.

4.4. Interpretation in light of other studies

There was little evidence that early child sleep problems at specific time points predicted six year child sleep problems. This contrasts with the two large community-based cohorts (one Canadian, N = 1492 [4] and one Swedish, N = 10,942 [42]) showing that night waking and delayed sleep onset in the first year of life predicted sleep problems at 5–6 years. Similarly, while increasing frequency of early child sleep problems predicted an increasing risk of six-year sleep problems measured using the CSHQ, the single existing comparative study (n = 68) reported that non-self soothing at six and nine months was associated with poorer sleep patterns at 24 months but not in later childhood (3–4 years) [43]. The difference in the current results may be because the construct measured was perception of a child's sleep problem rather than sleep patterns. Even so, previous research indicates that the two constructs correlate [2]. Alternatively, the differences may be explained by the reduced power of smaller samples to detect true associations.

The weak-to-moderate evidence from four comparisons suggesting that early individual sleep problems predicted poorer six year outcomes (i.e., 4 months sleep problems predicted maternal health, 12 months predicted self-reported HRQoL, and 24 months predicted maternal mental health) is consistent with existing clinical (n = 54) [9] and population (n = 1492) [10] studies which found that early childhood sleep problems and short sleep duration predicted poorer child outcomes (ADHD and hyperactivity, respectively). The weak evidence, however, for the child–parent relationship to be improved as a consequence of 2-year-old sleep problems contrasts with these studies, as do the majority of the comparisons, which did not show a relationship between early sleep problems and later outcomes.

This is the first study to examine whether frequency of early sleep problems predict child, maternal, and child–parent relationship outcomes at six years. While the weak evidence for recurring/persistent early sleep problems to predict later child global health and the child–parent relationship is consistent with large population-based longitudinal studies [5,44], the weak evidence for maternal global health to be improved as a consequence sits in contrast. Given their small effect sizes and relatively large p-values (p = 0.06–0.08), a more likely explanation for these findings and those from the individual models described above is that they arose by chance.

4.5. Unanswered questions/future research

Only infants with sleep problems at seven months were included in this study – half of whom were offered a sleep intervention that effectively reduced parent-reported sleep problems to

12 months – so this cohort may represent a narrow range of sleep problem trajectories. A future study with a representative, unselected population sample could identify whether associations between early sleep problems and later outcomes are more pronounced in the general population. Research that measures the effect of sleep problems throughout the preschool period (3–5 years) and assesses outcomes in later childhood (>6 years) will further identify whether sleep problem trajectories persist throughout and beyond early childhood.

4.6. Implications

Parents and health professionals can be reassured that the majority of sleep problems in early childhood are transient. A minority of children appears to be predisposed to a developmental trajectory of ongoing sleep difficulties through early childhood. Infant sleep problems at one or multiple time points are, however, unlikely to sustain long-term negative impacts on child, maternal, or child–parent relationship outcomes. Clinicians should intervene with sleep problems as they arise during childhood, with the aim of alleviating the considerable adverse child and maternal outcomes and health system costs associated in the short - to medium term [6,8,11].

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: doi:10.1016/j.sleep.2012.04.014.

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