



Sleep characteristics and changes in sleep patterns among infants in Bhaktapur, Nepal



Ram K. Chandyo, PhD^a, Suman Ranjitkar, PsyD^b, Jaya S. Silpakar, MA^b, Manjeswori Ulak, PhD^{b,c}, Ingrid Kvestad, PhD^{d,e}, Merina Shrestha, MD^b, Catherine Schwinger, PhD^c, Mari Hysing, PhD^{f,*}

^a Department of Community Medicine, Kathmandu Medical College, Kathmandu, Nepal

^b Department of Pediatrics, Child Health Research Project, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal

^c Center for Intervention Science in Maternal and Child Health, Centre for International Health, University of Bergen, Bergen, Norway

^d Innlandet Hospital Trust, Department of Research, Lillehammer, Norway

^e Regional Centre for Child and Youth Mental Health and Child Welfare, NORCE Norwegian Research Centre, Bergen, Norway

^f Department of Psychosocial Science, Faculty of Psychology, University of Bergen, Bergen, Norway

ARTICLE INFO

Article history:

Received 6 June 2023

Received in revised form 21 February 2024

Accepted 23 February 2024

Keywords:

BISQ

Infant

Nepal sleep

Trajectories

ABSTRACT

Objective: Sleep undergoes major changes during the first year of life, but the characteristics of sleep among infants in low and middle-income countries are not well documented. This study describes sleep characteristics and changes in sleep patterns in infants at 6 and 12 months of age from Bhaktapur, Nepal.

Methods: This was a community-based longitudinal study comprising 735 infants. Sleep characteristics were obtained by interview with the mother using the Brief Infant Sleep Questionnaires. The stability of sleep duration and night awakenings were estimated by logistic regression analysis.

Results: Cosleeping in the parent's bed at 6 and 12 months of age was almost universal (>97%). At 6 months of age, 254 (35%) and at 12 months of age, 341 (46%) infants had a total 24-hour sleep duration < 12 hours. Night awakenings ≥ 3 times per night were common (65%) both at 6 and 12 months of age. Infants with frequent nightly awakenings at 6 months had increased odds of frequent nightly awakenings at 12 months (OR = 2.2; 95% CI: 1.6, 2.9). Very few (<3%) mothers reported sleep problems in their infants at 6 and 12 months of age. **Conclusions:** Cosleeping was almost universal among Nepalese infants, and very few of the mothers reported sleep problems in their infants. Infants at 6 and 12 months had similar patterns for both sleep duration and nocturnal awakenings. For infants, there were increased odds of having similar sleep duration and nocturnal awakening at 6 and 12 months.

© 2024 The Author(s). Published by Elsevier Inc. on behalf of National Sleep Foundation. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Introduction

Sleep is a basic physiological need and is related to the physical, cognitive, and emotional development in infants.^{1–3} Poor sleep is considered one of the major sources of burden of disease in low- and middle-income countries.⁴ While sleep across different socio-economic and cultural settings has received increased attention,^{5,6} most of the studies on the development of sleep during the first years of life are based in Western countries.

During the first year of life, sleep undergoes major changes in the quantity, quality, and timing of sleep. Sleep duration is expected to

shorten gradually during the first years of life. Further, sleep duration has also been shown to differ across countries and cultures.⁷ This was shown in a large-scale international internet survey where infants from predominantly Asian countries had later bedtime and shorter sleep duration compared to infants from the United Kingdom, Australia, and North American countries.⁸ A study on infants in South-East Asia confirmed social-cultural characteristics of sleep, such as high rates of cosleeping and short sleep duration, but also documented large differences between countries within the region.⁹ In a systematic review of cross-cultural comparative studies of sleep in childhood, they also concluded that infants from Asia had longer daytime naps, more nocturnal awakenings and longer sleep onset latency.¹⁰ Bedsharing is more common in Asian countries,¹⁰ and can be a result of cultural practices, as well as crowded sleep environments due to poverty in low- and middle-income countries

* Corresponding author: Mari Hysing, Department of Psychosocial Science, Faculty of Psychology, University of Bergen, P.O. Box 7807, NO 5020 Bergen, Norway.
E-mail address: Mari.hysing@uib.no (M. Hysing).

in Asia.^{11,12} There is also a knowledge gap regarding sleep in these settings. In a review article, 43 (22%) out of 194 WHO state member countries had sleep information from a general population and the importance of collecting such data was highlighted.¹³

During the first year of life, there is a gradual consolidation of sleep with the establishment of circadian rhythms.¹⁴ In general, the frequency and duration of nocturnal awakenings decrease with age, but there might still be some consistency in sleep patterns on the individual level. For instance, in a general population study in Norwegian infants, 44% of those who were awake three or more times at night at 6 months of age were awake at least once per night at 18 months.¹⁵ Similarly, an Italian study found that infants who had short sleep duration and frequent nocturnal awakenings at 6 months had an increased risk of similar sleep problems at 12 months.¹⁶ The nature of the development of sleep patterns and the rate of awakenings may differ across cultures and countries, and whether early sleep patterns also predict the later sleep patterns in other cultural contexts needs further investigation.¹⁷

The definition of what parents perceive as a sleep problem, for instance, related to timing, duration, or frequency of night awakenings, may also vary across cultures and settings.¹⁰ Expectations as to the age when sleeping through the night is appropriate may also vary greatly. Thus, parental perception of the presence of a sleep problem is key to understanding what is normative in a current context and may also be relevant for help-seeking behavior for sleep problems.¹⁸

Since there are vast sociocultural differences in sleep patterns and sleep-related behavior,⁸ we need to explore what constitutes normative sleep patterns and sleep-related behavior in diverse settings.¹⁸ For the timely recognition and to address sleep-related problems during infancy, it is also important to understand sleep trajectories, for instance, if infants with frequent awakenings or short sleep duration are at increased risk of having similar sleep characteristics later.¹⁶ The few existing studies on sleep from Nepal are based on samples from hospitals in relation to health check-ups for infants.^{19,20} Unscheduled interviews particularly when children are sick, may under- or overestimate reporting of total sleep duration and problems.²¹ In the present longitudinal study, we aimed to characterize sleep patterns and parental perceptions of sleep problems among infants at 6 and 12 months of age in a community-based sample of mothers and their infants in urban Nepal.

Participants and methods

The current study is a secondary analysis of data collected in relation to a double-blind randomized controlled trial on vitamin B₁₂ supplementation in pregnancy and postpartum on growth and neurodevelopment in early childhood (ClinicalTrials registration number NCT03071666). Women from the general population were recruited mostly through ante-natal clinic-based surveillance early in pregnancy between March 2017 and October 2020 in Bhaktapur, Nepal. When infants were 6 and 12 months of age (± 2 weeks), follow-up visits were performed at the study hospital to assess growth and cognitive development and information on infant sleep. The period of data collection ended in May 2022.

Women with no known acute or chronic illnesses, aged between 20 and 40 years, residing and planning to reside in the area for at least the next 2 years participated in the study. They were enrolled within 15 weeks of pregnancy. In the main study, there were no effects of vitamin B₁₂ supplementations on growth and neurodevelopment until 1 year of age.²² Details of the main study protocol, and descriptions of the study site and population are published elsewhere.²²

The study area includes Bhaktapur municipality and surrounding communities where the majority of the population belongs to the Newar ethnic group and most people are engaged in small- or large-scale family business, service or agriculture. Bhaktapur is located

15 km east of the capital city Kathmandu at an altitude of 1400 m, and is one of the most densely populated cities in Nepal (11,430 inhabitants/km²).²³ In this setting, ante-natal check-ups and institutional delivery are almost universal. Mothers are mainly responsible for childcare in the community, but with many families living in joint family settings, others are also frequently involved in childcare. Oil massage is a common practice with newborn infants, often in the terrace areas (roof or floor) followed by a daytime nap, covering the baby with clothes to protect them from direct sun exposure. It is believed that the massage and swaddling of the infant will contribute to improved sleep.

Instruments

The Brief Infant Sleep Questionnaire (BISQ) assesses sleep patterns, parental perception and sleep-related behaviors in infants and toddlers (0–30 months).²⁴ It covers information on sleep parameters such as arrangement for sleep, position of infants during sleep, duration of sleep during night and daytime, and perception of parents on infant sleep problems. The questionnaire was administered in one-to-one interviews with the mothers by trained field workers when the infants were 6 and 12 months of age. The sleep duration for day and night was added up to obtain the total sleep duration for 24 hours. Sleep Onset Latency (SOL), which is the time it takes for the infant to fall asleep, and Wake After Sleep Onset (WASO), which is the sum of wake time during the night, were included.²⁵ Parental perception of their child's sleep problems was assessed by the question: "Do you consider your child's sleep as a problem?" with response categories: a very serious problem, a small problem, or not a problem at all.

Night awakenings (at 6 and 12 months) were assessed by a single question "Average number of night wakings per night." In addition, a dichotomous variable was created with a cut-off at three or more nightly awakenings which is also commonly used to describe sleep problems.²⁶

We also asked questions on usual bedtime and how the child fall asleep (with the response categories: while feeding, being rocked, being held, in bed alone or in bed near the parents). We used a Nepali version of the BISQ questionnaire that has been used in previous studies.^{19,20} Prior to the data collection, the study psychologists trained field workers to complete the BISQ questionnaires with the mothers.

Sociodemographic and household information was collected from the mothers during pregnancy by field workers. Families who used the kitchen room for sleeping were categorized as not having a separate kitchen. A nuclear family was considered a family where only two generations in the families (i.e., parents and children) were living in the household.

Birth-related variables were retrieved from hospital records by physicians or study supervisors. Gestational age was assessed by both the last menstruation period and ultrasonography during pregnancy (USG). Preterm delivery was defined as < 37 weeks of gestation. Low birth weight was defined as less than 2500 g. Exclusive breastfeeding for 6 months was defined as an infant who was only breastfed and that did not receive any other milk or food including water and herbal drops (except medicine) before the age of 6 months.

Statistical analysis

All collected forms were manually checked by supervisors before entered into a double-entry system. For the continuous variables, mean, standard deviation, and ranges are reported; for categorical variables, number of children and percentages below or above cut-off values are presented. Changes in the total sleep duration categories between 6 and 12 months are presented in a Sankey diagram

which is commonly used to visualize the flow of activities from one time point to another.²⁷ We also present sleep duration during the day, at night and in total by density plots using the Epanechnikov Kernel function. The stability of sleep between 6 and 12 months of age was examined in logistic regression analysis and in a scatter plot. In the logistic regression analysis, we examined the association of < 12 hours of total sleep at 12 months with < 12 hours total sleep duration at 6 months. The logistic regression analysis was adjusted for mother's age, education and occupation of the mother as well as family type, number of family members, ownership of the house and monthly income of the family. All analyses were performed using STATA statistical software version 16 (StataCorp, College Station, TX).

Results

Characteristics of the sample

Out of the 800 women enrolled in the main study, 760 gave live births. The sample for this analysis consisted of those who had BISQ data at both 6 and 12 months: a total of 735 infants.

The mean age of the mothers was 27.4 years at the time of enrollment and the majority had schooling up to grade 10 (77.5%). Most of the mothers were from the Newar ethnic group (77%) and resided in their own house (74%). The mean birth weight of the infants was 3019 g and 9% were born with low birth weight. Exclusive breastfeeding up to 6 months was practiced by 11% of the mothers (Table 1).

Sleep characteristics

Almost all of the children at 6 months (97%) and 12 months (98%) were reported to sleep in the same bed as their parents, more than half in a lateral position (62%). Most of the infants fell asleep while breastfeeding both at 6 and 12 months of age (83% and 88%).

The mean (SD) of sleep duration during the night was 9.4 (1.2) hours at both 6 and 12 months of age. The mean (SD) SOL was 15.4 (11.4) minutes at 6 months and 16.5 (12.2) minutes at 12 months, while 7% of infants had a SOL less than 5 minutes. The mean (SD)

Table 1
Characteristics of 735 infants and their families from Bhaktapur, Nepal

Perinatal and demographic	N (%) ^a
Male child	380 (51.8)
Cesarean section delivery	347 (47.2)
Birth weight in gram (mean/SD)	3019 (442)
Preterm birth (< 37 wk of gestation)	63 (8.6)
Low birth weight (< 2500 g)	68 (9.3)
Initiation of breastfeeding within 1 h	331 (45%)
Maternal age, mean (SD)	27.4 (3.9)
Occupation of mother	
No paid work/agriculture	262 (35.6)
Daily wage earner	96 (13.1)
Services/self-employed	377 (51.3)
Mother's education	
≤Grade 10	570 (77.5)
> Grade 10	124 (22.5)
Ethnic group	
Newar	568 (77.3)
Brahmin/Chhetri	73 (10)
Tamang/Rai/Lama	66 (9)
Nuclear family	189 (34)
Residing in rented house	191 (26)
Sleeping and kitchen in the same room	198 (27)
Main source of kitchen fuel use	
Firewood/residual crops	36 (5)
Liquid propane gas	691 (94)

^a Values are n%, unless otherwise mentioned.

Table 2

Sleep characteristics among 735 infants at 6 and 12 months of age in Bhaktapur, Nepal

	6 mo n (%)	12 mo n (%)
Sleeping arrangement		
In parent's bed	711 (97)	722 (98)
Position of child sleep		
On belly	30 (4)	82 (11)
On side	458 (62)	456 (62)
On back	247 (34)	197 (27)
How the child falls asleep		
While feeding	608 (83)	649 (88)
Being rocked	77 (11)	36 (5)
Being held	38 (5)	26 (4)
In bed alone	7 (0.9)	13 (2)
In bed near parent	5 (0.6)	11 (1)
Parental perception about child sleep problem		
Not a problem at all	719 (97.8)	725 (98.6)
Sleep duration and categories		
Nocturnal sleep duration in hours ^a	9.4 (1.2)	9.4 (1.1)
Daytime sleep duration in hours ^a	2.9 (1.5)	2.3 (1.2)
Total (day+night) sleep duration in hours ^a	12.3 (1.9)	11.7 (1.6)
< 10 h of total sleep	54 (7.4)	71 (9.7)
10–10.9 h of total sleep	79 (10.8)	106 (14.4)
11–11.9 h of total sleep	121 (16.6)	164 (22.3)
12–12.9 h of total sleep	173 (23.5)	176 (23.9)
≥13 h of total sleep	308 (41.7)	218 (29.7)
Wake after sleep onset		
Wake after sleep onset, min ^a	6.9 (16.5)	6.2 (16.4)
< 5 min	522 (71)	517 (70)
≥5 min	213 (29)	218 (30)
Sleep onset latency		
Sleep onset latency, min ^a	15.4 (11.4)	16.5 (12.2)
≤10 min	359 (49)	330 (45)
> 10 min	376 (51)	405 (55)
Frequency of night awakening		
0 times	33 (4.5)	26 (3.5)
1–2 times	223 (30.3)	235 (32.0)
≥3 times	479 (65.2)	474 (64.5)
Sleep before 8 PM in the evening	309 (42)	238 (32)

^a Values are mean (SD).

WASO was 6.9 minutes (16.5) at 6 months and 6.2 minutes (16.4) at 12 months.

A majority of the infants were awake three or more times per night at 6 months (65.2%) and 12 months (64.5%). Infants who were reported to be awake ≥3 times at 6 months had increased odds of frequent nightly awakenings at 12 months of age (OR = 2.2; 95% CI: 1.6, 2.9).

Very few mothers perceived that their infant had sleep problems (2.2% at 6 months; 1.4% at 12 months) (Table 2).

Sleep duration patterns from 6 to 12 months of age

Overall, 254 (35%) infants at 6 months and 341 (46%) infants at 12 months slept < 12 hours. The proportion of infants sleeping < 10 hours was 7.4% at 6 months and 9.7% at 12 months. There was a reduction in the proportion of infants sleeping ≥13 hours from 41.7% at 6 months to 29.7% at 12 months of age (Table 2). There was a mean (SD) daytime sleep duration of 2.9 hours (1.5) at 6 months and 2.3 hours (1.2) at 12 months (Fig. 1).

The patterns of sleep duration in infants from 6 to 12 months of age are shown in Figs. 2 and 3. Odds ratios from the adjusted logistic regression analysis of sleep duration categories are shown in Table 3. For instance, infants sleeping less than 10 hours at 6 months had an increased odds of sleeping less than 10 hours: OR = 2.4 (95% CI: 1.4, 3.8), and increased odds for sleeping less than 12 hours: OR = 3.7 (95% CI: 2.9, 5.9) at 12 months.

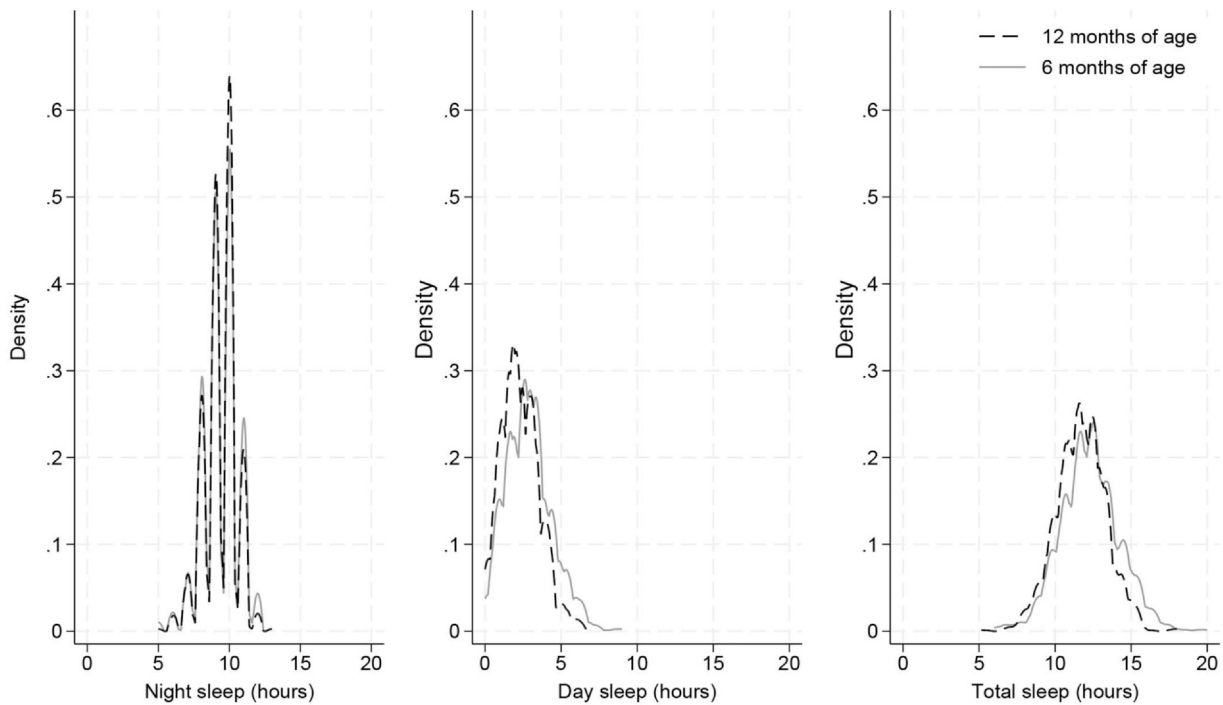


Fig. 1. Distribution of sleep duration at night, during the day, and as total at 6 and 12 months of age. The sleep duration for day and night were added up to obtain the total sleep for the 24 hours

Discussion

In the present community-based longitudinal study in Bhaktapur, Nepal, we have described sleep characteristics such as nocturnal awakening, sleep duration, and sleep practices in infants at 6 and 12 months of age. Total sleep duration < 12 hours were found for 35% at 6 months and 46% at 12 months. Frequent nocturnal awakening was also found in both age groups. Still, very few mothers reported that their infants had sleep problems. There was a stability of

nocturnal awakening and infants with short sleep duration at 6 months had an increased odds of shorter sleep duration at 12 months in a graded pattern.

The reported total sleep duration in our study was shorter in comparison to previous studies in infants.^{14,21} The mean total sleep duration of 12.3 hours at 6 months and 11.7 hours at 12 months were also somewhat lower than the estimated mean sleep duration in infancy (12.8 hours) in a systematic review that aimed at providing global norms.²⁸ However, the sleep duration in the present

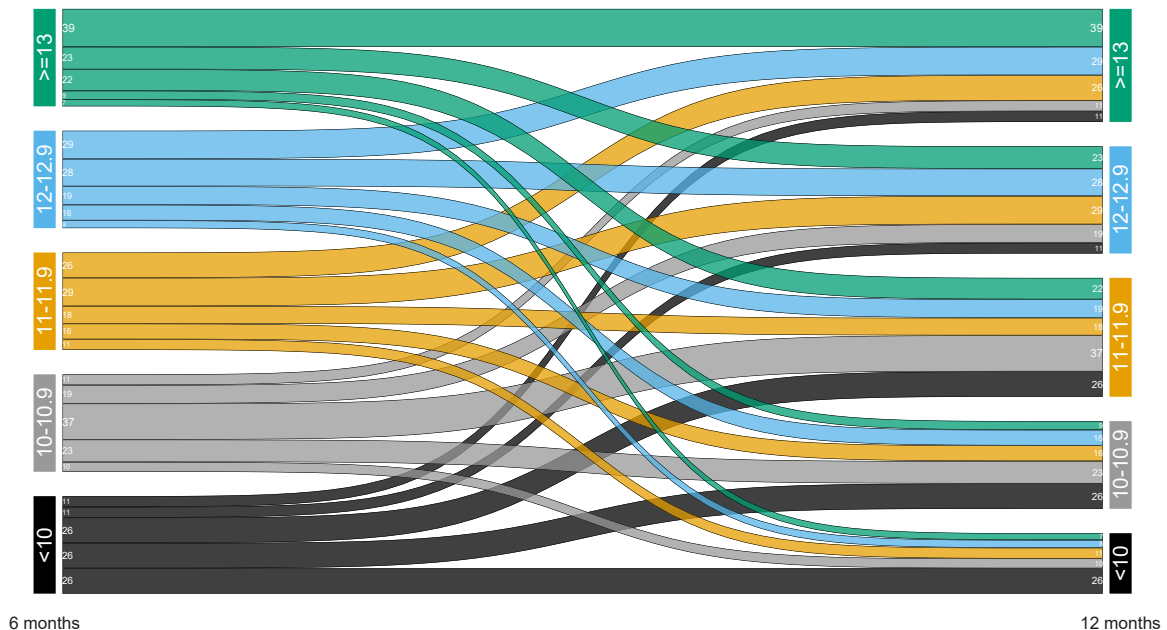


Fig. 2. Changes in the children's total sleep duration from 6 to 12 months ranging from < 10 to ≥13 hours categories. The diagrams were constructed using Sankey plot. The x-axis represents distribution of total sleep hours at 6 and 12 months of age and the y-axis in different colors represents total sleep hours categories. All the values in the y-axis represent percentages of total sleep categories. For example, in the > 13 hours sleep category at 6 months of age, 39% had similar hours of sleep at 12 months of age but 23% changed to 12-12.9 hours, 22% to 11-11.9 hours, 9% to 10-10.9 hours and 7% to < 10 hours at 12 months of age

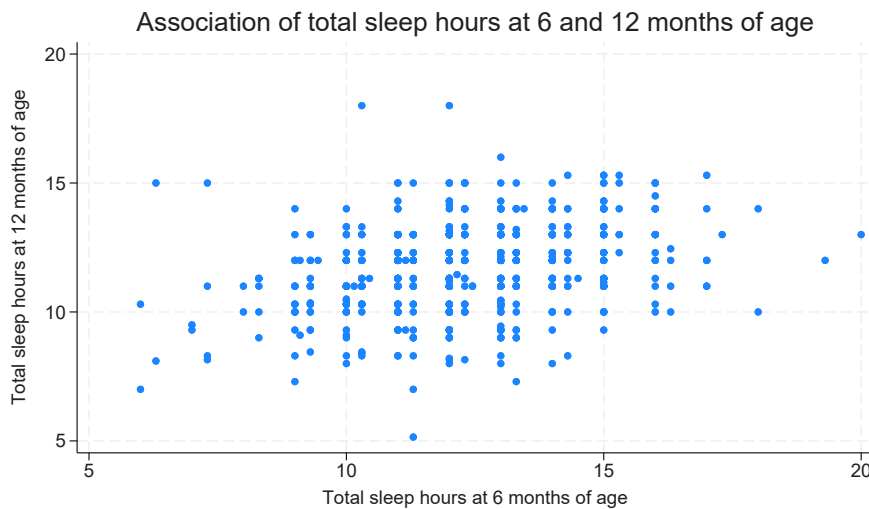


Fig. 3. Scatter plot of total sleep at 6 and 12 months of age. The x-axis is the total sleep hours at 6 months of age and y-axis is the total sleep hours at 12 months of age

study is in line with observed sleep duration in Asian countries in general as outlined in the same systematic review.²⁸

The relative stability of sleep duration and nightly awakenings was high and showed a graded pattern. Infants that had a total sleep duration < 10 hours at 6 months, had a more than twofold increased odds of sleeping less than 10 hours 6 months later, and a more than threefold increased odds of sleeping less than 12 hours 6 months later, which is in line with a previous study conducted in Western countries observing a high stability for sleep duration and nightly awakenings.^{15,16}

A majority of the mothers reported that their infants were awake more than three times per night. This is higher than in previous studies.^{26,29} The short duration of wake time could be due to breastfeeding practices.^{30,31} The practice of bed-sharing is predominant in Asian countries, and parental involvement in child sleep is also more common. This is also seen in the current study, where almost all infants bed-shared with their parents. Parents cosleeping with infants is a culturally acceptable practice in this community, and when the children are older, they often cosleep with their sibling. This practice may lead to brief awakenings due to movements from others in the bed.³² The need for nighttime diaper change may also give rise to frequent awakenings since reusable cloth diapers are commonly used at home in this population.

Previous studies have shown a consolidation of sleep and a reduction in nightly awakenings during the first year of life.^{28,33} This contrasts with findings in our study, where the stability of the mean numbers of nightly awakenings and the proportion with more WASO during the first year of life was quite stable.

Short sleep duration in infants is more common in Asian countries which could suggest cultural variation in sleeping habits.¹⁰ Short sleep duration has been shown to be a risk factor for poor growth and cognitive development,^{2,34} whether or not these associations are

similar in other cultural and socioeconomic contexts needs to be examined in the current context.^{35–38}

In the current study, most infants fell asleep while breastfeeding, which is in accordance with another study in Nepalese infants.²⁰ Being rocked was the second most common strategy to get the infant to sleep at 6 months of age and was practiced for 11% of the infants. Parental sleep strategies are known to be closely associated with infant sleep.³⁹ Parental behavior characterized by high parental involvement to help the child fall asleep is associated with nightly awakenings, which could contribute to the relatively high rate of nocturnal awakenings in the present study.⁴⁰ The practice of swaddling of infants has been suggested to be related to an increase in quiet sleep and a reduction in the number of sleep state changes in a narrative synthesis of the literature.¹² This could be of relevance for the present study since traditional clothes for infants are commonly used in Nepal. Babies are often wrapped in a thick blanket to protect against the cold and could also be related to the quality of sleep in the infant. However, we did not directly assess the role of these traditional clothes for sleep quality in the current study, which is a limitation to the study.

The present study is set in a low-resource setting characterized by various risk factors known to impact infant sleep such as low levels of parental education as exemplified by the many mothers without higher education. A social gradient of infant sleep has been shown previously.⁴¹ Health literacy has been associated with the level of education and may be a mechanism to account for the reported sleep and perception of sleep problems. Further, poverty-related factors may impact sleep in infants.⁴² For example, many of the families have restricted living conditions such as combined kitchen and sleeping facilities and thus both noise and indoor air pollution might impact sleep in these infants.⁴³ Late-night activities in the home, may keep the children awake, and some have TVs in the same room as the infant sleeps which may also impact the sleep

Table 3

Associations between sleep duration and night awakenings at 6 months and at 12 months among infants in Bhaktapur, Nepal^a

Sleep duration at 6 mo	Adjusted odds ratio total sleep duration < 10 h at 12 mo ^b	(95% CI)	Adjusted odds ratio total sleep duration < 12 h ^b	(95% CI)
Total sleep ≤10 h (n = 99)	2.4	(1.4, 3.8)	3.7	(2.9, 5.9)
Total sleep 11–12 h (n = 252)	1.3	(0.88, 1.9)	0.91	(0.67, 1.2)
Total sleep ≥13 h (n = 308)	0.52	(0.34, 0.79)	0.55	(0.41, 0.75)
Night awakening at 6 mo ≥3 times	Crude odds ratio		Adjusted odds ratio ^b	
No (n = 256)	Ref			
Yes (n = 479)	2.2	(1.6, 3.1)	2.2	(1.6, 2.9)

^a Based on logistic regression analyses.

^b Adjusted for mother age, education and occupation, family type, number of family members, ownership of house, and monthly income.

onset latency and nocturnal awakenings. In addition, it is not common to follow strict bedtime for children and parents let children sleep whenever parents feel their child is sleepy or tired.

Stunted growth and micronutrient deficiencies are widespread among young children in the current area.⁴⁴ For instance, around 50% of the current study infants had hemoglobin concentration corresponding to anemia at both 6 and 12 months.²² Iron deficiency has previously been shown to be related to sleep quality in children^{37,38} and could also partly explain the findings in the current study. Identifying risk factors for poor sleep was out of the scope of the current study and should be addressed in future research.

Very few mothers reported sleep problems in their infant. This could reflect that the sleep pattern and awakenings are as expected for infants in this setting, and not perceived as problems with possible negative consequences for the infant and their families. It is of interest that parental perceptions of sleep problems were much higher in a study on infant sleep across countries in South-Asia, ranging from 10%–45%.¹⁰ We cannot exclude the possibility that the mothers did not report problems in the interview setting, but given that the women had been in the study over time and had previously shared information in this setting we do not believe that this is a likely explanation.

Strengths and limitations

To our knowledge, this is the first large population-based study in Nepalese infants that describes sleep patterns at 6 and 12 months of age. Our study is also unique in terms of the community-based recruitment strategy and that the assessments were done during scheduled follow-up visits. Our results were based on mother's response, which may be prone to overestimations compared to actigraphy-measured sleep patterns.^{21,31} The use of more objective sleep parameters such as actigraphy or polysomnography could have given us more detailed information and day-to-day variations of sleep patterns.^{45,46} Our study mother-infant dyads participated in a randomized controlled trial where daily 50 µg of vitamin B₁₂ or placebo were given to the mother within 15 weeks of gestation till 6 months after delivery.²² Whether this supplementation had an impact on infant sleep is not known. However, our previous study in the same community among children six–23 months of age did not find any effect of vitamin B₁₂ supplementation on actigraphy-measured sleep pattern.⁴⁷ We do not have information regarding parental sleep patterns, emotional distress, and sleep-related cognition which have previously been found to influence sleep problems in children.^{25,48–50} Further, the present study assessed sleep characteristics and patterns, and it was beyond the scope of the present study to address risk factors for poor sleep as well as health outcomes of poor sleep, which needs further investigation.

Conclusion

In this Nepalese setting, bed-sharing was almost universal, and few mothers reported sleep problems in their infants. The reported total sleep duration in our study was shorter in comparison to previous studies in infants worldwide, but in line with previous Asian studies. There was also a higher rate of nocturnal awakening than commonly found at this age. There was increased risk of similar sleep patterns 6 months later for both sleep duration and nocturnal awakenings.

Ethical approval

Ethical approval was obtained from the Nepal Health Research Council in Nepal (NHRC, NHRC; 253/2016) and from the Regional Committee for Medical and Health Research Ethics in Norway (REK vest; reference number 2016/1620). We have taken written informed consent from all the participants to participate in this study.

Author contributions

RKC, SR, and MH conceptualized and designed the study, supervised the data collection, and performed the statistical analyses, interpretation of results and drafting of the initial manuscript. IK, JS, MS, MU, and CS coordinated the data collection, reviewed, and revised the manuscript, and approved the final manuscript.

Funding

This study has been funded by the Research Council of Norway (project number 223269), the GC Rieber Foundation, and the University of Bergen (UiB), Norway, to the Centre for Intervention Science in Maternal and Child Health (CISMAC).

Declaration of conflicts of interest

The authors declare that there are no conflicts of interest regarding commercial or any financial issues.

Acknowledgments

We would like to thank all the participants for their active participation and contribution to their valuable time. We would also like to thank Prof Tor A. Strand at Innlandet Hospital Trust, Lillehammer, Norway for securing funding for the study and all coordination for the completion of the study. Prof Laxman Shrestha and all the staff at Child Health Research Project, Department of Child Health and Siddhi Memorial Hospital who involved in the study for data collection, supervision, data entry and logistics management and support.

References

- Smithson L, Baird T, Tamana SK, et al. Shorter sleep duration is associated with reduced cognitive development at two years of age. *Sleep Med.* 2018;48:131–139. <https://doi.org/10.1016/j.sleep.2018.04.005>
- Sivertsen B, Harvey AG, Reichborn-Kjennerud T, Torgersen L, Ystrom E, Hysing M. Later emotional and behavioral problems associated with sleep problems in toddlers: a longitudinal study. *JAMA Pediatr.* 2015;169(6):575–582. <https://doi.org/10.1001/jamapediatrics.2015.0187>
- Hysing M, Sivertsen B, Garthus-Niegel S, Eberhard-Gran M. Pediatric sleep problems and social-emotional problems. A population-based study. *Infant Behav Dev.* 2016;42:111–118. <https://doi.org/10.1016/j.infbeh.2015.12.005>
- Matricciani L, Paquet C, Galland B, Short M, Olds T. Children's sleep and health: a meta-review. *Sleep Med Rev.* 2019;46:136–150. <https://doi.org/10.1016/j.smrv.2019.04.011>
- Yetish G, Samson D. Sleep research in non-Western populations reveals novel insights about the breadth and diversity of human sleep patterns. *Sleep Health.* 2018;4(6):495–496. <https://doi.org/10.1016/j.sleh.2018.10.006>
- Ball HL, Tomori C, McKenna JJ. Toward an integrated anthropology of infant sleep. *Am Anthropol.* 2019;121(3):595–612. <https://doi.org/10.1111/aman.13284>
- Paavonen EJ, Saarenpaa-Heikkila O, Morales-Munoz I, et al. Normal sleep development in infants: findings from two large birth cohorts. *Sleep Med.* 2020;69:145–154. <https://doi.org/10.1016/j.sleep.2020.01.009>
- Mindell JA, Sadeh A, Wiegand B, How TH, Goh DY. Cross-cultural differences in infant and toddler sleep. *Sleep Med.* 2010;11(3):274–280. <https://doi.org/10.1016/j.sleep.2009.04.012>
- Daban KDY, Goh DYT. Comparison of sleep characteristics, patterns, and problems in young children within the Southeast Asian region. *Behav Sleep Med.* 2019;17(3):281–290. <https://doi.org/10.1080/15402002.2017.1342168>
- Jeon M, Dimitriou D, Halstead EJ. A systematic review on cross-cultural comparative studies of sleep in young populations: the roles of cultural factors. *Int J Environ Res Public Health.* 2021;18(4) <https://doi.org/10.3390/ijerph18042005>
- Feld H, Ceballos Osorio J, Bahamonde M, Young T, Boada P, Rayens MK. Poverty and paternal education associated with infant safe sleep intentions in a peri-urban community in Ecuador. 2333794×211044112 *Glob Pediatr Health.* 2021;8. <https://doi.org/10.1177/2333794×211044112>
- Dixley A, Ball HL. The effect of swaddling on infant sleep and arousal: a systematic review and narrative synthesis. *Front Pediatr.* 2022;10:1000180. <https://doi.org/10.3389/fped.2022.1000180>
- Lim DC, Najafi A, Affi L, et al. The need to promote sleep health in public health agendas across the globe. *Lancet Public Health.* 2023;8(10):e820–e826. [https://doi.org/10.1016/S2468-2667\(23\)00182-2](https://doi.org/10.1016/S2468-2667(23)00182-2)
- Iglowstein I, Jenni OG, Molinari L, Largo RH. Sleep duration from infancy to adolescence: reference values and generational trends. *Pediatrics.* 2003;111(2):302–307. <https://doi.org/10.1542/peds.111.2.302>

15. Hysing M, Harvey AG, Torgersen L, Ystrom E, Reichborn-Kjennerud T, Sivertsen B. Trajectories and predictors of nocturnal awakenings and sleep duration in infants. *J Dev Behav Pediatr.* 2014;35(5):309–316. <https://doi.org/10.1097/DBP.000000000000064>
16. Sette S, Baumgartner E, Ferri R, Bruni O. Predictors of sleep disturbances in the first year of life: a longitudinal study. *Sleep Med.* 2017;36:78–85. <https://doi.org/10.1016/j.sleep.2017.04.015>
17. Teti DM, Ball HL, Tikotzky L. “Sleep and the family system” – a preface. *Sleep Health.* 2022;8(1):28–30. <https://doi.org/10.1016/j.sleh.2021.12.004>
18. Barry ES. What is “normal” infant sleep? Why we still do not know. *Psychol Rep.* 2021;124(2):651–692. <https://doi.org/10.1177/0033294120909447>
19. Dhakal AK, Shrestha D, Shah SC, Shakya H, Shakya A, Sadeh A. A Nepali Translation of Brief Infant Sleep Questionnaire (BISQ) for assessment of sleep in infants and toddlers: a preliminary report. *J Kathmandu Med Coll.* 2015;3(3):102–106. <https://doi.org/10.3126/jkmc.v3i3.12245>
20. Pandey S, Bhattarai S, Bhatta A. Sleep pattern and problems in young children visiting outpatient department of a tertiary level hospital in Kathmandu, Nepal. *Sleep Disord.* 2020;2020:8846288. <https://doi.org/10.1155/2020/8846288>
21. Quante M, Hong B, von Ash T, et al. Associations between parent-reported and objectively measured sleep duration and timing in infants at age 6 months. *Sleep.* 2021;44(4). <https://doi.org/10.1093/sleep/zsaa217>
22. Chandyo RK, Kvestad I, Ulak M, et al. The effect of vitamin B12 supplementation during pregnancy on infant growth and development in Nepal: a community-based, double-blind, randomised, placebo-controlled trial. *Lancet.* 2023;1508–1517. [https://doi.org/10.1016/S0140-6736\(23\)00346-X](https://doi.org/10.1016/S0140-6736(23)00346-X)
23. CBS. National Population Census. Central Bureau of Statistics (CBS). Government of Nepal. National Planning Commission. Preliminary report; 2021.
24. Sadeh A. A brief screening questionnaire for infant sleep problems: validation and findings for an Internet sample. *Pediatrics.* 2004;113(6):e570–e577. <https://doi.org/10.1542/peds.113.6.e570>
25. Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's updated sleep duration recommendations: final report. *Sleep Health.* 2015;1(4):233–243. <https://doi.org/10.1016/j.sleh.2015.10.004>
26. Makela TE, Peltola MJ, Nieminen P, et al. Night awakening in infancy: developmental stability and longitudinal associations with psychomotor development. *Dev Psychol.* 2018;54(7):1208–1218. <https://doi.org/10.1037/dev0000503>
27. Otto E, Culaikova E, Meng S, et al. Overview of Sankey flow diagrams: focusing on symptom trajectories in older adults with advanced cancer. *J Geriatr Oncol.* 2022;13(5):742–746. <https://doi.org/10.1016/j.jgo.2021.12.017>
28. Galland BC, Taylor BJ, Elder DE, Herbison P. Normal sleep patterns in infants and children: a systematic review of observational studies. *Sleep Med Rev.* 2012;16(3):213–222. <https://doi.org/10.1016/j.smrv.2011.06.001>
29. Bruni O, Baumgartner E, Sette S, et al. Longitudinal study of sleep behavior in normal infants during the first year of life. *J Clin Sleep Med.* 2014;10(10):1119–1127. <https://doi.org/10.5664/jcsm.4114>
30. McKenna JJ, Gettler LT. There is no such thing as infant sleep, there is no such thing as breastfeeding, there is only breastsleeping. *Acta Paediatr.* 2016;105(1):17–21. <https://doi.org/10.1111/apa.13161>
31. Rudzik AEF, Ball HL. Biologically normal sleep in the mother-infant dyad. *Am J Hum Biol.* 2021;33(5):e23589. <https://doi.org/10.1002/ajhb.23589>
32. Crittenden AN, Samson DR, Herlosky KN, Mabulla IA, Mabulla AZP, McKenna JJ. Infant co-sleeping patterns and maternal sleep quality among Hadza hunter-gatherers. *Sleep Health.* 2018;4(6):527–534. <https://doi.org/10.1016/j.sleh.2018.10.005>
33. Barry ES. Sleep consolidation, sleep problems, and co-sleeping: rethinking normal infant sleep as species-typical. *J Genet Psychol.* 2021;182(4):183–204. <https://doi.org/10.1080/00221325.2021.1905599>
34. Zhang Z, Sousa-Sa E, Pereira JR, Okely AD, Feng X, Santos R. Correlates of sleep duration in early childhood: a systematic review. *Behav Sleep Med.* 2021;19(3):407–425. <https://doi.org/10.1080/15402002.2020.1772264>
35. Hysing M, Reichborn-Kjennerud T, Markestad T, Elgen I, Sivertsen B. Sleep duration and nocturnal awakenings in infants born with gestational risk. *J Dev Behav Pediatr.* 2019;40(3):192–199. <https://doi.org/10.1097/DBP.0000000000000642>
36. Stangenes KM, Fevang SK, Grundt J, et al. Children born extremely preterm had different sleeping habits at 11 years of age and more childhood sleep problems than term-born children. *Acta Paediatr.* 2017;106(12):1966–1972. <https://doi.org/10.1111/apa.13991>
37. Peirano P, Algarin C, Chamorro R, Manconi M, Lozoff B, Ferri R. Iron deficiency anemia in infancy exerts long-term effects on the tibialis anterior motor activity during sleep in childhood. *Sleep Med.* 2012;13(8):1006–1012. <https://doi.org/10.1016/j.sleep.2012.05.011>
38. Kordas K, Siegel EH, Olney DK, et al. Maternal reports of sleep in 6–18 month-old infants from Nepal and Zanzibar: association with iron deficiency anemia and stunting. *Early Hum Dev.* 2008;84(6):389–398. <https://doi.org/10.1016/j.earlhumdev.2007.10.007>
39. Adams EL, Master L, Buxton OM, Savage JS. Sleep parenting practices are associated with infant self-soothing behaviors when measured using actigraphy. *Sleep Med.* 2022;95:29–36. <https://doi.org/10.1016/j.sleep.2022.04.018>
40. Ragni B, De Stasio S. Parental involvement in children's sleep care and nocturnal awakenings in infants and toddlers. *Int J Environ Res Public Health.* 2020;17(16). <https://doi.org/10.3390/ijerph17165808>
41. Newton AT, Honaker SM, Reid GJ. Risk and protective factors and processes for behavioral sleep problems among preschool and early school-aged children: a systematic review. *Sleep Med Rev.* 2020;52:101303. <https://doi.org/10.1016/j.smrv.2020.101303>
42. Etindele Sosso FA, Holmes SD, Weinstein AA. Influence of socioeconomic status on objective sleep measurement: a systematic review and meta-analysis of actigraphy studies. *Sleep Health.* 2021;7(4):417–428. <https://doi.org/10.1016/j.sleh.2021.05.005>
43. Cai J, Shen Y, Zhao Y, et al. Early-life exposure to PM(2.5) and sleep disturbances in preschoolers from 551 cities of China. *Am J Respir Crit Care Med.* 2023;207(5):602–612. <https://doi.org/10.1164/rccm.202204-07400C>
44. Morseth MS, Henjum S, Schwinger C, et al. Environmental enteropathy, micronutrient adequacy, and length velocity in Nepalese children: the MAL-ED Birth Cohort Study. *J Pediatr Gastroenterol Nutr.* 2018;67(2):242–249. <https://doi.org/10.1097/MPG.0000000000001990>
45. Strazisar BG. Sleep measurement in children—are we on the right track? *Sleep Med Clin.* 2021;16(4):649–660. <https://doi.org/10.1016/j.jsmc.2021.08.004>
46. Tikotzky L, Volkovich E. Infant nocturnal wakefulness: a longitudinal study comparing three sleep assessment methods. *Sleep.* 2019;42(1). <https://doi.org/10.1093/sleep/zsy191>
47. Hysing M, Strand TA, Chandyo RK, et al. The effect of vitamin B12-supplementation on actigraphy measured sleep pattern; a randomized control trial. *Clin Nutr.* 2022;41(2):307–312. <https://doi.org/10.1016/j.clnu.2021.11.040>
48. Tikotzky L, Volkovich E, Meiri G. Maternal emotional distress and infant sleep: a longitudinal study from pregnancy through 18 months. *Dev Psychol.* 2021;57(7):1111–1123. <https://doi.org/10.1037/dev0001081>
49. Vertsberger D, Tikotzky L, Baruchi O, Knafo-Noam A. Parents' perceptions of infants' nighttime sleep patterns predict mothers' negativity: a longitudinal study. *J Dev Behav Pediatr.* 2021;42(4):307–313. <https://doi.org/10.1097/DBP.0000000000000899>
50. Knappe S, Pfarr AL, Petzoldt J, Hartling S, Martini J. Parental cognitions about sleep problems in infants: a systematic review. *Front Psychiatry.* 2020;11:554221. <https://doi.org/10.3389/fpsy.2020.554221>