

Prevalence of Sleep Problems in Infancy and Developmental Outcomes From 6 to 24 Months

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Abstract

Background: The study objectives were to assess the prevalence of sleep problems in infants observed at 6, 12 and 24 months, to investigate the relationship between infants' sleep problems and development from 6 to 24 months, and to determine to what extent sleep problems at 6 months were related to changes in the developmental course from 12 to 24 months.

Methods: Infant sleep problems were measured by use of a parent-reported sleep questionnaire. The Ages & Stages Questionnaires (ASQ-II/ASQ:SE) were used to measure developmental skills in the areas of communication, motor, problem-solving, personal-social and social-emotional development in a large longitudinal study with a population-based sample of 1,555 infants. The sample was recruited from nine well-baby clinics in five municipalities in South-Eastern Norway. At 6, 12 and 24 months, ASQ domain scores were compared between infants with and without sleep problems by using two-sample t-tests. The relationship between infant sleep problems at 6 months and changes in ASQ/ASQ:SE scores from 12 to 24 months was investigated using linear mixed effects models.

Results: The prevalence of infant sleep problems during the infants' two first years of life decreased over time, with 14.6% at 6 months, 7.4% at 12 months, and 3.3% at 24 months. There was no clear evidence of differences in ASQ or ASQ:SE scores by sleep problems from 6 to 24 months, but the results suggested a slightly larger increase in communication and problem-solving ASQ scores for infants who had sleep problems at 6 months.

Conclusion: Our findings indicate prevalence rates of parent-reported sleep problems between 3 and 14% in infants aged from 6 to 24 months, with the highest prevalence in the youngest age group. There was no clear evidence of early sleep disturbance and later development problems, but our results show evidence of a relationship between sleep problems at 6 months and positive changes in communication and problem-solving scores from 12 to 24 months.

1.0 Introduction

Sleep is essential for infant growth, well-being, and particularly for cognitive functioning, as well as emotional and behaviour regulation (Chaput et al., 2016; Krause et al., 2017). Healthy sleep is generally defined by adequate duration, appropriate timing and the absence of sleep disturbance (Gruber et al., 2014). There is no definite consensus as to what constitutes sufficient sleep duration at different ages (Chaput et al., 2016), but the National Sleep Foundation recommends that for every 24-hour cycle, infants between 4 and 11 months should sleep between 12 and 15 hours, with the normal range being 10–18 hours (Hirshkowitz et al., 2015). Studies indicate that 10–35% of parents report that their children have sleep problems such as short sleep duration, prolonged sleep onset, or frequent night-awaking (Byars, Yolton, Rausch, Lanphear, & Beebe, 2012; Galland et al., 2017; Hanafin, 2018; Hysing et al., 2014). Such sleep problems in young children not only affect the individual children themselves, but also have a profound effect on family functioning and parents' well-being (Dennis & Ross, 2005; Martin, Hiscock,

Hardy, Davey, & Wake, 2007), and often result in increased use of multiple health services (McCallum et al., 2011; Morris, James-Roberts, Sleep, & Gillham, 2001; Vandenplas, Hauser, & Salvatore, 2019).

Sleep–wake regulation and sleep states evolve rapidly during the first year of life, with continued maturation throughout childhood (McLaughlin Crabtree & Williams, 2009). In the first months of an infant’s life, the circadian rhythm is not yet established and sleep is normally characterised by short, fragmented periods of sleep with several awakenings (Davis, Parker, & Montgomery, 2004), due to the infant’s feeding needs. The circadian rhythm begins to emerge at around 10–12 weeks of age, marked by declines in night-time wakefulness over the first 6 months of life, but also a decrease in the total sleep duration from 16–17 hours in the newborn period (0–3 months) to 13–14 hours by 6 months of age (Bruni et al., 2014; Hirshkowitz et al., 2015). However, sleep patterns vary between individuals, and are explained by a complex interplay between genetic, environmental and social factors, including family routines, parenting practices and expectations (McLaughlin Crabtree & Williams, 2009). For most children, sleep problems are transient and likely to resolve naturally (Wolke, Bilgin, & Samara, 2017), but studies also suggest that sleep problems in infancy are related to later negative development, emotional and behavioural problems (Chaput et al., 2017; Hemmi, Wolke, & Schneider, 2011; Hysing, Sivertsen, Garthus-Niegel, & Eberhard-Gran, 2016; Mindell, Leichman, DuMond, & Sadeh, 2017; Seegers et al., 2016; Sivertsen et al., 2015; Smithson et al., 2018). The causal explanation for these associations are that sleep affects neurodevelopmental changes related to brain maturation, learning and memory consolidation (Born & Wilhelm, 2012) and that sleep may impact the brain circuits that underlie executive functions and higher-order systems involved in cognition (Bernier, Carlson, Bordeleau, & Carrier, 2010)

A recent systematic review of the relationship between sleep duration and health indicators in the early years (0–4 years) found that a lack of age-adequate sleep is prospectively associated with mental health problems such as anxiety, depression and poor emotional regulation. The evidence related to cognitive and motor development, however, was not clear (Chaput et al., 2017). Two large Norwegian birth cohort studies found an association between sleep problems in young children and social-emotional problems (Hysing et al., 2016; Sivertsen et al., 2015). Hysing and colleagues (2016) showed that less total sleep, prolonged sleep onset, and frequent night waking among 2,014 two-year-old children corresponded to greater risk of having concurrent social-emotional problems in toddlerhood. Similarly, Sivertsen and colleagues (2015) found that sleep problems among 18-month-old children ($n = 32,662$) were predictive of having emotional regulation difficulties both concurrently and at 5 years of age. There is a lack of studies reporting on sleep problems among infants below one year. A small longitudinal study of 117 infants and toddlers (ages 6 to 18 months) in the United States reported limited relationships between sleep consolidation and social-emotional and cognitive development (Mindell et al., 2017), and no significant relationships between any sleep variables and developmental outcomes (ages 3 to 13 months) on ASQ communication, fine and gross motor skills, problem-solving and personal-social skills (Mindell & Lee, 2015).

There is still a need for longitudinal studies to identify the long term outcome of children’s behavioral sleep problems in the first years of life. Thus, the aims of the present study were to (1) assess the

prevalence of parent-reported sleep problems in a cohort of infants when they were 6, 12 and 24 months, (2) investigate the concurrent relationships between infants' behavioral sleep problems and motor, communication, problem-solving, personal-social and social-emotional skills at 6, 12 and 24 months, and (3) to determine to what extent sleep problems at 6 months were related to changes in the developmental course from 12 to 24 months.

2.0 Methods

2.1. Participants

The present study used data from a Norwegian population-based longitudinal study of infants' early development from birth to two years of age (Valla, Wentzel-larsen, Hofoss, & Slinning, 2015). Participants were recruited from nine well-baby clinics in five municipalities in South-Eastern Norway serving both urban and rural areas. Well-baby clinics are regularly attended by more than 95% of Norwegian parents and their children from birth to school age. The recruitment took place between May 2011 and May 2012. All families who were expecting a baby or who had recently given birth were invited to participate in the study by a midwife or a public health nurse at their first consultation, either during pregnancy or at the first home visit soon after birth. In total, 1,555 (88.6%) mothers and their children consented to participate. The number of participants at each time point varied to some extent mainly due to differences in the scheduled consultations at each well-baby clinic. Of the responding families ($n = 1,555$), 86.1% completed the ASQ at 6 months, 60.1% at 12 months, and 48.7% at 24 months. The study had no specific criteria for exclusion because the well-baby clinics offer services to all families with children below 5 years of age who live in the municipality.

2.2. Procedure

The public health nurse or midwife at each of the nine well-baby clinics provided oral and written information about the study to the women/couples based on procedures approved by the Norwegian Regional Committee for Medical Health Research Ethics (2011/124/REK Sør Øst B). Written informed consent was received from the parents who volunteered to participate in the study. On enrolment or at the first check-up after birth, background information on the parents and infant, such as maternal educational level, ethnicity and the child's gender and gestational age, was recorded. Age-specific ASQ and ASQ:SE forms were mailed to the participants' home address two weeks before each well-baby visit. For infants born prematurely, the corrected age was used when completing the ASQ (Squires, Potter, & Bricker, 1999). The mothers brought the completed ASQ and ASQ:SE forms to the scheduled appointments, and the information obtained from the questionnaire formed part of the overall clinical assessment that took place during the consultation. Two two questions about the infant's sleep were completed by the mothers at 6 weeks, 4 months and 6 months postpartum in the well-baby clinics, and the responses were integrated in the conversation between the public health nurse and the parents during the consultation. The public health nurses that participated in this study received lectures about early developmental psychology and infant sleep states and sleep cycles before study start. They were

encouraged to advise parents to observe their infant during daytime sleep to learn the difference between deep and light sleep states to avoid mis-interpreting light sleep as an early sign of awakening which often lead to a parental response such as starting to talk to or lifting the infant up from bed. All participants, infants and mothers with scores indicating severe sleep- or developmental problems were offered further in-depth evaluations or support within two weeks, and were referred to specialist care in the most severe cases.

2.3 Measures

The Ages and Stages Questionnaire (ASQ-II)

Motor, communication, problem-solving and personal-social skills were assessed through parent ratings from the Norwegian version of the Ages and Stages Questionnaire, 2nd edition (ASQ-II; (Janson & Smith, 2003; Squires et al., 1999). The ASQ is a 30-item, parent-reported screening instrument that assesses five developmental areas (communication, gross motor, fine motor, problem-solving and personal-social). Each area consists of six age-specific items for use among children aged 4 to 60 months (Squires et al., 1999). Parents were asked to observe their child performing a number of specific skills and to rate whether the skill was observed often (rated 10 points), sometimes (5 points) or not yet (zero points), resulting in total domain scores ranging from 0 to 60. A Norwegian construct validity study found that the ASQ is an effective diagnostic tool for identifying developmental delays

(Richter & Janson, 2007). In the Norwegian reference sample the overall Cronbach's alpha values ranged from .75 to .88 (Janson & Smith, 2003). In the present study, the overall ASQ reliability range from .76 to .85 from 4 to 24 months.

Ages and Stages Questionnaire: Social-Emotional (ASQ:SE).

The ASQ:SE is a brief parent-reported instrument designed to assist in identifying developmental delays in children aged 6 to 60 months (Squires, Bricke, & Twombly, 2002). Different forms are used depending on the child's age, and the number of scored items range from 19 (6 months) to 33 (48 and 60 months). There are three response options (rarely or never, sometimes, most of the time) for each item, which are scored 0, 5 and 10 with a possible additional 5 points if the specific behaviour worries the informant. A total difficulty score is calculated by adding the points from all the items and the items related to expressed concerns. The ASQ:SE has been proven to be a valid and reliable tool (Squires et al., 2002).

Sleep

Nocturnal awakenings and daytime sleep were assessed on the basis of two questions: "*How does your child usually sleep during the night?*" and "*How does your child usually sleep during the day?*". Both questions employed a five-point scale from very bad (score 5) to very good (score 1). Sleep problems were defined as score 4 or 5, either day or night, or both day and night.

2.4 Statistical analysis

The prevalence of sleep problems was computed at each time point. At 6, 12 and 24 months, ASQ and ASQ:SE scores were compared for infants with and without a defined sleep problem at 6 months using two-sample Welch t-tests. The relationships between sleep problems at 6 months with ASQ scores and the ASQ:SE scores at 12 and 24 months were investigated by using linear mixed effects models. The interaction between time and sleep problems was included to investigate possible relationships between sleep problems at 6 months and changes in ASQ scores from 12 to 24 months.

3.0 Results

The background characteristics of the participating children and their mothers are presented in Table 1. The sample consisted of 52.1% boys. A large proportion of the participating mothers had higher levels of education and were of Scandinavian ethnicity.

Table 1. Characteristics of the study population (n=1555)

Children

Male % (n = 1,324)	52.1
Gestational age, mean (SD) (n = 1,278)	39.5 (1.8)
Gestational age < 37 weeks % (n = 1,278)	5.7 3,535 (562)
Birth weight, mean grams (SD) (n = 1,323)	
Birth weight < 2,500 grams % (n=1,323)	3.9
Apgar score < 7 after 5 minutes, % (n=1,323)	3.3
Mothers	
Maternal age, mean (SD) (n=1,324)	30.1 (4.9)
Education (n=1,295)	
Completed lower secondary school % (n = 120)	9.3
Completed upper secondary school % (n = 363)	28.0
College/university 1-3 years % (n = 579)	44.7
College /university ≥ 4 years % (n = 233)	18.0
Scandinavian ethnicity % (n = 1,320) (n= 1,320)	87.3

The results showed that the prevalence of infants' sleep problems was 14.6% (152 of 1,042) during the day and/or night at 6 months. Of these, 7.4% had difficulty sleeping during the day and 12.0% during the night. At 12 months, 7.4% (37 of 501) of the infants had sleep problems during the day and/or night, 2.6% during the day and 7.0% during the night. At 24 months, 3.3% (5 of 151) had difficulty sleeping during the day and/or night, 1.3% during the day and 3.3 during the night.

Table 2 shows concurrent differences in ASQ and ASQ:SE scores by sleep problems at 6, 12 and 24 months. There was generally no clear evidence of differences in ASQ and ASQ:SE scores by sleep problems at any of these measurement points. However, the ASQ mean scores were consistently lower for children with sleep problems at 6 and 12 months and slightly higher at 24 months, but these differences were not significant.

Table 2
Differences in ASQ and ASQ:SE scores by sleep problems at 6, 12 and 24 months.

Time	ASQ/ASQ:SE	Sleep Problems	No sleep problems	Difference	Confidence Interval	p-value
6 months, N = 134 with sleep problems and 801 without	Communication	50.45	50.46	0.01	-1.39 to 1.40	0.991
	Gross motor	40.34	41.25	0.92	-1.05 to 2.89	0.358
	Fine motor	50.00	51.48	1.48	-0.24 to 3.20	0.091
	Problem solving	54.96	55.09	0.12	-1.09 to 1.34	0.839
	Pers/social	49.29	50.10	0.81	-0.95 to 2.57	0.365
12 months, N = 20 with sleep problems and 302 without	Social-emotional	74.46	75.50	1.04	-0.49 to 2.57	0.183
	Communication	41.00	44.49	3.49	-2.97 to 9.94	0.274
	Gross motor	42.00	46.32	4.32	-3.33 to 11.98	0.253
	Fine motor	53.25	55.07	1.82	-1.32 to 4.95	0.241
	Problem solving	48.25	51.16	2.91	-3.21 to 9.03	0.334
Pers/social	45.75	48.38	2.63	-1.80 to 7.05	0.231	
Social-emotional	78.46	78.14	-0.33	-4.88 to 4.23	0.884	

Number of valid observations: 6 months, n = 152 with sleep problems, n = 890 without. At 12 months, n = 37 with sleep problems, n = 501 without and at 24 months n = 5 with sleep problems, n = 151 without. Both questions employed a five-point scale from very bad (score 5) to very good (score 1). Sleep problems were defined as score 4 or 5, either day or night, or both day and night.

Welch t-tests used throughout (not assuming equal standard deviations).

* Only one child with sleep problems in this comparison, no test performed.

Time	ASQ/ASQ:SE	Sleep Problems	No sleep problems	Difference	Confidence Interval	p-value
24 months, N = 3 with sleep problems and 91 without	Communication	58.33	56.32	-2.01	-7.87 to 3.84	0.355
	Gross motor	56.67	58.35	1.68	-12.41 to 15.78	0.664
	Fine motor	56.67	55.71	-0.95	-14.74 to 12.83	0.803
	Problem solving	51.67	52.91	-1.25	-24.00 to 26.49	0.856
	Pers/social	56.67	53.96	-2.71	-16.19 to 10.77	0.504
	Social-emotional*	80.00	106.44	26.44		
Number of valid observations: 6 months, n = 152 with sleep problems, n = 890 without. At 12 months, n = 37 with sleep problems, n = 501 without and at 24 months n = 5 with sleep problems, n = 151 without. Both questions employed a five-point scale from very bad (score 5) to very good (score 1). Sleep problems were defined as score 4 or 5, either day or night, or both day and night.						
Welch t-tests used throughout (not assuming equal standard deviations).						
* Only one child with sleep problems in this comparison, no test performed.						

The mixed effects models showed some evidence of a relationship between sleep problems at 6 months and changes in ASQ communication scores from 12 to 24 months (p -value for interaction 0.024), weaker evidence (p -value for interaction 0.053) for ASQ problem solving, and no evidence for the other domains (p -values for interactions ≥ 0.136).

4.0 Discussion

This large population-based study suggests that between 3 and 14% of infants between 6 and 24 months had parent-reported sleep problems, with the highest rate at 6 months and the lowest at 24 months. The results indicated a pattern of lower mean ASQ and ASQ:SE scores at 6 and 12 months for infants with parent-reported sleep problems, but, in general, these differences did not reach statistical significance at any time point. However, the results suggest a relationship between sleep problems at 6 months and positive changes in communication and problem-solving ASQ scores over time.

Our findings suggest that the prevalence of parent-reported infant sleep problems in the present study is lower than that found in previous studies of the same age group (Byars et al., 2012; Hanafin, 2018; Hysing et al., 2014; Wake et al., 2006; Williamson, Mindell, Hiscock, & Quach, 2019). However, drawing

comparisons between studies is challenging for many reasons. Children's sleep duration is found to vary between countries and regions due to cultural factors (Hense et al., 2011), and a number of methodological issues make it difficult to compare prevalence rates because of variations in the definition of sleep problems, the type of sleep measures used and the age of the participants when sleep was measured. In our study, two single items based on parent reporting were used to measure sleep problems during daytime and night time at 6, 12 and 24 months.

In their Norwegian Mother and Child cohort study, Hysing and colleagues (2014) found that at 18 months, 26.6% of infants (n = 55,831) had night time awakenings based on the recommended hours of sleep per day (24 hours), whereas only 9.4% of these infants' mothers endorsed a question indicating that their infant had a sleep problem. In our study, even fewer infants at 12 and 24 months had sleep problems during the night according to their mothers.

The results from the current study show a consistent pattern of slightly lower ASQ and ASQ:SE scores at 6 and 12 months, although not significantly lower, for infants with sleep problems. Consistent with our results, no significant relationships were found between infants' sleep and concurrent ASQ scores on communication, motor, problem-solving and personal-social development in a Brazilian sample of infants between 3 and 13 months (Mindell & Lee, 2015). However, our results show evidence of a relationship between sleep problems at 6 months and positive changes in communication and problem-solving scores from 12 to 24 months. For infants with sleep problems at 6 months, communication and problem-solving scores were lower than for those without sleep problems at 12 months but increased somewhat faster and were slightly higher (although not significantly higher) for infants without sleep problems at 24 months.

There are several potential mechanisms that may explain the finding of a relationship between sleep problems at 6 months and a slightly greater increase in communication and problem-solving scores over time. Sleep affects neurodevelopmental changes related to brain maturation, learning and memory consolidation (Born & Wilhelm, 2012), which are required in early language learning. Sleep may also impact the brain circuits that underlie executive functions and higher-order systems involved in cognition. Therefore, as sleep-wake cycles mature, children's abilities in terms of abstract reasoning, attention regulation and problem-solving will also increase (Bernier, Carlson, Bordeleau, & Carrier, 2010). Although the maturation process concerning executive functions and other complex cognitive functions continues into early adulthood, this might be part of the explanation. Other suggested mechanisms between sleep and development include overlapping genetic features and shared family and parenting factors (Touchette et al., 2013). For example, the child's environment may have an organising effect on both sleep-wake cycles and development. Mothers affected by their infants' unconsolidated and fragmented sleep may provide less optimal stimulation or overall inadequate parental practices that may negatively affect both sleep and development in infants. In the opposite sense, when the infant's sleep problems decrease, better sleep for the infant as well as for the parents may provide more stimulation and adequate parental practices, which in turn can contribute to a catch-up in development (Touchette et al., 2013). Since this study took place in the context of regular well-baby check-ups during the infants' first

two years, it can be assumed that parents who reported infant sleep difficulties most likely received advice and support that may have contributed to promoting healthy infant sleep patterns and thus a more healthy development in general. Furthermore, systematic sleep assessment in the early months may have contributed to increased attention on topics relating to infant sleep and thereby a higher awareness among parents of the importance of promoting healthy sleep behaviour. This could also explain the lower prevalence rates of infant sleep problems in the current study.

Our findings extend the outcomes to a younger age group and underscore the importance of assessing infant sleep at an early age. Support should be provided to families throughout infancy and early childhood, including advice and information about sleep states, sleep cycles and the development of sleep behaviour. Public health nurses have a key role to play in supporting families with infants and children who experience sleep problems, because they are directly involved with the families through child health programmes that are free and universally available. Information about sleep behaviour for parents can be beneficial in preventing further problems. Hence, efforts should be made in practice to protect and preserve infants' sleep as much as possible.

The results from the present study must be interpreted by considering several methodological limitations. Firstly, an unintended intervention effect may have occurred by introducing systematic questioning and conversations about the infant's sleep at day-and night time at several of the consultations at the well-baby clinics during the first year. (Repeated conversations about infant sleep with the PHN likely provided the parents with increased knowledge on the topic as well as concrete information that may have strengthened their ability to improve their infant's sleep quality and thus have facilitated corrections of negative sleep trends).

Secondly, we did not use a validated or objective measures of sleep, thus the subjective nature of the sleep question used in the present study may have affected the results. For example, night awakening or delayed sleep onset might be considered problematic by some parents but not others. Other variables that could have influenced the association, such as maternal depression or parenting practices, were left unexplored. However, most studies typically show that parental reports of a global sleep problem are usually confirmed by objective measures (Allik, Larsson, & Smedje, 2006), and the sleep questions used in the current study are similar to those used by many physicians and public health nurses during routine clinic visits (Meltzer, Johnson, Crosette, Ramos, & Mindell, 2010). Hence, the findings may still be of clinical relevance.

5.0 Conclusions

This large representative regional-based study suggests a prevalence rate of parent-reported sleep problems of between 3 and 14% in infants aged from 6 to 24 months, with the highest prevalence in the youngest age group. Mean ASQ global scores were consistently lower for children with sleep problems at 6 and 12 months. For infants with sleep problems at 6 months, communication and problem-solving

scores were lower than for infants without sleep problems at 12 months, but increased somewhat faster and were slightly higher for those without sleep problems at 24 months.

Abbreviations:

ASQ - Ages and Stages Questionnaire

ASQ:SE - Ages and Stages Questionnaire: Social-Emotional

Declarations

Ethics approval and consent to participate: Not applicable

Written informed consent was obtained from all KVIK participants upon recruitment. Written informed consent was also obtained from a parent or guardian for participants under 16 years old.

The study was approved by the Regional Committee for Medical Research Ethics in South-Eastern Norway

Consent for publication: Not applicable

Availability of data and materials: The data that support the findings of this study are available from Regional Centre for Child and Adolescent Mental Health, Eastern and Southern

Norway (RBUP), Oslo, Norway, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are

however available from the author upon reasonable request and with permission of the Regional Centre for Child and Adolescent Mental Health, Eastern and Southern Norway

(RBUP)

Accordance: All methods were performed in accordance with the relevant guidelines and regulations

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions:

LV: Responsibility for the study design, analysis and interpretation, and in the writing of the manuscript

TWL: Was involved in and supervised the statistical analysis.

KS: Primary responsibility for the study design, Participated in the analytic framework of the study, with the data interpretation, and in the writing of the manuscript

All the authors have given their final approval of the final version of the manuscript.

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Figures

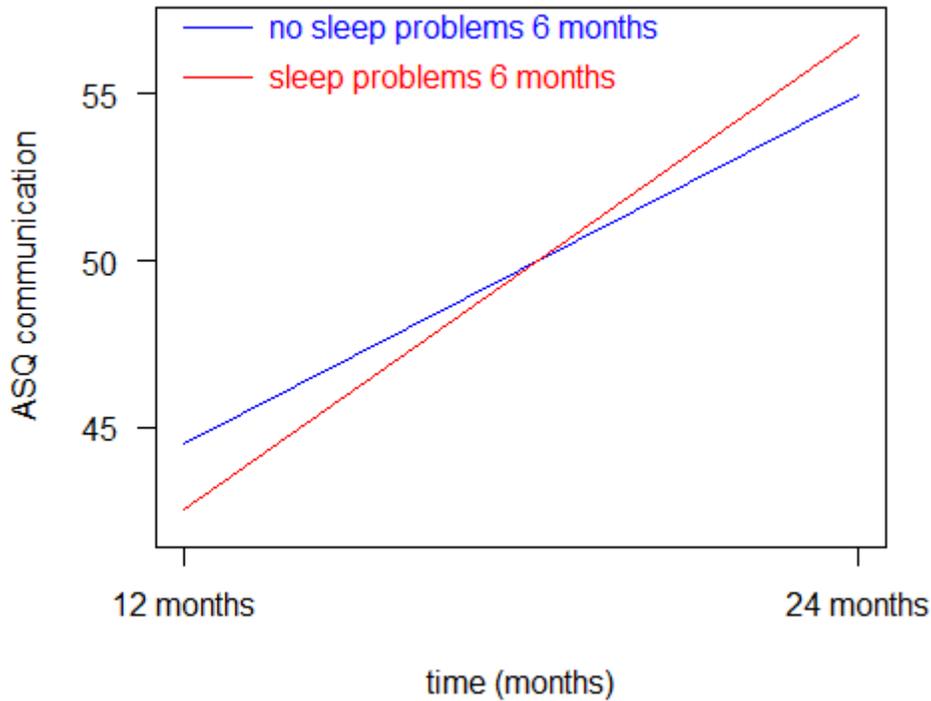


Figure 1

Interaction diagram for ASQ communication score at 12 and 24 months by sleep problems at 6 months.

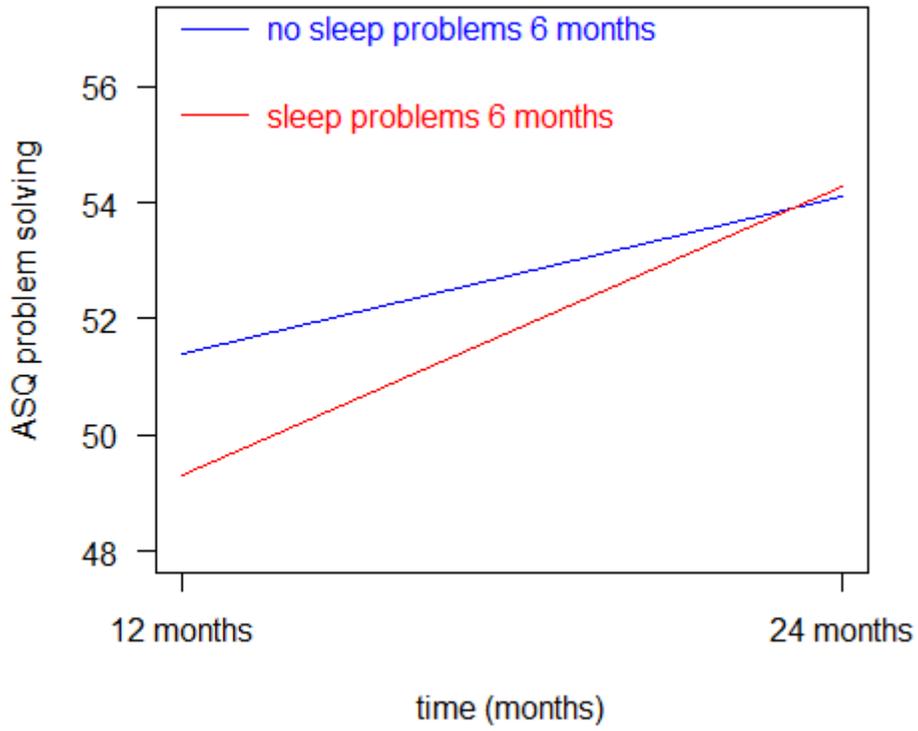


Figure 2

Interaction diagram for ASQ problem-solving score at 12 and 24 months by sleep problems at 6 months