

Sleep and sleep ecology in the first 3 years: a web-based study

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SUMMARY This study was designed to provide data on sleep patterns during the first 3 years, based on a large US–Canada Internet sample, to assess the prevalence of parental interventions and related factors of infant sleep ecology and to evaluate the links between sleep ecology and sleep. Five thousand six parents completed a web-based online questionnaire about their children, aged from birth to 36 months. The questionnaire included items pertaining to sleep patterns, sleep environment, sleep-related parental interventions, sleep position, and demographic information. The results reflected clear sleep-related developmental changes including a decrease in daytime sleep and total sleep time, as well as consolidation of sleep during the night, which was manifested in a decrease in night wakings and nocturnal wakefulness. Sleep ecology and parental behaviors significantly explained a portion of the variance in the child's sleep patterns. Parental interventions that encourage independence and self-soothing were associated with extended and more consolidated sleep, especially in comparison to more active interactions that were associated with shorter and more fragmented sleep. These findings provide parents and professionals reference data for assessing sleep in young children. Furthermore, the results provide information on specific ecological factors that are associated with increased risk for sleep problems.

KEYWORDS infants, internet, parents, sleep, survey, toddlers

Sleep patterns evolve rapidly during the first years of life (Acebo *et al.*, 2005; Armstrong *et al.*, 1994; Coons and Guilleminault, 1984). During these years of rapid change, sleep problems are a source of major concern to parents and professionals (Johnson, 1991; Mindell, 1993; Sadeh and Anders, 1993; Thunstrom, 1999). It has been estimated that between 20 and 30% of children experience sleep problems during the first 3 years of life (Armstrong *et al.*, 1994; Johnson, 1991; Ottaviano *et al.*, 1996; Petit *et al.*, 2007; Sadeh, 2004; Thunstrom, 1999; Wake *et al.*, 2006). These problems appear to be persistent (Kataria *et al.*, 1987; Lam *et al.*, 2003; Wake *et al.*, 2006; Zuckerman *et al.*, 1987), and are associated with daytime behavior problems (Kataria *et al.*, 1987; Lam *et al.*, 2003; Thunstrom, 1999; Zuckerman *et al.*, 1987) and

parental distress (Lam *et al.*, 2003; Thunstrom, 1999; Wake *et al.*, 2006; Zuckerman *et al.*, 1987).

The most common sleep complaints during early childhood are those related to excessive night wakings and difficulties with sleep initiation. Research into the correlates of infant sleep problems has repeatedly demonstrated that excessive parental involvement and lack of infant's self-soothing skills are closely linked to night wakings and difficulty falling asleep (Adair *et al.*, 1991; Anders *et al.*, 1992; Sadeh, 2004). Furthermore, prevention and intervention strategies for non-medical sleep disorders in early childhood have mainly focused on changing and adapting infant sleep ecology to encourage consolidated sleep during the night (Kuhn and Elliott, 2003; Mindell, 1999; Mindell *et al.*, 2006; Ramchandani *et al.*, 2000; Sadeh, 2005; Wolfson, 1998). Positive results have been achieved with behavioral interventions based on educating parents on how to change their expectations and the sleep environment they provide to their child (Mindell *et al.*, 2006;

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Morgenthaler *et al.*, 2006). The common factor underlying these interventions is the withdrawal of parents from intense and excessive behavioral involvement during sleep initiation and night wakings, thus eliminating the rewarding power of these parental responses and facilitating the child's self-soothing skills (Sadeh, 2005). Specific recommendations presented in prevention and intervention programs include encouraging the child to fall asleep in his or her own crib (or bed) alone or with passive presence and limiting interventions such as feeding and other forms of physical contact, as well as out-of-crib time, when the child wakes up at night (Kuhn and Elliott, 2003; Kuhn and Weidinger, 2000; Mindell, 1999; Mindell *et al.*, 2006; Sadeh, 2005; Wolfson, 1998; Wolfson *et al.*, 1992). As many behaviors and factors have been implicated in the etiology of sleep problems there is a real need to examine a broad spectrum of factors in a large-scale study to determine the unique contribution of these factors.

In recent years, the growing availability of the Internet has led to the development of telemedicine and to expanding Internet-based professional tools aimed at online assessment and intervention programs for various medical and behavioral problems (Andersson *et al.*, 2005; Bussey-Smith and Rossen, 2007; Christensen *et al.*, 2004; Cook *et al.*, 2000; Evers *et al.*, 2003; McDaniel and Stratton, 2006; Saperstein *et al.*, 2007; Strom *et al.*, 2004; Wantland *et al.*, 2004). These studies have shown that the Internet can be effectively used for assessment and treatment of health-related problems. In a previous study, an online infant sleep questionnaire was validated and the derived data found to be comparable to previous studies (Sadeh, 2004). In this study, we have used an expanded version of this online questionnaire to obtain data from a large cohort across the US and Canada and to provide a broad picture of sleep-wake patterns during the first 3 years in these countries.

Because of the rapid maturational changes occurring in sleep-wake patterns during the first years of life, a large sample is required to represent each age group. The aims of this study were (i) to provide a dataset on sleep patterns during the first 3 years in a large US-Canada sample; (ii) to assess the prevalence of various parental interventions and related factors of infant sleep ecology; and (iii) to evaluate the links between sleep ecology and sleep.

METHOD

Participants

Parents of 5006 infants and toddlers (48.12% girls) completed an online survey. Four thousand five hundred and five (4505) US and 501 Canadian participants were included.

Children's ages ranged from 0 to 36 months. The cohort included 718 0 to 2-month-old infants, 725 3 to 5-month olds, 712 6 to 8-month olds, 715 9 to 11-month olds, 720 12 to 17-month olds, 716 18 to 23-month olds, and 700 24 to 36-month-old toddlers. The majority of the respondents were mothers (97.20%), with only 2.08% fathers, and the remaining 0.72%

grandparents and others. Additional demographic characteristics are described in the Results section.

Measures

The expanded version of the Brief Infant Sleep Questionnaire

The online questionnaire used in this study is an expanded version of the Brief Infant Sleep Questionnaire (BISQ) (Sadeh, 2004). The BISQ has been validated against actigraphy and daily-logs and its sensitivity in documenting expected developmental changes in infant sleep and the effects of environmental factors has been established (Sadeh, 2004). The BISQ includes specific questions about infant daytime and nighttime sleep patterns, and sleep-related behaviors. Sleeping arrangements, bedtime rituals, and other parental interventions were also assessed in the expanded version of the BISQ. The respondents were asked to describe their child's behavior during the last 2 weeks. The online version used pull-down menus with optional responses for each presented question. Skipping items on the questionnaire was not allowed, but some sensitive questions included the option: 'Prefer not to answer.' Therefore, all included respondents fully completed the questionnaire.

Procedure

All data were collected via BabyCenter.com, a popular parenting website (4.5 million unique visitors per month). The online expanded version of the BISQ (Sadeh, 2004) was set as a pop-up screen and invited parents to complete a sleep survey for children aged 3 years old or younger. All questions had to be completed before the next screen was presented. Completion of the questionnaire was voluntary and parents were not offered any compensation or feedback for their participation. Average individual completion time was 6.21 min (SD = 28.9 s). The complete sample was collected during May and June 2006.

In addition to the BISQ, demographic information was collected, including parental age, education, race, employment status, and child's birth order (see Appendix). In addition, US zip code information was used to derive geographic location (latitude and longitude) and median household income through the US census data. For quality control, 106 replies with inappropriate or extreme data (e.g., sleep onset before bedtime, total sleep time < 4 h or total sleep time > 22) were excluded, resulting in a final sample of 5006 children. Because of the large cohort size and the multiple analyses, findings were considered significant if $P < 0.001$.

RESULTS

Demographic characteristics

Zip codes provided by the US participants enabled description of the representation across the US. The distribution of the US

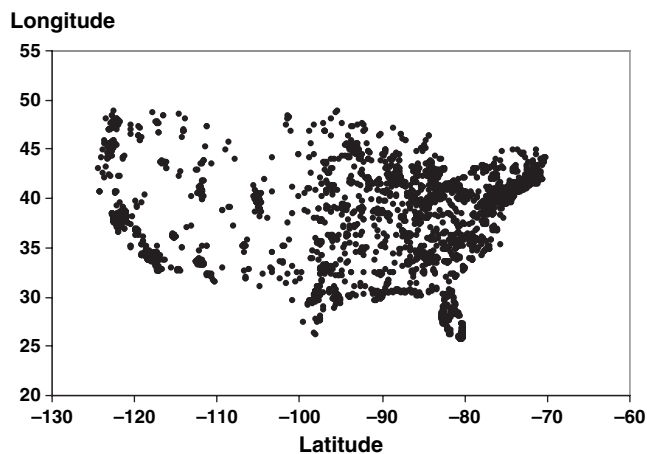


Figure 1. Distribution of respondents across the US.

Table 1 Demographic characteristics of the cohort		
Race	White/Caucasian	79.64
	African-Americans	4.89
	Hispanic	6.55
	Asian	2.94
	Native Americans	0.54
	Other/not specified	5.44
Respondent's education	Postgraduate degree	18.78
	College education or a college degree	68.10
	High school degree	11.67
	Less than high school degree	1.45
Respondent's employment	Full time	40.11
	Part-time	11.84
	Homemaker or at-home parent	43.07
	Student status, unemployment, or other	4.97
Respondent's age range	35–39 years	17.38
	25–34 years	61.13
	21–24 years	12.98
	<21 or >39	8.51
Child's birth order	Only child	56.35
	Youngest child	28.05
	Oldest child	12.36
	Middle or a multiple child	3.24

Values are in percentages.

responders covers the entire US and is highly similar to US population density maps (see Fig. 1).

Additional demographic characteristics are described in Table 1. In comparison to the US Census 2000 report, our cohort is characterized by higher education and higher representation of White-Caucasians.

Infant sleep: descriptive data and developmental changes

Data analysis was based on ANOVA with age group and gender as the independent variables. Duncan *post-hoc* analyses were

used to test for specific age group differences. The analyses were performed on the following sleep measures: (i) total sleep time (hours), (ii) daytime sleep (between 8:00 and 19:00 hours, in hours), (iii) nighttime sleep (between 19:00 and 8:00 hours, in hours), (iv) night–day sleep ratio (the percentage of nighttime sleep from total sleep time), (v) average number of night wakings, (vi) longest period of consolidated sleep, and (vii) duration of nocturnal wakefulness.

Data on these measures are presented in Fig. 2 and Table 2. There were no significant gender-related effects. Total sleep time decreased significantly across development ($F = 98$, $P < 0.0001$). *Post-hoc* Duncan analysis revealed that only the age groups between 6 and 17 months are not significantly different from each other. All the other, younger and older, age groups are significantly different from each other and from the groups in the age range between 6 and 17 months. The main decrease in sleep time occurs in daytime sleep ($F = 694$, $P < 0.0001$), with all age groups significantly different from each other. Significant increases also occurred in nighttime sleep ($F = 130$, $P < 0.0001$). The youngest age groups between 0 and 5 months were significantly different from each other and from the older age groups. Nighttime sleep of the age groups between 12 and 23 months was significantly higher than in all other age groups. Significant increases occurred in night to day sleep ratio ($F = 714$, $P < 0.0001$), with all age groups significantly different from each other.

The assessment of sleep consolidation was based on three measures: the average number of nocturnal night wakings, the average duration of nocturnal wakefulness, and the average duration of the longest continuous sleep episode at night. In addition, we analyzed the number of daytime naps. The results are summarized in Table 2.

No significant gender-related effects were found. Significant age differences were found on all four measures. The average number of night wakings, the duration of nocturnal wakefulness, and the number of daytime naps decrease with age and the longest sleep episode extends.

Sleep ecology: setting and parental behaviors

We analyzed a broad spectrum of common parental sleep-related behaviors and infants' sleep ecology. The age-dependent frequencies of parental sleep-related behaviors are presented in Table 3 and the distributions of four major sleep-related factors are presented in Fig. 3.

Significant age-related changes occur in the sleep setting as far as parental interventions are involved, both in the sleep initiation process and in response to nocturnal awakenings. The percentage of parents reporting bottle feeding, nursing, rocking, and holding the infant during sleep initiation sharply decrease with age; whereas, the percentage of infants falling asleep in their crib alone increases. When resuming sleep following night waking is addressed, significant age-related changes are also evident. Interventions such as holding, rocking, giving a bottle, and nursing show a sharp decrease with age. Interventions like letting cry to fall asleep and verbal

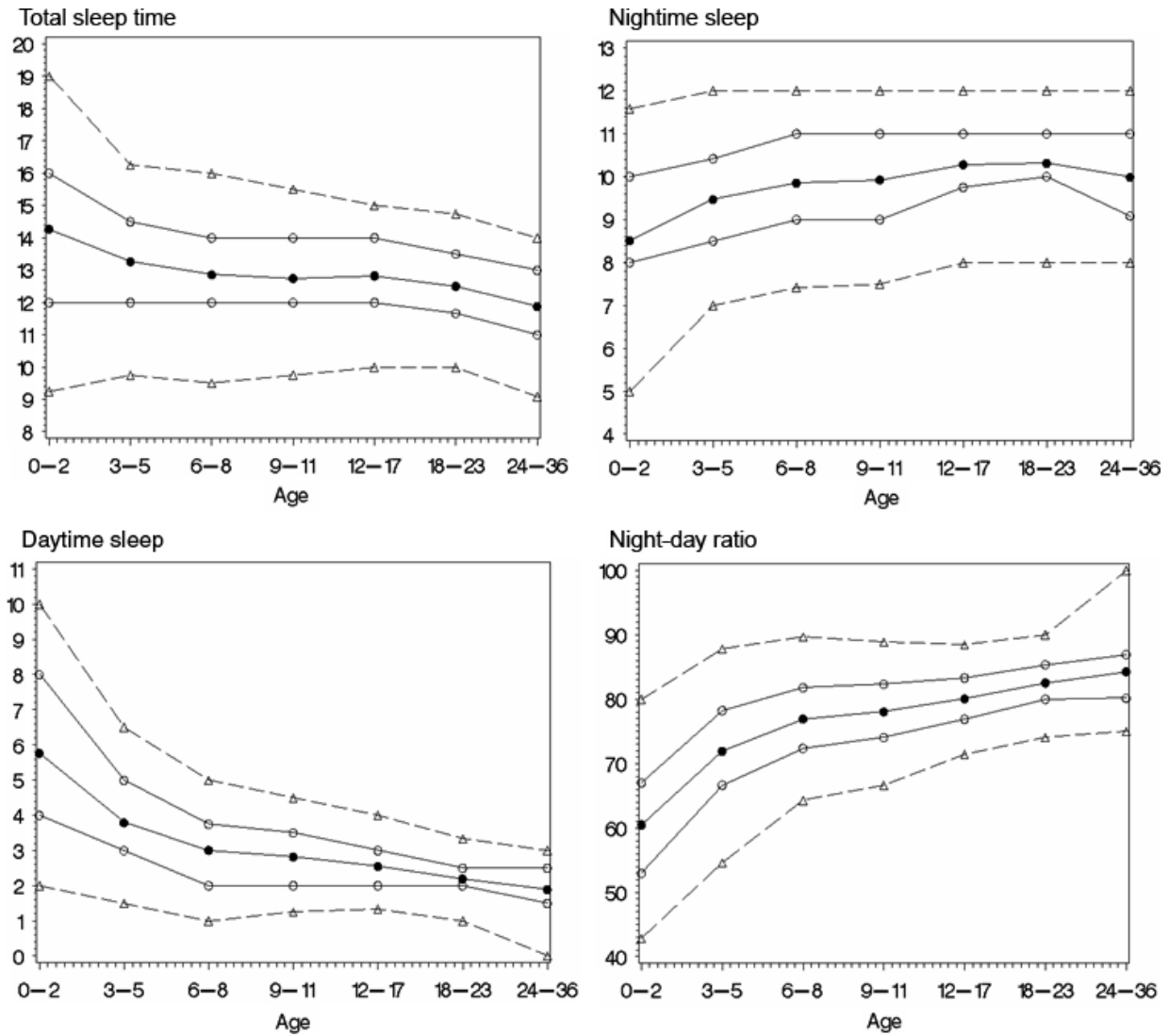


Figure 2. Sleep according to age groups: filled circles represent group means, blank circles represent 25th and 75th percentiles, and triangles represent 5th and 95th percentiles.

Table 2 Sleep measures across age groups

	Age group (months)								F
	0-2	3-5	6-8	9-11	12-17	18-23	24-36		
Total sleep time (h)	14.3 ± 3.00	13.3 ± 2.04	12.9 ± 1.90	12.8 ± 1.74	12.8 ± 1.59	12.5 ± 1.47	11.9 ± 1.54		98*
Nighttime sleep (h)	8.50 ± 1.83	9.47 ± 1.55	9.86 ± 1.44	9.92 ± 1.45	10.3 ± 1.39	10.3 ± 1.26	10.0 ± 1.30		130*
Daytime sleep (h)	5.75 ± 2.28	3.79 ± 1.61	3.01 ± 1.20	2.82 ± 1.04	2.54 ± 78	2.19 ± 67	1.89 ± 95		693*
Night wakings (N)	1.89 ± 1.09	1.24 ± 1.19	1.25 ± 1.20	1.16 ± 1.17	0.93 ± 1.18	0.82 ± 93	0.82 ± 92		81*
Longest sleep episode (h)	4.99 ± 1.84	7.06 ± 2.44	7.67 ± 2.59	8.03 ± 2.81	0.8.73 ± 2.78	9.01 ± 2.67	9.03 ± 2.40		232*
Nocturnal wakefulness (h)	1.16 ± 98	0.52 ± 73	0.36 ± 48	0.31 ± 47	0.22 ± 37	0.18 ± 38	0.19 ± 42		253*
Naps (N)	3.59 ± 1.18	2.93 ± 83	2.42 ± 75	2.02 ± 52	1.53 ± 55	1.11 ± 34	0.92 ± 37		1373*

Black lines under the means related to age groups that are not significantly different from each other in Duncan *post-hoc* analysis. On nighttime sleep the 24-36 month age group was not significantly different from the groups between the ages 6-11 months. Values are represented as mean ± SD.

*P < 0.0001.

Table 3 Percentages of children in each age group using specific method

	Age group (months)							χ^2
	0–2 n = 718	3–5 n = 725	6–8 n = 712	9–11 n = 715	12–17 n = 720	18–23 n = 716	24–36 n = 700	
Sleep initiation method								
Bottle Feeding	29.25	24.97	30.06	26.01	12.78	7.26	2.57	350**
Nursing	50.28	36.14	27.81	21.82	9.03	5.73	2.00	780**
Rocking	50.42	39.72	30.62	27.13	17.78	9.92	3.57	611**
Holding	71.73	49.24	36.38	32.45	20.97	12.01	6.57	990*
Watching TV	2.79	4.69	3.79	3.92	3.89	6.42	11.43	73**
In crib alone in the room	18.94	36.97	48.17	52.73	59.44	64.39	62.86	459**
In parents' bed alone	2.65	2.34	2.25	1.68	1.25	1.26	3.00	9.9
In crib with parental presence	21.31	13.79	9.55	8.81	8.89	11.59	17.00	85**
In parents' bed with parent	17.13	13.24	13.90	12.17	13.89	14.94	15.00	8.7
In another room of the house	11.56	7.86	5.62	4.48	5.14	4.19	4.14	55**
Resuming sleep								
Holding or rocking to sleep	39.97	25.79	28.09	30.77	25.14	18.30	10.86	190**
Picking up – returning awake	11.00	8.41	12.50	14.69	22.92	21.37	22.43	113**
Rub or pat in crib	16.57	26.07	33.85	32.03	32.36	30.59	31.86	76**
Giving a bottle	39.83	30.21	30.90	27.69	19.58	12.57	4.86	340**
Nurse back to sleep	60.31	43.31	31.32	25.31	11.11	4.89	2.43	1023**
Verbal comfort in crib	8.22	9.24	14.33	13.99	14.03	19.97	27.43	143**
Bring child to parents' bed	20.33	21.52	22.47	21.68	20.83	21.37	20.71	1.3
Let cry to fall asleep	3.62	7.03	16.71	19.86	22.36	24.44	11.86	209**
Wait a few minutes	36.21	41.79	49.30	50.63	51.94	51.40	40.29	70**
Play until ready for sleep	2.92	1.66	1.69	2.24	1.39	0.84	0.43	19
Watch TV or video	2.79	1.93	1.83	0.70	1.25	1.96	2.43	12
Sing to child	14.62	8.41	10.53	9.93	11.39	12.29	8.14	23*

Black lines under the means related to age groups that are not significantly different from each other in chi-square *post-hoc* analysis.

* $P < 0.001$; ** $P < 0.0001$.

comfort in crib increase with age; whereas other interventions (e.g., bring child to parents' bed, watch TV) do not show any age-related tendency.

As can be seen in Fig. 3, other major sleep-related factors show age-related changes. ($P < 0.0001$). Sleep position is another important factor showing a significant decrease from supine to other sleep positions during the first 18 months of life and then slightly increasing in later ages ($\chi^2 = 909$, $P < 0.0001$). Significant age-related changes also occur with regard to sleep location. Sleeping in a separate room increases during the first 18 months and then remains relatively constant ($\chi^2 = 928$, $P < 0.0001$). The regularity of bedtime rituals also increases with age during the first 2 years ($\chi^2 = 386$, $P < 0.0001$).

Predictors of sleep

To assess the relationships between sleep ecology and sleep patterns we used stepwise regression analysis using sleep ecology and demographic variables as predictors of the most prominent sleep variables: nighttime sleep duration, daytime sleep duration, longest sleep episode, and the number of night wakings. The sleep ecology and demographic variables considered as potential predictors in each regression analysis included child variables (child's age, sex, race, location in the family), parent variables (age, education level, employment

status, geographic location: latitude and longitude, and median household income), and sleep ecology measures (sleeping arrangements, location, and position, method of falling asleep and resuming sleep, including all parental interventions). In light of the large cohort size, we limited the analysis to highly significant measures and set the level for entry into the regression model to $P < 0.0001$, and to variables with at least 5% contribution to the explained variance. Therefore, all measures reported here meet these criteria (Table 4).

Daytime sleep duration was mostly explained by the age of the child. Additional variables (teething and learning to crawl) had very limited contribution to the explained variance. Together, these variables explained 40.06% of the variance. In contrast, nocturnal sleep duration was mostly explained by multiple ecological factors with sleeping in a separate room the strongest predictor. The total explained variance of these measures was 20.65%.

The number of night wakings was explained by a somewhat overlapping set of variables. Higher number of night wakings was associated with breastfeeding back to sleep, not sleeping in a separate room, giving a bottle during the night, bringing child to parents' bed, and an irregular bedtime routine. These variables explained 20.55% of the variance in night wakings.

The longest continuous sleep episode was explained (38.39% of the variance) by a very similar set of variables to number of

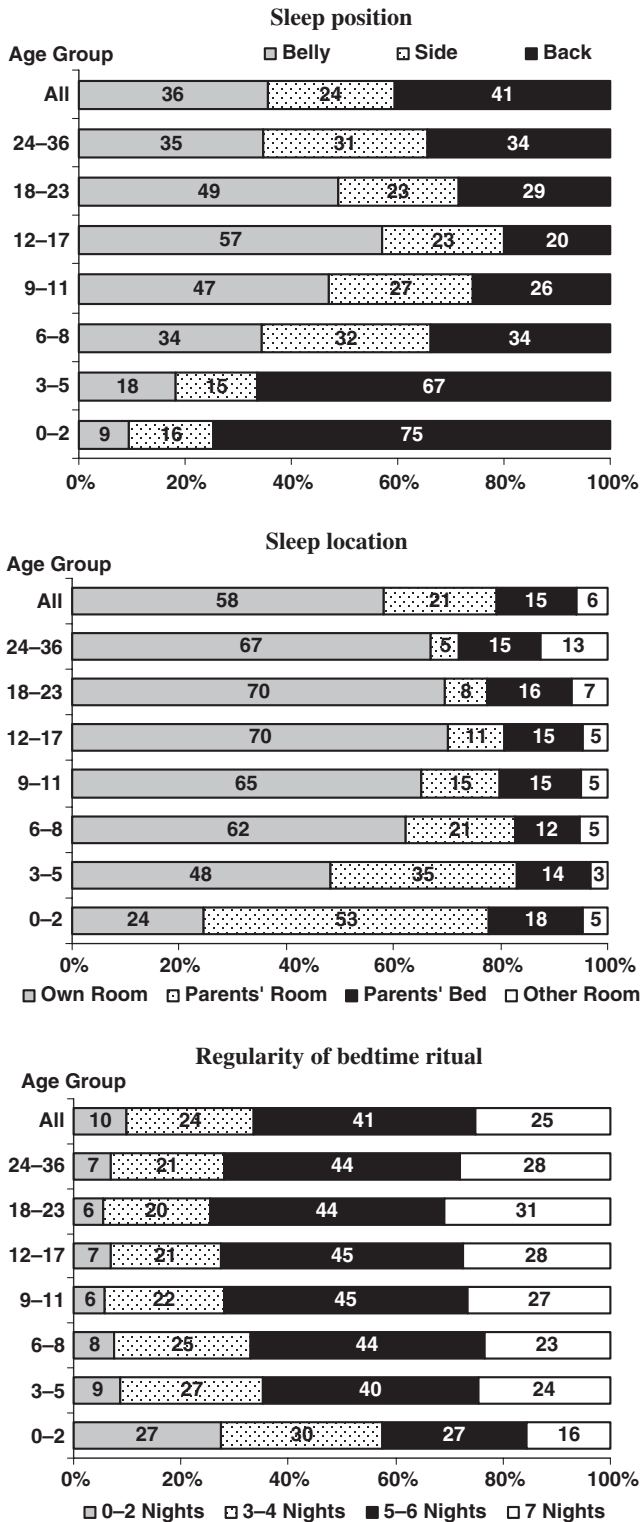


Figure 3. Distribution of sleep position, sleep location and regularity of bedtime ritual across the age groups.

night wakings, in addition to age. Longest continuous sleep period was associated with sleeping in a crib in a separate room, older age, not breastfeeding back to sleep, not giving a bottle during the night, a regular bedtime routine, and not bringing the child to the parents' bed.

Parentally-defined sleep problem

Seventy-five percent of the parents defined their child's sleep as non-problematic, 23% defined their child's sleep as a small problem, and 2% as a serious problem. To better understand what determined parental definition of their child's sleep as a problem; we performed a stepwise regression analysis with parental definition as a criterion and sleep measures and ecological measures as predictors. The first and best predictor was the average number of night wakings, explaining 13.27% of the variance ($\beta = -0.08$; $F = 759$, $P < 0.0001$). The second predictor was sleep latency that accounted for an additional 3.86% of the variance ($\beta = -0.08$; $F = 231$, $P < 0.0001$). The third variable was longest sleep episode accounting for 2.07% of the variance ($\beta = 0.05$; $F = 127$, $P < 0.0001$). The fourth variable was daytime sleep explaining 3.36% of the variance ($\beta = 0.04$; $F = 215$, $P < 0.0001$). The fifth variable was the child's age accounting for 0.65% of the variance ($\beta = -0.02$; $F = 42$, $P < 0.0001$). Additional variables explained $< 0.5\%$ of the variance each and were not included. The summary of this analysis is that increased number of night wakings, longer sleep latency, shorter longest sleep episode, shorter daytime sleep, and younger age increase the likelihood of parentally defined sleep problem.

DISCUSSION

To the best of our knowledge, this is the largest US-Canada Internet survey on infant and toddler sleep to date. The size of the cohort enabled powerful analyses of age-related changes and of factors predicting sleep measures and sleep problems.

As could be expected from an Internet survey, the cohort is skewed toward higher education and higher representation of White-Caucasians participants (Bucy, 2000; Hsu *et al.*, 2005; Martin and Robinson, 2007). Given that the cohort was skewed toward higher education, this perhaps affected the minimal role that socio-economic and other background variables played in our findings. However, the data are based on anonymous parental reports and thus minimize response biases associated with reporting in clinical or other health-care settings. In addition, the data were collected online through a parenting website, which may have influenced the representative nature of this cohort. However, a recent study revealed that data on sleep of young children obtained over the Internet are very similar in nature to data obtained by more traditional forms of research (Sadeh, 2004). Overall, our present Internet-based findings are very similar to those based on traditional (non-computerized) surveys. For instance, with regard to night wakings our data indicate that the average number of night wakings in our sample ranged between 0.89 and 1.89 (per night) for the different age groups. Very similar ranges (between 0.5 and 2 night-wakings per night) were reported in traditional surveys (Adair *et al.*, 1991; Hiscock and Wake, 2001; Karraker and Young, 2007; Scher *et al.*, 1995). However, given the concerns about external validity considering the inherent Internet sampling biases, our data can be considered

Table 4 Stepwise regression analyses explaining sleep measures using sleep ecology and demographic variables*

Explained variable	Predictors	Beta	% explained variance	F
Daytime sleep duration	Age	-0.55	37.18	2953
	Teething	-0.30	2.13	174
	Learning to crawl	-0.46	0.75	62
Nocturnal sleep duration	Child sleeps in a separate room	0.59	10.88	609
	Age	0.17	4.70	278
	Regularity of bedtime routine	0.23	3.07	188
	Caucasian	0.31	1.15	72
	Watch TV before bedtime	-0.32	0.85	54
Night Wakings	Breastfeeding back to sleep	0.81	10.84	606
	Sleeping in a crib in a separate room	-0.44	5.78	347
	Giving a bottle during the night	0.41	2.38	147
	Bring child to parents' bed	0.26	1.01	63
	Regularity of bedtime routine	-0.09	.54	34
Longest sleep episode	Sleeping in a crib in a separate room	1.56	20.59	1294
	Age	0.24	9.78	701
	Breastfeeding back to sleep	-1.81	3.71	281
	Giving a bottle during the night	-1.08	2.37	186
	Regularity of bedtime routine	0.32	1.43	115
	Bring child to parents' bed	-0.52	0.51	41

*All entered variables met the criteria of $P < 0.0001$ and contribution to explained variability of at least 0.5%. On all variables, high scores reflect higher levels (or approval) of the items as described. Beta values are derived from the final regression model with all predictors. Percentages of explained variability refer to the unique contribution of each variable.

as reference data for future Internet-based studies and interventions (Andersson *et al.*, 2005; Bussey-Smith and Rossen, 2007; Christensen *et al.*, 2004; Cook *et al.*, 2000; Evers *et al.*, 2003; McDaniel and Stratton, 2006; Saperstein *et al.*, 2007; Strom *et al.*, 2004; Wantland *et al.*, 2004).

The other limitation of this study is the use of parental report. The reliance on parental reports in assessing the infant sleep has inherent limitations because parents' awareness of night wakings is largely influenced by the child's tendency to signal (e.g., cry or call for attention) (Anders *et al.*, 1992; Burnham *et al.*, 2002; Goodlin-Jones *et al.*, 2001; Sadeh, 1994, 1996). However, when it comes to seeking clinical help, what appears to determine parental perception of a problem is the child's sleep fragmentation, as they are aware of it (Sadeh *et al.*, 2007).

Sleep patterns

Our results provide a broad perspective on age-related sleep patterns considering the rapid developmental changes occurring in the first 3 years. As was expected, total sleep time decreases with age, mostly due to the gradual disappearance of daytime sleep and concentration of sleep during the nighttime. Interestingly, daytime sleep is mostly determined by maturation (age) whereas nocturnal sleep is better predicted by ecological factors. The other major age-related change is related to the consolidation of sleep during the night. Sleep becomes less fragmented as seen in the reduction in night wakings and the increase in the duration of the longest continuous sleep episode. These developmental changes have been demonstrated in the past and more recently using various assessment methods and in different cultures (Acebo *et al.*, 2005; Burnham *et al.*, 2002;

Iglowstein *et al.*, 2003; Montgomery-Downs and Gozal, 2006; Ottaviano *et al.*, 1996; Sadeh, 2004; Weissbluth, 1995). In particular, our results on sleep times during the second and third years of life are very similar to those obtained recently by actigraphy and daily log in a recent study in the US (Acebo *et al.*, 2005). One interesting point that can be seen in Fig. 2 and is not often addressed in the literature is the large variability that exists in sleep duration, particularly during the first year of life. Similar variability was reported in a recent normative sample in Europe (Iglowstein *et al.*, 2003). For instance, during the 3–11 months age period, the 5th percentile of total sleep time is between 9 and 10 h, whereas the 95th percentile is close to 16 h. Such dramatic differences indicate significant individual variability in sleep need or sleep opportunity, which may reflect underlying biologic or environmental factors that should be further explored. However, some of the predictors of shorter nocturnal sleep are related to sleep ecology and therefore suggests that environmental factors are associated with sleep duration (and not only sleep quality) in these early ages.

Sleep ecology and related issues

Our study provides a broad picture of sleep ecology and other sleep-related issues. When sleep initiation methods were assessed, parental interventions and involvement vis-à-vis the child's sleep showed age-related changes. Physical, active, and touch-related interventions decline with age. These methods include bottle feeding, nursing, rocking, and holding. Independent sleep initiation (child in crib alone in the room) significantly increased with age. Similar findings were found with regard to the methods of resuming sleep following night

wakings. Physical and active methods such as holding/rocking to sleep, giving bottle, and nursing back to sleep showed a clear decline with age. Methods emphasizing self-soothing such as letting cry to fall asleep, wait a few minutes, and verbal comfort in crib increased with age. Similar developmental changes in sleep ecology have been demonstrated in earlier studies (Burnham *et al.*, 2002; Morrell and Cortina-Borja, 2002).

Regularity of bedtime rituals increases steadily during the first 2 years. A dramatic increase also occurs in the proportion of children in this study sleeping in their own room from 24% during the first 2 months to close to 70% after the first year of life. However, in light of the death and accident risks associated with cosleeping in parents' bed (Blair *et al.*, 1999; Carolan *et al.*, 1995; McGarvey *et al.*, 2006; Tappin *et al.*, 2005; Thoman, 2006; Willinger *et al.*, 2003) in the early months of life, it is important to emphasize that between 12 and 18% of the parents report cosleeping with their infants during this risk period.

Predictors of sleep patterns

The results of the regression analyses provide a very consistent picture by which nocturnal sleep quality and sleep duration are associated with a very similar set of measures mostly related to parental interventions or soothing methods. It is important to emphasize that these associations do not necessarily imply causality. There is solid basis for the assertion that infant sleep could be influenced by parental behaviors as well as for the opposite assertion that parental behaviors could be influenced by the child's sleep patterns. For instance, if the child wakes up very often, his or her parents are more likely to actively intervene in comparison to parents of a calm sleeper. The research into clinical intervention provides substantial support to the first assertion by consistently demonstrating that alteration of parental bedtime behaviors leads to improved infant sleep (Kuhn and Elliott, 2003; Mindell *et al.*, 2006; Ramchandani *et al.*, 2000; Sadeh, 2005).

Considering the results from this clinical perspective, the data show that increased number of night wakings is predicted by breastfeeding, not having a crib in a separate room, giving a bottle during the night, bringing the child to parents' bed, and by irregular bedtime routines. The duration of the longest sleep episode is predicted by age and the same set of variables. Interestingly, regularity of bedtime routines was found to be a predictor of better sleep. Although, it is often recommended to parents to develop a regular bedtime routine our data provide initial empirical support for this common recommendation. Taken together, these results highlight the notion that sleep ecology, and particularly parental bedtime interventions, are strongly linked to sleep consolidation in early childhood, even after controlling for other important factors such as the child's age and other socio-economic factors. Interventions based on educating parents about these predictive factors and how to modify them to improve sleep consolidation have been implemented with a high degree of success (Kuhn and Elliott,

2003; Mindell *et al.*, 2006; Ramchandani *et al.*, 2000; Sadeh, 2005).

Parental perception of infant sleep as a problem

Parental perception of their child's sleep as a problem is mostly predicted by their reports on the child's sleep variables that relate to sleep fragmentation. Interestingly, parental characteristics (e.g., socio-economic status, education, and age) did not have a significant contribution in predicting parental perception. These results are consistent with a recent study on the differences in sleep between referred and non-referred infants and toddlers, indicating that the main difference was related to the number of reported (rather than the objective) night wakings (Sadeh *et al.*, 2007).

CONCLUSIONS

Overall, data drawn from a large cohort demonstrate clear developmental changes that occur in sleep patterns from birth through the age of three. Our data provide a broad picture needed to assess sleep in this period of rapid maturational changes in sleep-wake patterns. These data can also serve as reference data for projects conducted via the Internet (e.g., telemedicine or cross-cultural comparisons).

Our findings emphasize the strong relationship between parental bedtime interactions and sleep consolidation in early childhood. After including a wide range of background variables as potential predictors of sleep quality, the best predictors that explained a substantial portion of the variability were those related to bedtime interactions and choices related to the setting (e.g., location of sleep). These findings highlight the role of bedtime interactions which are commonly addressed in clinical behavioral interventions for infant sleep problems.

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APPENDIX – THE EXTENDED BRIEF INFANT SLEEP QUESTIONNAIRE

1. Please enter your child's name.
2. Please select your child's birthdate.
3. Does your child snore during sleep?
 - Never
 - Only when he/she has a cold or allergies
 - Sometimes
 - Almost always/always

Please think about your child's sleep over the past 2 weeks in answering the following questions:

4. Where does your child sleep most of the time?: (CHECK ONE)
 - In his/her own room
 - In parents' room
 - In sibling or other's room
 - In another room of the house
 - Other, please specify:
5. Which of the following does your child sleep in most of the time?
 - Crib
 - Own bed (any size)
 - Parents' bed (any size)
 - Bassinet
 - Infant seat
 - Swing
 - Other, please specify:
6. In what position does your child sleep most of the time? (CHECK ONE)
 - On his/her belly
 - On his/her side
 - On his/her back
7. Which of the following usually occurs on most nights for your child in the hour before bedtime?(CHECK ALL THAT APPLY)
 - Bath
 - Massage
 - Read books/being read to
 - Rocked
 - Watch television

Have dinner or a snack
Have a bottle, drink, or nurse
Run around
Brush teeth
Play
Cuddle
Say prayers
Sing songs
Listen to music
Other, please specify:

8. How does your child fall asleep most of the time? (CHECK ALL THAT APPLY)

While being bottle-fed
While being breast-fed/nursing
While being rocked
While being held
While watching television
In swing or stroller
In his/her own crib/bed alone in the room
In parent's bed alone in the room
In his/her own crib/bed and with a parent in the room
In parent's bed and with a parent in the room
In another room of the house (e.g. living room)
Other, please specify:

9. In a typical 7-day week, how often does your child have the exact same bedtime routine?

Never
1–2 nights per week
3–4 nights per week
5–6 nights per week
Every night

10. What time do you usually start your child's bedtime routine?

11. What time do you usually put your child to bed at night? (*time of turning out the light*)

12. Typically, how difficult is bedtime for your child, for example, fussing, crying, protesting?

Very easy
Somewhat easy
Neither easy nor difficult
Somewhat difficult
Very difficult

13. How long does it typically take your child to fall asleep at night?

EXAMPLE: If you put your child to bed at 20:15 hours and your child falls asleep at 20:30 hours, it took 15 min for your child to fall asleep.

Less than 5 min
5–15 min
16–30 min
31–60 min
More than 1 h

14. How often, if ever, does your child have a difficult time falling asleep at night?

Every night
5–6 nights per week

- 3–4 nights per week
- 1–2 nights per week
- 1–3 nights per month
- Less than once a month
- Never

15. How many times does your child typically wake during the night? _____ times per night

16. How often does your child wake during the night, if ever?

- Every night
- 5–6 nights per week
- 3–4 nights per week
- 1–2 nights per week
- 1–3 nights per month
- Less than once a month
- Never

17. When your child wakes up during the night, what do you do? (CHECK ALL THAT APPLY)

- Pick up my child and hold/rock him/her until child falls asleep
- Pick up my child and put him/her back down while child is still awake
- Rub or pat my child but do not pick up or take out of crib/bed
- Bottle feed child back to sleep
- Breastfeed/nurse child back to sleep
- Give my child a pacifier
- Change diaper
- Comfort my child verbally but don't pick child up or take child out of crib/bed
- ring my child into my bed
- Let my child cry and fall back to sleep by himself/herself
- Give my child a few minutes to see if he/she falls back to sleep
- Play with my child until child is ready to go back to sleep
- Watch television/a video with my child until he/she falls asleep
- Sing to child
- Other, please specify:

18. On a typical night, how much total time during the NIGHT is your child awake?

_____ hours _____ minutes

EXAMPLE: If your child woke up two times and was awake for about 15 min each time, your child's total time spent awake would be 30 min.

19. On a typical night, what is the longest stretch of time that your child is asleep during the night without waking up?

_____ hours _____ minutes

20. How much total time does your child spend sleeping during the NIGHT (between 7 in the evening and 8 in the morning)

_____ hours _____ minutes

21. How many naps does your child take during a typical DAY (between 8 in the morning and 7 in the evening):

_____ naps

22. How much total time does your child spend sleeping during the DAY (between 8 in the morning and 7 in the evening)

_____ hours _____ minutes

23. Please rate how well your child usually sleeps at night: (CHECK ONE)

- Very well
- Well
- Fairly well

Fairly poorly
Poorly
Very poorly

24. Do you consider your child's sleep as a problem? (CHECK ONE)

A very serious problem
A small problem
Not a problem at all

25. Is your child a...

Girl
Boy

26. What is the birth order of your child?

Oldest
Middle
Youngest
A multiple (e.g., a twin or triplet)
Only

27. Are you the child's...?

Father
Mother
Grandparent
Other, please specify:

28. What is your age?

Under 21
21–24
25–29
30–34
35–39
40–44
45–49
50 or older
Prefer not to answer

29. Which category describes your current occupational status?

Employed full-time
Employed part-time
On maternity leave
Homemaker/at-home parent
Student
Unemployed/in-between jobs
Other

30. What is the highest level of schooling you have completed?

Less than high school degree
High school degree
Some college
College degree
Postgraduate degree
Prefer not to answer

31. What is your race/ethnicity?

White/Caucasian

African-American
Asian
Hispanic
Native American
Other:
Prefer not to answer

32. What country do you live in?

If United States, what zip code do you live in?
