Factors associated with shorter night-time sleep in toddlers: The Survey of Young Canadians

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ABSTRACT

OBJECTIVES: Adequate sleep in childhood is important for healthy development. No information exists on the predictors of night-time sleep among toddlers in Canada. The aim of this study was to determine the prevalence of and to identify factors associated with sleeping <11 consecutive hours per night among children aged 1–2 years in Canada.

METHODS: Data from the cross sectional Survey of Young Canadians (SYC) 2010 were used. The biological mother reported on toddlers' sleep duration at night. Based on cut-off values used in previous studies, shorter night-time sleep was defined as sleeping <11 hours per night. Multivariable logistic regression was conducted to identify the associations between socio-demographic, maternal, sleep and child-related variables with shorter sleep at night.

RESULTS: Analysis of 3675 toddlers revealed that 57% slept <11 hours per night. Results of the regression analysis showed that being from an immigrant family was significantly associated with shorter night-time sleep. Being from a higher income household, having a mother aged between 25 and 34 years at the time of the survey, and napping ≥2 hours during the day were significantly related to sleeping ≥11 hours per night. Other socio-demographic, maternal and child-related variables were not associated with night-time sleep.

CONCLUSION: This was the first population-based, nationally representative study to examine factors related to shorter night-time sleep in Canadian toddlers. Socio-demographic factors and nap duration were associated with night-time sleep duration. More adequate early childhood sleep hygiene awareness efforts are recommended, especially in vulnerable populations.

KEY WORDS: Children; sleep duration; factors; Canada

I n recent decades, sleep during childhood has become a burgeoning research focus, given its importance in physical and mental health development.[1] Although this period of life is accompanied by significant changes in the duration and timing of sleep,[2] a decrease in children's total sleep duration is being consistently reported, resulting in more children being sleep deprived.[3] In fact, between 20% and 30% of children experience sleep problems during the first 3 years of life.[4] Clear clinical recommendations for optimal sleep duration in infancy and early childhood do not exist currently,[5,6] however, at around 18 months of age, children sleep 11.3 hours per night and 1.5 hours during the day, on average.[6] Sleeping <11 hours per night substantially increases the risk of obesity in children under 5 years of age,[7] therefore reflecting a sleep level that does not promote health. Epidemiologic studies from infancy to adolescence have demonstrated a high prevalence of sleep disturbances that are associated with physiological, psychological, cognitive and behavioural consequences. Insufficient sleep in early childhood can impair learning and memory,[8] disrupt emotional regulation,[9] and increase the risk of childhood obesity.[7,10]

Sleep duration in children, in addition to being influenced by biological and psychological factors, is also influenced by cultural, social and parental factors.[11–13] Low socio-economic status, non-Caucasian ethnic group, higher maternal age, maternal stress and/or depression, prematurity, low birth weight, care outside the home, TV/screen viewing especially before going to sleep, and male gender have been found to be factors associated with shorter night sleep duration in school-aged children and toddlers.[5,14–16] Moreover, parental behaviour at bedtime (e.g., parental presence until sleep onset, feeding), especially among toddlers, presents an additional important risk factor for fragmented sleep[17] and consequently shorter sleep duration.[18] Few studies report on sleep problems among a representative sample of Canadian children;[19] with the majority examining the link between poor sleep and childhood obesity,[20–24] and hyperactivity.[25]

The factors that play a role in toddlers' night-time sleep duration are unknown in Canada and have yet to be addressed in a single national study. The health implications of shorter sleep duration warrant understanding of its associated factors, particularly in early life during which time sleep gradually consolidates into night-time hours with a cessation of daytime naps, and when patterns of sleep behaviour are being established.[26] Moreover, Sadeh et al.[27]

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demonstrated that ecological factors, which include cultural factors, are related to nocturnal sleep in toddlers. Therefore, the concept of "normal sleep" varies according to cultural backgrounds.[27,28] In fact, one quarter of parents in predominantly Caucasian countries perceive that their child has a sleep problem.[28] Clinicians and parents will therefore benefit from a context-specific estimate of night-time sleep duration in relationship to various characteristics in this age group. Results of this study can also provide important information for stakeholders and researchers in conceptualizing and effectively addressing sleep problems by developing strategies to improve sleep habits in early childhood. Therefore, using a large Canadian dataset, the aim of this study was to determine factors associated with toddlers' night-time sleep duration.

METHODS

Study design and sample

The 2010 component of the Survey of Young Canadians (SYC) was the source of data used in this analysis. This cross-sectional survey, drawn using simple stratified sampling, aimed to produce indicators of early childhood development for 10 810 younger children. The SYC was a voluntary survey, conducted between November 2010 and March 2011, targeting all children between the ages of 1 and 9 who reside in the 10 Canadian provinces. Specifically excluded were children living in the Yukon, the Northwest Territories and Nunavut, as well as those residing on Indian reserves.

Data collection

Respondents were randomly selected from administrative files produced by Statistics Canada using information obtained from the Canada Revenue Agency. The sampling unit was the child, however the respondent was his/her parent or guardian; as such, to reduce response burden, the design prohibited two children from the same household from being selected for the sample. The parent or guardian of the selected child was initially contacted with an introductory package mailed to the address on the sample file. The parent or guardian was then contacted by a Statistics Canada interviewer for an interview. Data collection was completed using computer-assisted telephone interviewing (CATI), and information was gathered from the selected child, the Person Most Knowledgeable (PMK) about the selected child and the spouse of the PMK (when applicable). Proxy responses were allowed for the Spouse portion of the interview and it was the PMK who provided responses to the Child portion and the PMK portion. For more information on the methods used in the SYC, please refer to the following: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5179.

Outcome definition and assessment

The PMK reported on several aspects of sleep behaviour. The main outcome of the study, night-time sleep duration, was determined in response to the following question: "How many hours in a row does the child usually sleep at night?" This question was restricted in the questionnaire to children aged 1–2. Shorter night-time sleep in this study was defined as sleep <11 hours per night, a cut-off based on age-specific reference values previously established by Blair et al.[5] and Iglowstein et al.,[29] and employed by McDonald et al.,[14]

although individual variability does exist and a clinical consensus has not been clearly established on appropriate night-time sleep duration in this cohort. A sensitivity analysis using different cut points of night-time sleep duration (<9.5 hours, and <10 hours per night) was also conducted. Because patterns of results were identical to those obtained using <11 hours cut-off, data are presented using <11 hours as the cut-off point for short sleep to be consistent with prior studies cited, and its relevancy from a public health perspective to have a category of short sleep duration per night. Other sleep-related variables included naptime during the day, reported in hours ("What is the longest time this child naps during the day?"), and sleep onset delay, reported in minutes ("In general, how long does it take this child to fall asleep?"), as provided by the PMK.

Other covariates

A wide range of covariates were used to investigate the associated factors of night-time sleep duration in toddlers. These variables were: i) socio-demographic factors, including child's gender, Aboriginal status, immigration status, total household income, and the PMK's level of education, current work status and marital status; ii) maternal factors, including number of pregnancies (gravidity), mode of delivery, health problems during pregnancy (gestational diabetes or hypertension), smoking and alcohol consumption during pregnancy and current maternal age; and iii) child-related variables, including preterm birth, birthweight, health at birth, breastfeeding duration and daycare use. Daytime napping, dichotomized as <2 hours vs. ≥2 hours, was also included as a covariate given its previous correlation with nocturnal sleep duration.[26,30] The 2 hours cut-off for nap duration was based on closely related age-specific reference values previously obtained by Blair et al.,[5] and extrapolated to fit the current study's responses available to this variable. All variables were self-reported. Mode of delivery was assessed in SYC using three separate variables: delivery mode ("Was the delivery vaginal or caesarian?"); forceps use during delivery ("For delivery, were forceps used?"); and vacuum extraction (VE) during delivery ("For delivery, was vacuum extraction used?"). For the purpose of this analysis, mode of delivery was recoded into one variable by combining the latter two variables with the first. Therefore, mode of delivery included the following categories: vaginal delivery, caesarean section (CS) and instrumental delivery (which encompassed VE and/or forceps use). The analysis was restricted to answers provided by the child's biological mother to ensure adequate recall of the maternal variables.

STATISTICAL ANALYSIS

The study sample was limited to children 1–2 years of age at the time of the survey, and with complete information on sleep habits, as reported by their biological mothers (34% of 10 810). The prevalence of shorter night-time sleep duration was estimated through population weights and examined at the national level. Applying the appropriate sample weights to the SYC data allowed the survey data to be representative of the population. Descriptive statistics of the main outcome and other sleep parameters were conducted. A chi-square test was performed to assess the differences in the proportion of shorter sleep duration at night among the different levels of the main independent variable as well

as covariates. Unadjusted odds ratios (ORs) and 95% confidence intervals (CIs) to assess the association between poor night-time sleep and socio-demographic, maternal and child indicators were also obtained. Multivariable logistic regression analysis adjusting for all variables was conducted to predict the likelihood of having shorter night-time sleep. Adjusted ORs and their 95% CIs were estimated. To account for the complex sampling design, bootstrapping was performed to calculate the 95% CI estimates. Population weights, normalized weights and bootstrap weights were all created by Statistics Canada and provided with the SYC data file. All analyses were conducted using Stata Data Analysis and Statistical Software (Stata, version 13.0). Statistical significance for all analyses was set at $\alpha = 0.05$ for a two-tailed test.

RESULTS

The final sample considered 3675 toddlers who had full information on the main outcome variable, night-time sleep duration, and whose biological mothers have provided this information for analysis (34%). The sample was weighted to represent 577 461 Canadian toddlers. The average night-time sleep duration in the sample was 9.5 hours (SD = 39 minutes), with shorter night-time sleep being reported in approximately 57% (95% CI = 55.2–58.6) of children aged 1–2 years, as shown in Table 1. Over 50% of toddlers required <15 minutes to fall asleep at night (95% CI = 54.4–54.6), and 46% of toddlers napped for 2 to <3 hours during the day (95% CI = 45.7–46.0).

Table 2 presents the unadjusted and adjusted odds of experiencing shorter night-time sleep by socio-demographic, maternal, sleep, and child-related characteristics. In the adjusted model, neither delivery via caesarean section nor an instrumental delivery was associated with shorter night-time sleep. Immigrant toddlers were at a significantly increased odds of shorter night-time sleep than their Canadian-born counterparts (OR = 1.41; 95% CI = 1.03–1.93). On the other hand, toddlers who came from a household with a total annual income ranging between $60,000 and <$100,000 were 35% less likely to sleep <11 hours per night (OR = 0.65; 95% CI = 0.43–0.98), and those who came from a household earning ≥$100,000 per year were 50% less likely to have a shorter night-time sleep duration (OR = 0.50;

95% CI = 0.32–0.77) compared to households earning <$30,000 per year. In addition, toddlers whose mothers reported their age to be between 25 and 34 years at the time of the survey (OR = 0.76; 95% CI = 0.60–0.98), and those who napped ≥2 hours per day (OR = 0.74; 95% CI = 0.58–0.94) were significantly less likely to sleep <11 hours at night compared to their counterparts, i.e., those with mothers aged 35 and above, and those who napped <2 hours per day respectively.

DISCUSSION

In this analysis of over 3000 toddlers, a higher risk of shorter night-time sleep was demonstrated among toddlers from immigrant families. On the other hand, toddlers whose parents had a relatively higher household income, with mothers aged between 25 and 34 years at the time of the survey, and who napped ≥2 hours per day had a lower risk of shorter night-time sleep. This study offers a unique opportunity to describe factors associated with night-time sleep duration in Canadian toddlers based on epidemiological data.

The average night-time sleep duration in this sample was 9.5 hours, similar to that obtained by Kohyama et al.,[13] where Japanese toddlers slept for a mean 9.4 hours per night. Toddlers in our sample slept less during the night than their French[18] (10.51 hours) and British[5] (11.15 hours) counterparts. Over half of our study sample reported sleeping <11 hours per night. Large variation in prevalence of shorter sleep duration exists between studies, mainly due to: cultural variability; different study measures used, such as actigraphy, polysomnography, parent-completed sleep diaries, or parental report; and developmental stages of the examined populations.[28] Contrary to the results obtained by the Gemini cohort study of British twins[14] where, using the same cut-off of <11 hours, 14.1% of the sample reported shorter night-time sleep, the percentage of toddlers with shorter night-time sleep in our sample was higher. Our findings were similar to those of Touchette and colleagues,[25] who, using data from 2057 children from the Quebec Longitudinal Study of Child Development, found that almost 40% of children in their sample slept for a persistent 11 hours at night while the remainder did not.

Young children from immigrant families were significantly more likely to sleep for <11 hours per night than children born in Canada. An explanation for this observation may be that immigrant households experience increased stress levels depending on the time since immigration, which may create lower levels of structure and routines, or a lack of awareness of the importance of establishing bedtime routines at an early age.[31] Also, many immigrant families are sometimes at a disadvantage in terms of household income. Moreover, ethnic background and culture could also play a role in nocturnal sleep. For example, Crosby et al.[32] in a cross-sectional study on pre- and early school-aged children in Mississippi, USA, found that black children were much more likely to have less reported nocturnal sleep than their white counterparts. Our finding was consistent with that reported by McDonald and colleagues[14] in the Gemini cohort study, a twin birth cohort including 2402 families with twins born in the UK in 2007. They found that children living in non-white families were at increased odds of sleeping <11 hours per night. These cultural differences in sleep duration coincided with later bedtimes and earlier morning wake times among children of non-white ethnic

Table 1. Distribution of sleep parameters among Canadian toddlers in the SYC, 2010

Variables	Weighted N (%)	95% CI
Night-time sleep duration		
<11 hours per night	393 000 (57.0)	55.2–58.6
≥11 hours per night	296 800 (43.0)	41.3–44.7
Sleep onset delay		
<15 minutes	375 000 (55.0)	54.4–54.6
16–30 minutes	212 400 (31.0)	30.8–30.9
31–45 minutes	45 200 (6.6)	6.50–6.60
46–60 minutes	33 100 (4.9)	4.80–4.90
>60 minutes	22 200 (3.0)	2.9–3.0
Naptime during day		
<1 hour	20 400 (3.0)	2.90–3.00
1 to <2 hours	201 600 (29.0)	29.0–29.3
2 to <3 hours	315 600 (46.0)	45.7–46.0
3 to <4 hours	108 300 (15.7)	15.6–15.7
≥4 hours	17 500 (2.50)	2.50–2.60
Does not nap anymore	26 800 (3.90)	3.87–3.90

Table 2. Unadjusted and adjusted associations of shorter night-time sleep and potential risk factors

Variables	Sample size	Shorter sleep (<11 hours)	Unadjusted OR	95% CI	Adjusted OR*	95% CI
	Weighted N (%)	**Weighted N (%)**				
Socio-demographic factors						
Gender						
Male	357 100 (50.4)	204 100 (59.0)	1.00		1.00	
Female	351 100 (49.6)	188 900 (55.0)	0.87	0.71–1.05	0.85	0.68–1.07
Aboriginal status						
No	644 300 (96.0)	363 000 (56.0)	1.00		1.00	
Yes	27 600 (4.0)	16 800 (61.0)	1.21	0.75–1.94	1.08	0.61–1.89
Immigration status						
No	482 300 (78.4)	261 200 (54.0)	1.00		1.00	
Yes	132 500 (21.6)	86 500 (65.0)	**1.60**	**1.21–2.08**	**1.41**	**1.03–1.93**
Household income						
<$30,000	114 700 (16.2)	73 400 (66.0)	1.00		1.00	
$30,000–<$60,000	168 600 (23.8)	101 200 (62.0)	0.84	0.60–1.20	0.84	0.56–1.30
$60,000–<$100,000	226 600 (32.0)	125 000 (56.0)	**0.67**	**0.48–0.95**	**0.65**	**0.43–0.98**
≥$100,000	196 200 (28.0)	93 300 (25.0)	**0.50**	**0.35–0.70**	**0.50**	**0.32–0.77**
Mother's work status						
Currently working	403 900 (64.5)	224 800 (56.0)	1.00		1.00	
Not currently working	222 500 (35.5)	126 400 (57.0)	1.06	0.85–1.32	0.90	0.70–1.16
Mother's education level						
College graduate or less	387 000 (62.0)	222 500 (58.0)	1.00		1.00	
More than college graduate	238 500 (38.0)	128 000 (54.0)	0.85	0.70–1.05	0.79	0.61–1.01
Mother's marital status						
Partner	461 400 (65.0)	140 700 (58.0)	1.00		1.00	
No partner	246 800 (35.0)	252 300 (56.0)	1.08	0.87–1.34	1.04	0.78–1.40
Household size						
<4 members	266 600 (38.0)	151 680 (58.0)	1.00		1.00	
≥4 members	441 500 (62.0)	241 300 (56.0)	1.07	0.87–1.31	1.04	0.78–1.42
Maternal factors						
Gravidity						
Once	133 300 (22.0)	78 600 (59.0)	1.00		1.00	
More than once	468 900 (78.0)	257 800 (55.0)	0.84	0.66–1.07	0.78	0.57–1.08
Mode of delivery						
Vaginal	426 200 (61.0)	232 800 (56.0)	1.00		1.00	
Caesarean section	187 900 (27.0)	109 300 (60.0)	1.14	0.90–1.44	1.02	0.78–1.34
Instrumental (vacuum extraction or forceps)	81 300 (12.0)	42 100 (53.0)	0.89	0.65–1.20	0.75	0.53–1.06
Maternal age (years)						
<25	63 000 (9.0)	34 200 (57.0)	0.83	0.55–1.26	0.70	0.41–1.15
25–34	415 300 (59.0)	222 700 (55.0)	**0.77**	**0.62–0.96**	**0.76**	**0.60–0.98**
≥35	229 900 (32.0)	136 100 (61.0)	1.00		1.00	
Health problems during pregnancy						
No	524 800 (74.0)	283 800 (56.0)	1.00		1.00	
Yes	182 500 (26.0)	108 500 (61.0)	1.25	0.99–1.57	1.36	0.94–1.96
Cigarette smoking during pregnancy						
No	607 700 (86.0)	335 300 (57.0)	1.00		1.00	
Yes	99 600 (14.0)	57 100 (59.0)	1.12	0.85–1.50	0.90	0.58–1.38
Alcohol use during pregnancy						
No	626 400 (88.5)	350 400 (57.0)	1.00		1.00	
Yes	81 300 (11.5)	42 200 (54.0)	0.89	0.64–1.23	0.80	0.54–1.16
Child-related factors						
Preterm birth						
No	73 900 (10.5)	40 000 (55.0)	1.00		1.00	
Yes	627 200 (89.5)	348 700 (57.0)	0.93	0.67–1.28	0.88	0.56–1.37
Birthweight						
<2.5 kg	45 700 (6.0)	26 400 (59.0)	1.00		1.00	
≥2.5 kg	662 500 (94.0)	366 600 (57.0)	1.11	0.74–1.67	0.93	0.55–1.60
Child health at birth						
Excellent	478 500 (68.0)	255 300 (55.0)	0.69	0.43–1.09	0.65	0.35–1.19
Good/very good	199 200 (28.0)	118 500 (62.0)	0.90	0.57–1.46	0.77	0.42–1.41
Poor/fair	30 100 (4.0)	18 900 (64.0)	1.00		1.00	
Breastfeeding duration						
Never breastfed	85 200 (12.1)	47 300 (57.0)	1.14	0.81–1.60	1.14	0.76–1.69
<6 months	279 600 (39.5)	167 200 (61.0)	**1.35**	**1.08–1.68**	1.21	0.95–1.56
≥6 months	342 400 (48.4)	178 100 (54.0)	1.00		1.00	
Daycare use						
No	514 000 (76.0)	290 500 (57.0)	1.00		1.00	
Yes	164 100 (24.0)	93 700 (57.0)	1.03	0.82–1.30	1.16	0.89–1.53
Sleep-related factors						
Naptime duration during day						
<2 hours	248 800 (36.0)	152 100 (61.0)	1.00		1.00	
≥2 hours	441 400 (64.0)	239 100 (54.0)	**0.75**	**0.61–0.93**	**0.74**	**0.58–0.94**

Note: Bolding in the table indicates statistical significance of $p < 0.05$.
* Controlling for all variables listed in the table.

minorities.[11,32] It is possible that the observed differences may be related to culturally specific parental beliefs and practices regarding sleep, such as bedtime routines, sleep location, and mothers' level of concern about their child's sleep, and co-sleeping.[33]

Previous studies have shown, albeit inconsistently, that lower socio-economic status (SES) is associated with shorter sleep duration when assessed objectively using actigraphy and through self- and parent-report method.[14,32,33] Our study findings were similar in that children who came from middle-class households were significantly less likely to report shorter night-time sleep than children who came from families whose household income was at the poverty line. Indicators of SES along with ethnicity impact various aspects of a child's physical and social environment, including parental attitudes towards sleep behaviour.[5] Studies have found higher rates of sleep problems in children from low-income families as well as those who live in lower-income neighbourhoods.[34–36] Lower SES was correlated with lower sleep duration in children. Using the Panel Survey of Income Dynamics, family income was related to shorter sleep duration.[37] Also, a composite measure of SES that included parental education was associated with actigraphy-based poorer sleep in school-age children.[38] Yet, few studies have examined the role of SES on sleep duration in this age group.

No association was present between mode of delivery and shorter night-time sleep at all stages of this analysis. A limited number of physiological studies have investigated the effect of mode of delivery on neonatal sleep architecture, by assessing sleep–wake cycles captured by electroencephalogram (EEG), with contradictory findings.[39–43] A longitudinal population-based study in Australia found a significant positive association between CS and instrumental vaginal deliveries, and sleep apnea among children between 2 and 6 years of age,[44] while other studies reported no correlation between CS and sleep disordered breathing[45] and snoring in infants.[46] The birth process is a major stressor for the developing neonatal brain,[47,48] which may be reflected in early neonatal sleep–wake cycling. Further studies are needed to clearly elucidate the role of delivery mode and other early life factors on infants' and children's sleep patterns.

Interestingly, daytime napping was a protective factor against shorter night-time sleep; toddlers who napped for 2 hours or more were at a decreased risk for shorter night-time sleep than their counterparts who napped for <2 hours. This is in contrast to findings reported by Akacem et al.[49] Moreover, Nakagawa et al.,[50] in a cross-sectional study among 50 children 1.5 years of age at a clinic in Tokyo, demonstrated that the longer the nap duration as denoted by "later nap-ending time", the later the toddlers' sleep onset and consequently the shorter the sleep duration at night. On the other hand, Komada et al.[51] in a sample of 967 children aged 0–5 years found no significant differences in night sleep duration associated with napping duration in children younger than 2 years of age. One explanation might lie in a systematic review by Thorpe et al.[52] that examined the effects of napping on child development; they reported that napping was associated with later sleep onset and poor sleep quality and duration, beyond age 2, i.e., after the age where children are still meeting part of their sleep need by napping. Beyond age 2, children consolidated sleep into one episode in that shorter night-time sleep duration and later bedtime occurred on nights following napping.[52] Longitudinal studies

describing sleeping patterns and assessing circadian rhythms are needed to understand the transition into night-time sleep consolidation in early childhood. Moreover, the relationship between daytime napping and night-time sleep duration among toddlers remains unclear, and further research is required to elucidate the effect of napping on sleep domains in this age group.

The study had several strengths. First, data for this study considered all Canadian provinces, resulting in a representative picture of the population, thereby enabling the generalizability of our results. Second, this study utilized a large sample size, allowing for ample statistical power, with population weights accounting for nonresponse bias. Third, to our knowledge, this is the first nationwide study that examined the relationship between various socio-demographic, maternal and child-related factors and night-time sleep duration in this age population. However, a few caveats do exist. Incomplete information on some exposure and outcome variables (11%) might lead to potential selection bias. The outcome was reported by the mother, thereby introducing potential misclassification bias. Parent reporting of children's sleep is not accurate and tends to overestimate sleep duration, unlike objective measures of sleep.[5] Although bedtime and wake time are components to calculate sleep duration, our sleep duration variable was dichotomized and neither bedtime nor wake time was used to obtain data on shorter night-time sleep. However, wake-up times and bedtimes might vary on a day-to-day basis and are difficult for parents to recall. Sleep duration here only involves continuous night-time sleep and is a valid measure of sleep duration widely used by other studies.[14] Given that this study is a secondary analysis, no comprehensive information regarding other sleep disorders, such as sleep disordered breathing and sleep apnea, is available. Although confounding bias was minimized due to the variety of potential predictors that were controlled for in the analysis, nonetheless, important variables such as toddlers' physical activity, sleep environment, parental behaviours around bedtime, and seasonality were not accounted for due to their unavailability. It is important to note that some of the variables included in the multivariable analysis might be correlated to each other and even causal of others, including night-time sleep duration, so this might have led to false significant or nonsignificant associations. In addition, the cross-sectional nature of the study design does not allow us to infer causality. Last, these limitations may have led to an overestimation of night-time sleep duration in the study sample and the ability to predict more factors associated with shorter night-time sleep duration.

CONCLUSION

In summary, the prevalence of shorter night-time sleep was 57%. Results of this study demonstrated that immigration status, SES and daytime nap duration are important factors associated with night-time sleep duration among toddlers. Nap duration might represent a potential means of controlling sleep during early childhood, however this warrants further investigation. Results of this study are relevant to clinicians treating sleep problems among toddlers whereby the investigation of napping patterns might be indicated. Given that adverse physical and mental health outcomes are linked to shorter total sleep duration in childhood and adolescence,[53] and given the relatively high prevalence of short night-time sleep duration our study revealed, educational efforts in

the form of programs or interventions on the importance of sleep and healthy sleep practices, such as early and consistent bedtimes for toddlers, merit intensification in Canada, especially among immigrant and low-income communities. These efforts should account for environmental factors, such as culture, and incorporate families, health care providers and society at large. Also, future studies should aim to understand the factors behind ethnic differences in nocturnal sleep duration in this population. Our findings also suggest the need for extensive and higher-quality studies of prenatal and early life, as well as psychosocial factors related to sleep patterns and problems in children.

REFERENCES

1. Dahl RE. The regulation of sleep and arousal: Development and psychopathology. *Dev Psychopathol* 1996;8(1):3–27. doi: 10.1017/S0954579400006945.
2. Acebo C, Sadeh A, Seifer R, Tzischinsky O, Hafer A, Carskadon MA. Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5-year-old children. *Sleep* 2005;28(12):1568–77. PMID: 16408417. doi: 10.1093/sleep/28.12.1568.
3. 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):213–22. PMID: 21784676. doi: 10.1016/j.smrv.2011.06.001.
4. Sadeh A, Raviv A, Gruber R. Sleep patterns and sleep disruptions in school-age children. *Dev Psychol* 2000;36(3):291–301. PMID: 10830974. doi: 10.1037/0012-1649.36.3.291.
5. Blair PS, Humphreys JS, Gringras P, Taheri S, Scott N, Emond A, et al. Childhood sleep duration and associated demographic characteristics in an English cohort. *Sleep* 2012;35(3):353–60. PMID: 22379241. doi: 10.5665/sleep.1694.
6. Matricciani LA, Olds TS, Blunden S, Rigney G, Williams MT. Never enough sleep: A brief history of sleep recommendations for children. *Pediatrics* 2012;129(3):548–56. PMID: 22331340. doi: 10.1542/peds.2011-2039.
7. Bell JF, Zimmerman FJ. Shortened nighttime sleep duration in early life and subsequent childhood obesity. *Arch Pediatr Adolesc Med* 2010;164(9):840–45. PMID: 20819966. doi: 10.1001/archpediatrics.2010.143.
8. Steenari MR, Vuontela V, Paavonen EJ, Carlson S, Fjällberg M, Aronen ET. Working memory and sleep in 6- to 13-year-old schoolchildren. *J Am Acad Child Adolesc Psychiatry* 2003;42(1):85–92. PMID: 12500080. doi: 10.1097/00004583-200301000-00014.
9. Berger RH, Miller AL, Seifer R, Cares SR, Lebourgeois MK. Acute sleep restriction effects on emotion responses in 30- to 36-month-old children. *J Sleep Res* 2012;21(3):235–46. PMID: 21988087. doi: 10.1111/j.1365-2869.2011.00962.x.
10. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity* 2008;16(2):265–74. PMID: 18239632. doi: 10.1038/oby.2007.63.
11. Liu X, Liu L, Owens JA, Kaplan DL. Sleep patterns and sleep problems among schoolchildren in the United States and China. *Pediatrics* 2005;115(Suppl 1):241–49. PMID: 15866858. doi: 10.1542/peds.2004-0815F.
12. Jiang F, Shen X, Yan C, Wu S, Jin X, Dyken M, et al. Epidemiological study of sleep characteristics in Chinese children 1–23 months of age. *Pediatr Int* 2007;49(6):811–16. PMID: 18045277. doi: 10.1111/j.1442-200X.2007.02449.x.
13. Kohyama J, Mindell JA, Sadeh A. Sleep characteristics of young children in Japan: Internet study and comparison with other Asian countries. *Pediatr Int* 2011;53(5):649–55. PMID: 21199167. doi: 10.1111/j.1442-200X.2010.03318.x.
14. McDonald L, Wardle J, Llewellyn CH, van Jaarsveld CH, Fisher A. Predictors of shorter sleep in early childhood. *Sleep Med* 2014;15(5):536–40. PMID: 24726571. doi: 10.1016/j.sleep.2014.01.005.
15. Foley LS, Maddison R, Jiang Y, Marsh S, Olds T, Ridley K. Presleep activities and time of sleep onset in children. *Pediatrics* 2013;131(2):276–82. PMID: 23319532. doi: 10.1542/peds.2012-1651.
16. Nevarez MD, Rifas-Shiman SL, Kleinman KP, Gillman MW, Taveras EM. Associations of early life risk factors with infant sleep duration. *Acad Pediatr* 2010;10(3):187–93. PMID: 20347414. doi: 10.1016/j.acap.2010.01.007.
17. Touchette É, Petit D, Paquet J, Boivin M, Japel C, Tremblay RE, et al. Factors associated with fragmented sleep at night across early childhood. *Arch Pediatr Adolesc Med* 2005;159(3):242–49. PMID: 15753267. doi: 10.1001/archpedi.159.3.242.
18. Plancoulaine S, Lioret S, Regnault N, Heude B, Charles MA. Gender-specific factors associated with shorter sleep duration at age 3 years. *J Sleep Res* 2015;24(6):610–20. PMID: 26041449. doi: 10.1111/jsr.12308.
19. Michaud I, Chaput JP. Are Canadian children and adolescents sleep deprived? *Public Health* 2016;141:126–29. PMID: 27931987. doi: 10.1016/j.puhe.2016.09.009.
20. Chaput JP, Brunet M, Tremblay A. Relationship between short sleeping hours and childhood overweight/obesity: Results from the 'Québec en Forme' Project. *Int J Obes* 2006;30(7):1080–85. PMID: 16534525. doi: 10.1038/sj.ijo.0803291.
21. Chaput JP, Lambert M, Gray-Donald K, McGrath JJ, Tremblay MS, O'Loughlin J, et al. Short sleep duration is independently associated with overweight and obesity in Quebec children. *Can J Public Health* 2011;102(5):369–74. PMID: 22032104.
22. Seegers V, Petit D, Falissard B, Vitaro F, Tremblay RE, Montplaisir J, et al. Short sleep duration and body mass index: A prospective longitudinal study in preadolescence. *Am J Epidemiol* 2011;173(6):621–29. PMID: 21303806. doi: 10.1093/aje/kwq389.
23. McNeil J, Tremblay MS, Leduc G, Boyer C, Bélanger P, Leblanc AG, et al. Objectively-measured sleep and its association with adiposity and physical activity in a sample of Canadian children. *J Sleep Res* 2015;24(2):131–39. PMID: 25266575. doi: 10.1111/jsr.12241.
24. Khan MK, Chu YL, Kirk SF, Veugelers PJ. Are sleep duration and sleep quality associated with diet quality, physical activity, and body weight status? A population-based study of Canadian children. *Can J Public Health* 2015;106(5):e277–82. PMID: 26451988. doi: 10.17269/cjph.106.4892.
25. Touchette E, Côté SM, Petit D, Liu X, Boivin M, Falissard B, et al. Short nighttime sleep-duration and hyperactivity trajectories in early childhood. *Pediatrics* 2009;124(5):e985–93. PMID: 19841107. doi: 10.1542/peds.2008-2005.
26. Byars KC, Yolton K, Rausch J, Lanphear B, Beebe DW. Prevalence, patterns, and persistence of sleep problems in the first 3 years of life. *Pediatrics* 2012;129(2):e276–84. PMID: 22218837. doi: 10.1542/peds.2011-0372.
27. Sadeh AVI, Mindell JA, Luedtke K, Wiegand B. Sleep and sleep ecology in the first 3 years: A web-based study. *J Sleep Res* 2009;18(1):60–73. PMID: 19021850. doi: 10.1111/j.1365-2869.2008.00699.x.
28. Mindell JA, Sadeh A, Wiegand B, How TH, Goh DY. Cross-cultural differences in infant and toddler sleep. *Sleep Med* 2010;11(3):274–80. PMID: 20138578. doi: 10.1016/j.sleep.2009.04.012.
29. Iglowstein I, Jenni OG, Molinari L, Largo RH. Sleep duration from infancy to adolescence: Reference values and generational trends. *Pediatrics* 2003;111(2):302–7. PMID: 12563055. doi: 10.1542/peds.111.2.302.
30. Staton SL, Smith SS, Pattinson CL, Thorpe KJ. Mandatory naptimes in child care and children's nighttime sleep. *J Dev Behav Pediatr* 2015;36(4):235–42. PMID: 25853460. doi: 10.1097/DBP.0000000000000157.
31. Hawkins SS, Takeuchi DT. Social determinants of inadequate sleep in US children and adolescents. *Public Health* 2016;138:119–26. PMID: 27207726. doi: 10.1016/j.puhe.2016.03.036.
32. Crosby B, LeBourgeois MK, Harsh J. Racial differences in reported napping and nocturnal sleep in 2- to 8-year-old children. *Pediatrics* 2005;115(Suppl 1):225–32. PMID: 15866856. doi: 10.1542/peds.2004-0815D.
33. Milan S, Snow S, Belay S. The context of preschool children's sleep: Racial/ethnic differences in sleep locations, routines, and concerns. *J Fam Psychol* 2007;21(1):20–28. PMID: 17371106. doi: 10.1037/0893-3200.21.1.20.
34. Crabtree VM, Korhonen JB, Montgomery-Downs HE, Jones VF, O'Brien LM, Gozal D. Cultural influences on the bedtime behaviors of young children. *Sleep Med* 2005;6(4):319–24. PMID: 15978515. doi: 10.1016/j.sleep.2005.02.001.
35. Smaldone A, Honig JC, Byrne MW. Sleepless in America: Inadequate sleep and relationships to health and well-being of our nation's children. *Pediatrics* 2007;119(Suppl 1):S29–37. PMID: 17272582. doi: 10.1542/peds.2006-2089F.
36. Singh GK, Kenney MK. Rising prevalence and neighborhood, social, and behavioral determinants of sleep problems in US children and adolescents, 2003–2012. *Sleep Disord* 2013;2013:394320. PMID: 23819057. doi: 10.1155/2013/394320.
37. Adam EK, Snell EK, Pendry P. Sleep timing and quantity in ecological and family context: A nationally representative time-diary study. *J Fam Psychol* 2007;21(1):4–19. PMID: 17371105. doi: 10.1037/0893-3200.21.1.4.
38. El-Sheikh M, Kelly RJ, Buckhalt JA, Benjamin Hinnant J. Children's sleep and adjustment over time: The role of socioeconomic context. *Child Dev* 2010;81(3):870–83. PMID: 20573110. doi: 10.1111/j.1467-8624.2010.01439.x.
39. Scher MS, Steppe DA, Banks DL. Postnatal adaptation of brain function in full-term neonates as assessed by EEG sleep analyses. *Sleep* 1995;18(7):531–35. PMID: 8552922. doi: 10.1093/sleep/18.7.531.
40. Sadeh A, Dark I, Vohr BR. Newborns' sleep-wake patterns: The role of maternal, delivery and infant factors. *Early Hum Dev* 1996;44(2):113–26. PMID: 8745423. doi: 10.1016/0378-3782(95)01698-8.
41. Freudigman KA, Thoman EB. Infants' earliest sleep/wake organization differs as a function of delivery mode. *Dev Psychobiol* 1998;32(4):293–303. PMID: 9589218. doi: 10.1002/(SICI)1098-2302(199805)32:4<293::AID-DEV4>3.0.CO;2-I.
42. Nikkola EM, Kirjavainen TT, Ekblad UU, Kero PO, Salonen MAO. Postnatal adaptation after Caesarean section or vaginal delivery, studied with the static-charge-sensitive bed. *Acta Paediatr* 2002;91(9):927–33. PMID: 12412867. doi: 10.1111/j.1651-2227.2002.tb02879.x.

43. Kim HR, Jung KY, Kim SY, Ko KO, Lee YM, Kim JM. Delivery modes and neonatal EEG: Spatial pattern analysis. *Early Hum Dev* 2003;75(1–2):35–53. PMID: 14652158. doi: 10.1016/j.earlhumdev.2003.09.004.

44. Raynes-Greenow CH, Hadfield RM, Cistulli PA, Bowen J, Allen H, Roberts CL. Sleep apnea in early childhood associated with preterm birth but not small for gestational age: A population-based record linkage study. *Sleep* 2012; 35(11):1475–80. PMID: 23115396. doi: 10.5665/sleep.2192.

45. Montgomery-Downs HE, Young ME, Ross MA, Polak MJ, Ritchie SK, Lynch SK. Sleep-disordered breathing symptoms frequency and growth among prematurely born infants. *Sleep Med* 2010;11(3):263–67. PMID: 20022298. doi: 10.1016/j.sleep.2009.06.007.

46. Piteo AM, Lushington K, Roberts RM, van den Heuvel CJ, Nettelbeck T, Kohler MJ, et al. Prevalence of snoring and associated factors in infancy. *Sleep Med* 2011;12(8):787–92. PMID: 21865083. doi: 10.1016/j.sleep.2011.01.019.

47. Boksa P, Krishnamurthy A, Sharma S. Hippocampal and hypothalamic type I corticosteroid receptor affinities are reduced in adult rats born by a caesarean procedure with or without an added period of anoxia. *Neuroendocrinology* 1996;64(1):25–34. PMID: 8811663. doi: 10.1159/000127094.

48. Morrison J, MacKenzie IZ. Cesarean section on demand. *Semin Perinatol* 2003; 27(1):20–33. PMID: 12641300. doi: 10.1053/sper.2003.50002.

49. Akacem LD, Simpkin CT, Carskadon MA, Wright KP Jr, Jenni OG, Achermann P, et al. The timing of the circadian clock and sleep differ between napping and non-napping toddlers. *PLoS ONE* 2015;10(4):e0125181. PMID: 25915066. doi: 10.1371/journal.pone.0125181.

50. Nakagawa M, Ohta H, Nagaoki Y, Shimabukuro R, Asaka Y, Takahashi N, et al. Daytime nap controls toddlers' nighttime sleep. *Sci Rep* 2016;6:27246. PMID: 27277329. doi: 10.1038/srep27246.

51. Komada Y, Asaoka S, Abe T, Matsuura N, Kagimura T, Shirakawa S, et al. Relationship between napping pattern and nocturnal sleep among Japanese nursery school children. *Sleep Med* 2012;13(1):107–10. PMID: 22172963. doi: 10.1016/j.sleep.2011.10.017.

52. Thorpe K, Staton S, Sawyer E, Pattinson C, Haden C, Smith S. Napping, development and health from 0 to 5 years: A systematic review. *Arch Dis Child* 2015;100(7):615–22. PMID: 25691291. doi: 10.1136/archdischild-2014-307241.

53. Chaput JP, Gray CE, Poitras VJ, Carson V, Gruber R, Olds T, et al. Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab* 2016;41(6 Suppl 3): S266–82. PMID: 27306433. doi: 10.1139/apnm-2015-0627.

RÉSUMÉ

OBJECTIFS : Un sommeil suffisant est important pour le développement sain des enfants. Il n'existe aucune information sur les variables prédictives du sommeil nocturne chez les tout-petits au Canada. Notre étude visait à déterminer la prévalence du sommeil de <11 heures consécutives par nuit et à cerner les facteurs associés chez les enfants de 1 à 2 ans au Canada.

MÉTHODE : Nous avons utilisé les données d'une enquête transversale : l'Enquête sur les jeunes Canadiens (EJC) de 2010. La mère biologique y indique la durée du sommeil de son enfant pendant la nuit. D'après les valeurs limites utilisées dans des études antérieures, le sommeil nocturne de courte durée a été défini comme étant un sommeil de <11 heures par nuit. Nous avons mené une analyse de régression logistique multivariée pour cerner les associations entre, d'une part, les variables sociodémographiques, maternelles, et les variables liées au sommeil et à l'enfant, et d'autre part, le sommeil nocturne de courte durée.

RÉSULTATS : L'analyse de 3 675 tout-petits a révélé que 57 % d'entre eux dormaient <11 heures par nuit. Selon les résultats de l'analyse de régression, l'appartenance à une famille d'immigrants présentait une corrélation significative avec le sommeil nocturne de courte durée. L'appartenance à un ménage à revenu élevé, le fait d'avoir une mère âgée de 25 à 34 ans au moment de l'enquête et les siestes de ≥2 heures durant la journée présentaient des corrélations significatives avec le sommeil de ≥11 heures par nuit. Les autres variables sociodémographiques, maternelles et liées à l'enfant n'étaient pas associées au sommeil nocturne.

CONCLUSION : Il s'agit de la première étude populationnelle représentative à l'échelle nationale à avoir examiné les facteurs liés au sommeil nocturne de courte durée chez les tout-petits canadiens. Les facteurs sociodémographiques et la durée des siestes étaient associés à la durée du sommeil nocturne. Des efforts de sensibilisation plus poussés sur l'hygiène du sommeil durant la petite enfance sont recommandés, surtout auprès des populations vulnérables.

MOTS CLÉS : enfants; durée du sommeil; facteurs; Canada