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Impact of sleep on injury risk among rural children

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Abstract

Objectives: To examine sleep patterns in a large cohort of rural children and explore the association between sleep patterns and injury occurrence.

Methods: Cross-sectional analyses of the baseline survey from a prospective cohort study (2012 to 2017) was conducted with 46 rural schools in Saskatchewan, Canada who distributed surveys to parents of 2275 rural dwelling farm and nonfarm children aged 0 to 17 years. Parents reported child sleep characteristics and farm or nonfarm injury in the previous calendar year. Multivariable log-binomial regression examined associations between sleep characteristics and injury risk.

Results: There was a significant trend of decreasing sleep duration with increasing age (P-trend < 0.001). Short sleep duration on weekdays (RR: 2.14; 95% CI: 1.25 to 3.66) and sleep debt (RR: 1.89; 95% CI: 1.21 to 2.95) increased injury risk in school-age children (7 to 12 years) but not in teens. A nearly fivefold increase in injury risk was identified among school-age children reporting all sleep problems (RR: 4.99; 95% CI: 1.99 to 12.50). Snoring in teens (13 to 17 years), often a symptom of obstructive sleep apnea, was associated with increased injury risk (RR: 1.98; 95% CI: 1.17 to 3.33). There were no statistically significant associations identified between sleep characteristics and injury risk in preschool children.

Conclusion: Injuries to rural children are an important public health concern. This study highlights the impact of sleep problems on risk for injury among rural children. These findings are discussed in light of the recent American Academy of Pediatrics Technical Report on Insufficient Sleep in Adolescents and Young Adults.

Keywords: *Injury risk; Risk factors/reduction; Rural children/adolescents; Sleep; Snoring.*

Injury is the leading cause of death in children ages 1 to 18 years (1,2). Rural children experience higher overall injury risk than urban children and their injuries are more severe (3). Farm injuries are important contributors to high injury risk among rural children (4,5). However, rural children are also at higher risk for other unintentional injuries including motor vehicle crashes, drowning, falls, poisoning and bicycle-related crashes (3).

Current injury prevention theory suggests interventions focus first on environmental, then behavioural risk factors and sometimes their interactions. Higher injury risk experienced by rural children has primarily been explained by the geographic, environmental and social milieu that define rural areas and these factors are not readily amenable to modification (3). On the individual level, the role of sleep as a modifiable injury risk factor in rural children has rarely been studied (6).

Sleep is critical in child health and safety. The recent American Academy of Pediatrics (AAP) (7) technical report highlights health consequences of inadequate sleep and provides clinical recommendations. Inadequate sleep may result in poor cognitive function, impaired judgment, inattention and compromised decision-making (7), which can increase injury risk in hazardous environments like the farm worksite.

We explored sleep and its possible health consequences in a large cohort of rural children. Our objectives were to profile sleep duration on school nights and weekends, profile other sleep characteristics (sleep debt, falling asleep in class, snoring and sleep apnea) and explore the potential impact of sleep patterns on injury risk. Such evidence could inform clinical guidelines and injury prevention recommendations for parents.

METHODS

Study design

The study base was the *Saskatchewan Farm Injury Cohort Study* (SFIC). The SFIC is an ongoing study of injury and its possible determinants on Saskatchewan farms (8,9). In Phase 2 of this project (2012 to 2017), a new cohort was developed consisting of rural dwelling farm and nonfarm children. Upon initiation, a large baseline survey was conducted of study participants that lent itself to cross-sectional analyses. Protocols for this SFIC component were reviewed and approved by the Behavioural Research Ethics Board at the University of Saskatchewan and Queen's University Health Sciences and Affiliated Teaching Hospital Research Ethics Board.

Study population

Our study population included children from rural Saskatchewan who lived on farms or in small rural towns. The cohort was recruited through a multistage process, with individual students nested within families, families within schools and schools within school divisions. Our primary target population included all children younger than 18 years.

Eleven rural school divisions were targeted for participation and seven (64%) agreed to participate. Within the seven school divisions, individual schools were randomly selected until a study population of 12,000 students was identified. Of the 64 schools contacted, 46 (71.8%) representing 9300 students agreed to participate. Study packets were distributed by the schools and 1129 families completed questionnaires. Useable questionnaires included personal level data on 2328 children (including 325 prekindergarten children). Excluding prekindergarten children, the final participation rate for the school students was 21.5%.

Study instrument

The questionnaire contained items assessing children's engagement in farm activities, injury occurrence in the past calendar year, general health status, health behaviours and sociodemographic characteristics. Where possible, questions were selected from the SFIC adult questionnaire to enhance comparability between cohorts. Questions were tested for face validity through extensive piloting of the child survey, past testing and use of items in the adult SFIC (8) or use in other population-based surveys. The final questionnaire content and data retrieval method (return through schools) were based upon input from content experts and pilot testing in four Saskatchewan regions (10).

Key study variables

Sleep duration

Typical weekday and weekend sleep duration in hours was estimated for each child, derived from variables describing typical times the child went to bed and got up in the morning for school days and weekends, respectively. We separated children into categories of sleep duration based upon past precedents (6) and distribution of sleep in our sample: short duration was <11 hours per night in preschool children, <10 hours in school-age children and <9.25 hours in teens.

Sleep debt

This was estimated by calculating the difference between weekend and weekday sleep duration and defined operationally as sleeping longer on weekends than on weekdays (7).

Other sleep characteristics

For each child, parents reported (yes or no) whether the child snores, has ever fallen asleep in class and has been medically diagnosed with sleep apnea. A summative index for reported sleep problems (*0, 1, 2 or 3*) was created from short sleep duration on weekdays, sleep debt and snoring.

Individual-level covariates

For each participant, we documented sex; age, categorized into three groups based on developmental characteristics and farm injury risk (*preschool: 0 to 6 years, school-age: 7 to 12 years, teens: 13 to 17 years*); body mass index (BMI) based on reported height and weight, separated into *nonoverweight*, *overweight* and *obese* categories using age/sex specific thresholds for children 2 to 17 years old (11), physical activity for at least 60 minutes per day over a typical week (0 to 7 days); number of comorbidities (*0, 1 and* ≥2) and exposure to farms in the past year (*family operates a farm, visited a farm, none*). In regression analyses, farm exposure was modelled as '*yes*' or '*no*' as to whether the child lived on a farm.

Injury

For each child, parents reported the number of self-treated and medically-treated farm injuries (occurred in a farm environment or off farm but involved farm work) and nonfarm injuries (all other injuries, excluding sports injuries) that occurred in the previous calendar year. Parents provided additional details about the most serious injury experienced by each child.

Statistical analyses

All analyses were conducted in SAS version 9.4 (SAS Institute, Cary, NC, 2013). The cohort was described by demographic and health characteristics. Average hours of reported weekday and weekend sleep duration and sleep debt (mean [SD]) were graphed separately by age (modelled in 2-year intervals) and sex. Tests for linear trend in these sleep indicators were calculated separately for boys and girls across age categories.

Sleep patterns were described and analyses stratified by age group and sex. Rao-Scott chi-square tests, adjusted for clustering of children within families, were used to test for differences between boys and girls within each age group. Fisher's exact chi-square test was used in cases with small cell sizes.

Multivariable log-binomial regressions, using SAS PROC GENMOD, were conducted to examine associations between sleep characteristics and injury risk in the three age groups. Adjusted relative risks (RR) and associated 95% confidence intervals (CI) were estimated, using the generalized estimating equation (GEE) to account for clustering by family. Physical activity, BMI, comorbidities and farm exposure were examined as potential confounders. Age and sex were forced into these models, with selection of additional covariates governed by backwards elimination (P<0.15) and change in estimate approach (>10% change in the main effects comparing models that included/excluded potential confounders). The final multivariable models, fitted separately for each sleep variable, adjusted for age, sex and BMI status in school-age children and teens and for age and sex in preschool children.

RESULTS

The sample

Overall, 28% of the cohort were preschool age (mean±SD age 4.2 ± 1.7 years), 45% were school-age (mean±SD age 9.4 ± 1.7 years) and 27% were teens (mean±SD age 14.8 ± 1.4 years) (Table 1). One-quarter of children were from a family that operated a farm, while 53% had no exposure to farms in the previous year. The majority of children were nonoverweight (69%), physically active at least 5 days a week (61%) and had no comorbidities (85%). In the previous calendar year, 11% of children had sustained an injury.

Sleep duration

Average weekday and weekend sleep duration decreased with age in both sexes (P-trend < 0.001) (Figure 1). Decreases in sleep duration with increasing age were larger on weekdays than weekends. Sleep debt significantly increased across age groups in both sexes, with the steadiest increase from 10 to 11 to 16 to 17 years.

Other sleep characteristics

Snoring prevalence in children ranged from 13.2% in teenage boys to 19.9% in preschool girls and was not significantly different by age group or sex (Table 2). Falling asleep in class was more common among teens. Sleep debt increased with age in both sexes but among school-age children and teens, it was more common in girls. The frequency of reported sleep problems (short sleep duration, sleep debt and snoring) was significantly higher in teens. In school-age children, sleep problems were more common in girls.

Table 1. Description of children and youth participating in the Saskatchewan Farm Injury Project: Child cohort (n=2275)

	n	Col %
Age, years		
0–6	646	(28)
7–12	1014	(45)
13–17	615	(27)
Sex		
Male	1103	(49)
Female	1163	(51)
Missing	9	
Exposure to farms		
Family operates a farm	577	(25)
Visited a farm	504	(22)
None	1194	(52)
Body mass index		
Nonoverweight	1062	(69)
Overweight	299	(19)
Obese	182	(12)
Missing	732	
Physical activity over a typical week (days physically active at least 60 min)		
0	62	(3)
1–2	196	(9)
3–4	599	(27)
5–6	852	(38)
7	527	(24)
Missing	39	
Comorbidities		
0	1857	(85)
1	269	(12)
2+	68	(3)
Missing	81	
Specific comorbidities:		
Asthma	173	(8)
Respiratory allergies (e.g., hay fever)	106	(5)
Attention deficit disorder	67	(3)
Anxiety disorder	35	(2)
Stomach or intestinal problems	34	(1)
Migraines	32	(1)
Depression	20	(1)
Mood disorder	12	(1)
Injury		
Farm injury	24	(1)
Missing	44	
Nonfarm injury	212	(10)
Missing	108	

Sleep characteristics and injury risks

The effects of sleep characteristics on injury risk varied by age group (Table 3). In preschool children, there were no statistically significant associations identified, although based upon a liberal interpretation of the CI, there was a suggestion of increased risk associated with snoring (RR: 1.71; 95% CI: 0.90 to 3.24). In school-age children, short sleep duration on weekdays (RR: 2.14; 95% CI: 1.25 to 3.66) and sleep debt (RR: 1.89; 95% CI: 1.21 to 2.95) were each significantly associated with increased injury risk, while snoring was suggestive (RR: 1.55; 95% CI: 0.92 to 2.61). Results from examining the summative index indicated that reporting two (RR: 2.59; 95% CI: 1.42 to 4.71) or all (RR: 4.99; 95% CI: 1.99 to 12.5) of short sleep duration on weekdays, sleep debt and snoring compared to reporting none of these sleep problems was associated with increasingly greater injury risk. Among teens, paradoxically, short sleep duration on weekends appeared protective against injury (RR: 0.53; 95% CI: 0.29

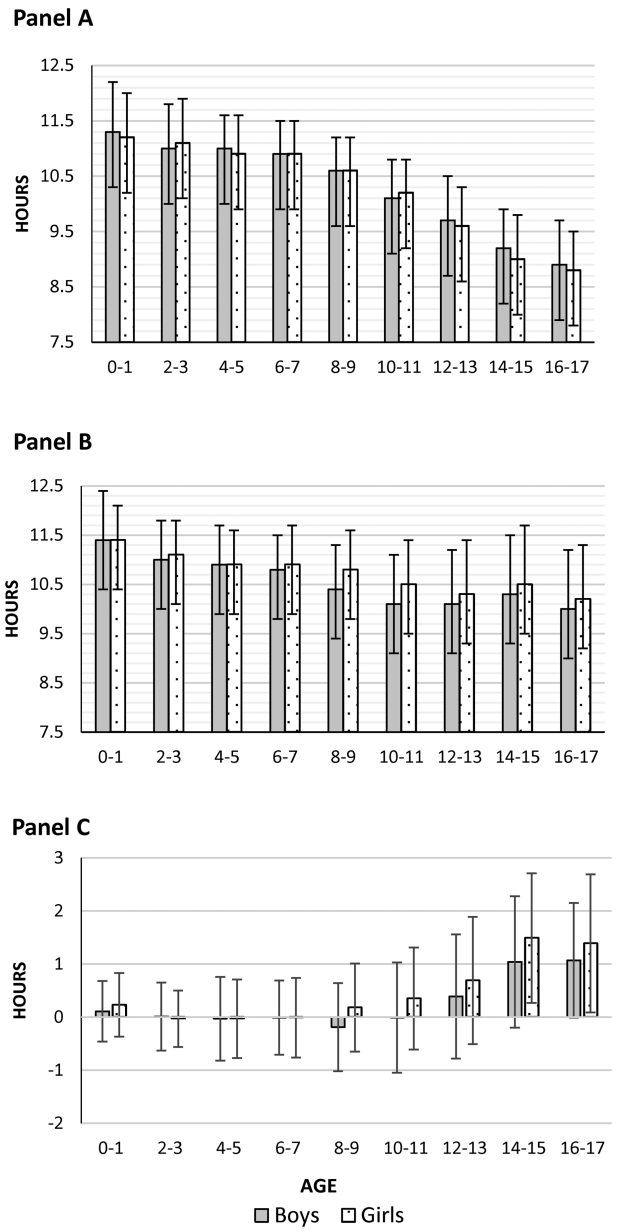

Figure 1. Average weekday (Panel A) and weekend (Panel B) sleep duration, and sleep debt on weekdays (Panel C), presented by age for boys and girls. Values represent the mean and error bars the standard deviation. Tests for trend by age were significant at P<0.001

Table 2. Description of sleep characteristics in children and youth, stratified by age and sex

	Preschool (0–6)			School age (7–12)			Teens (13–17)				
	Boys (n=324)	Girls (n=316)		Boys (n=496)	Girls (n=515)		Boys (n=283)	Girls (n=332)		Boys	Girls
	(col%)	(col%)	P*	(col%)	(col%)	P*	(col%)	(col%)	P*	P†	P†
Short sleep duration on weekdays[b]											
Yes	31.8	29.7	0.56	17.8	17.7	0.97	55.4	61.5	0.13	<0.01	<0.01
Missing (n)	13	16		1	6		3	2			
Short sleep duration on weekends[b]											
Yes	34.3	30.4	0.32	20.1	9.5	<0.01	25.0	20.0	0.17	<0.01	<0.01
Missing (n)	12	17		8	10		11	12			
Sleep debt‡											
None	77.7	73.7	0.25	70.1	53.5	<0.01	30.9	22.5	0.02	<0.01	<0.01
>0–1 h	17.1	22.0	0.13	22.8	32.8	<0.01	31.6	29.7	0.61	<0.01	<0.01
>1 h	5.2	4.4	0.66	7.2	13.7	<0.01	37.5	47.8	0.01	<0.01	<0.01
Missing	14	20		8	12		11	12			
Falling asleep in class											
Yes	2.9	1.0	0.07	2.8	1.8	0.25	10.8	13.4	0.32	<0.01	<0.01
Missing	8	8		3	1		4	4			
Snoring											
Yes	15.0	19.9	0.12	17.6	17.7	0.96	13.2	14.6	0.62	0.25	0.23
Missing	3	4		1	1		2	4			
Sleep apnea											
Yes	0.0	0.6	0.24[a]	0.4	0.0	0.24[a]	0.4	0.3	0.99[a]	0.62[a]	0.11[a]
Missing	12	13		15	19		10	12			
Summative index**											
0	48.2	45.1	0.45	52.2	41.6	<0.01	17.0	12.0	0.08	<0.01	<0.01
1	35.0	34.9	0.99	32.9	37.4	0.14	33.0	30.6	0.54	0.97	0.06
2	15.9	18.0	0.50	12.5	18.5	0.01	45.6	50.5	0.24	<0.01	<0.01
3	1.0	2.0	0.28	2.5	2.6	0.91	4.4	6.9	0.21	0.02	<0.01
Missing	15	21		9	12		13	15			

*P value for Rao-Scott chi-square test comparing boys and girls within the age group. †P value for Rao-Scott chi-square test comparing preschool, school-age and teens across each row. ‡Calculated as the difference between typical weekend and weekday sleep duration. **Summative index: 0 = no sleep problems, 1 = one of short sleep duration on weekdays, sleep debt or snoring, 2 = two of short sleep duration, sleep debt or snoring, 3 = short sleep duration, sleep debt and snoring. [a]Fishers exact chi-square test. [b]Short sleep duration in preschool-age children modelled as < 11 h, in school-age children as < 10 h and in Teens as < 9.25 h

to 0.99). However, snoring was associated with increased injury risk (RR: 1.98; 95% CI: 1.17 to 3.33).

DISCUSSION

We examined sleep patterns in a large cohort of rural children and explored associations between sleep patterns and injury occurrence. We documented a significant trend of decreasing sleep duration with increasing age. We found that sleep debt increased with age in both sexes but was more common in girls. We identified that short sleep duration on weekdays and sleep debt increased injury risk in school-age children but not in teens. Also, in school-age children, we identified through our summative index a nearly fivefold increase in injury risk compared to children with none of these sleep problems. Finally, we found that snoring increased the injury risk among teens and potentially preschool and school-age children.

AAP technical report

Teens

The recent AAP technical report highlighted causes and consequences of insufficient sleep and focused exclusively on adolescents and young adults (13 to 22 years) (7). Focus on adolescents is important, as our study identified significant sleep debt in teens. Thus, clinicians must continue to focus on insufficient sleep in adolescents, especially during weekdays when teens are involved with school, work and other responsibilities simultaneously.

A key finding from our study is that snoring but not sleep debt increased injury risk in rural teens. Snoring may be a symptom of obstructive sleep apnea and has been shown to impair cognitive skills and increase risk-taking behaviour (12), both known injury risk factors. Thus, clinicians need to broaden their focus on sleep to include the full spectrum of sleep issues (quantity and quality) to address injury and other health consequences of inadequate sleep (13).

School-age children

Cognitive development plays a key role in children's safety (14). Many cognitive skills, like attention, reaction time, information-processing and decision-making are not fully developed in school-age children. These cognitive skills may be further compromised by short sleep duration and sleep debt, thus increasing injury risk.

While the AAP Technical Report centred on adolescents and young adults, our results suggest the need to extend the focus to school-age children. We identified both short sleep duration on weekdays and sleep debt as injury risk factors in rural school-age children. Thus, directing attention to school-age children

Table 3. Multivariable regression examining the associations between sleep characteristics and injury risk among children and youth

	Preschool (0–6)				School age (7–12)				Teens (13–17)			
Sleep Characteristics	n	%inj	RR	(95% CI)	n	%inj	RR	(95% CI)	n	%inj	RR	(95% CI)
Duration												
Short sleep duration on weekdays†												
No	398	8.5	1.00	Ref.	523	8.2	1.00	Ref.	192	14.1	1.00	Ref.
Yes	173	6.4	0.73	(0.38–1.39)	121	15.7	**2.14**	**(1.25–3.66)**	264	15.2	1.17	(0.75–1.84)
Short sleep duration on weekends†												
No	385	8.3	1.00	Ref.	543	9.8	1.00	Ref.	351	16.2	1.00	Ref.
Yes	186	7.0	0.82	(0.44–1.53)	101	8.9	0.78	(0.41–1.48)	105	9.5	**0.53**	**(0.29–0.99)**
Sleep Debt‡												
No	433	7.2	1.00	Ref.	402	7.7	1.00	Ref.	120	15.8	1.00	Ref.
Yes	138	10.1	1.43	(0.79–2.59)	242	12.8	**1.89**	**(1.21–2.95)**	336	14.3	0.96	(0.58–1.58)
Falling asleep in class												
No				N/A	627	9.6	1.00	Ref.	400	14.3	1.00	Ref.
Yes					17	11.8	1.13	(0.36–3.57)	56	17.9	1.18	(0.64–2.16)
Snoring												
No	467	7.1	1.00	Ref.	538	8.7	1.00	Ref.	399	13.0	1.00	Ref.
Yes	104	11.5	1.71	(0.90–3.24)	106	14.2	1.55	(0.92–2.61)	57	26.3	**1.98**	**(1.17–3.33)**
Summative Index*												
0	266	6.0		Did not converge	305	6.9	1.00	Ref.	66	19.7	1.00	Ref.
1	203	10.3			223	9.4	1.43	(0.81–2.53)	148	8.8	**0.46**	**(0.22–0.93)**
2	94	8.5			102	15.7	**2.59**	**(1.42–4.71)**	217	15.2	0.85	(0.48–1.52)
3	8	0.0			14	28.6	**4.99**	**(1.99–12.5)**	25	32.0	1.77	(0.80–3.91)

In preschool children, relative risk (RR) estimates adjusted for age and gender; in school-age children and teens adjusted for age, gender and BMI; all models adjusted for clustering by family. †Short sleep duration in preschool-age children modelled as < 11 h; in school-age children as < 10 h and in teens as < 9.25 h. ‡Sleep debt defined as sleeping less on weekdays than weekends on average. *Summative index: 0 = No sleep problems, 1 = one of short sleep duration on weekdays, sleep debt or snoring, 2 = two of short sleep duration, sleep debt or snoring, 3= short sleep duration, sleep debt and snoring

may provide an earlier window of time to intervene to improve sleep practices before adolescence.

Although not statistically significant, snoring appeared to be associated with increased injury risk. When snoring was added to the summative index that included sleep duration and sleep debt, we demonstrated an almost five-fold increase in injury risk in this age group. Again, this highlights the need for clinicians to broaden their focus on sleep to include the full spectrum of sleep issues (quantity and quality), since snoring has been linked to impaired cognitive functioning.

Preschool children

We found no statistically significant associations between sleep patterns and injury risk in preschool children. However, there was a suggestion of increased risk associated with snoring. Snoring in this age group may be an important predictor of obstructive sleep apnea. Thus, it is never too early for clinicians to begin asking rural parents about sleep patterns that may place their children at a higher injury risk.

Sleep impairment in the presence of hazards

Previous research has shown a relationship between short sleep duration and injury among rural adults (13) and between snoring and injury in adult male farmers (15). Our results suggest that both short sleep duration and snoring are important risk factors from childhood to adulthood in rural populations. It may be that sleep impairment in the presence of hazards, whether the hazards are mechanized or nonmechanized risks on farms, or the unique challenges and risks of rural environments increases the vulnerability of rural people to injury. This may explain the association between sleep and injury risk we observed among rural children in our study.

Implications for paediatric practice

Sleep characteristics are modifiable risk factors and clinicians can play a pivotal role in identifying and managing these sleep problems. Initial strategies should include incorporating sleep duration and snoring history into previsit questionnaires, counselling parents about sleep hygiene and unhealthy sleep practices and referring children with persistent snoring for follow-up care. The latter point deserves particular emphasis, as evidence shows that snoring among children and youth may be an important symptom of obstructive sleep apnea (12), thus meriting full diagnostic approaches and treatment.

Strengths and limitations

Major strengths of this study include our focus on rural children who are at high risk for injury and the practical implications of our findings for clinicians. The large sample size and wide age range are also strengths, as it permitted meaningful subanalyses by age group and sex. Limitations of our study warrant comment. The sample was designed to be large and heterogeneous to permit study of relationships between health-related variables, as opposed to being representative per se. Hence, the modest response rate at the student level is of less concern in terms of possible selection biases. We did not use a validated sleep questionnaire, as that was not the focus of the larger study. Thus, there may be some potential inaccuracies in parental reports of sleep characteristics, particularly for teens. Parental reports of injury may have been subject to errors in recall. In addition, our cross-sectional survey design does not allow us to infer causation; we acknowledge that multiple risk factors for injury may be at play within the geographic, environmental, and social milieu that defines the rural experience. Nonetheless, these findings demonstrate that sleep patterns are important factors in rural childhood injury.

CONCLUSION

Injuries to children in rural areas are an important public health concern. Our study highlights the impact of sleep problems on injury risk among rural children and adds to the growing body of evidence about the importance of sleep for safety and health.

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Conflict of Interest

The authors have indicated they have no potential conflicts of interest to disclose.

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