Impact of excessive daytime sleepiness on the safety and health of farmers in Saskatchewan

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BACKGROUND: Sleep disorders may negatively impact the health and well-being of affected individuals. The resulting sleepiness and impaired cognitive functioning may also increase the risks for injury.
OBJECTIVE: To examine the relationship between daytime sleepiness, defined as an Epworth Sleepiness Scale score >10, and self-reported sleep apnea, as potential determinants of farming-related injury and self-perceived physical health.
METHODS: Phase 2 of the Saskatchewan Farm Injury Cohort Study (2013) involved a baseline survey that included 2849 individuals from 1216 farms. A mail-based questionnaire was administered to obtain self-reports regarding sleep, demographics, farm injuries and general physical health. Multilevel logistic regression was used to quantify relationships between excessive daytime sleepiness and health.
RESULTS: The prevalence of excessive daytime sleepiness was 15.1%; the prevalence of diagnosed sleep apnea was 4.0%. Sleepiness was highest in the 60 to 79 (18.7%) and ≥80 (23.6%) years of age groups, and was higher in men (19.0%) than in women (9.3%). Injuries were reported by 8.4% of individuals, and fair or poor health was reported by 6.2%. Adjusting for confounding, individuals with excessive daytime sleepiness appeared more likely to experience a farming-related injury (OR 1.34 [95% CI 0.92 to 1.96]) and were more likely to report poorer physical health (OR 2.19 [95% CI 1.45 to 3.30]) than individuals with normal daytime sleepiness.
CONCLUSION: Excessive daytime sleepiness, a potentially treatable condition, appeared to be common in farmers and to negatively affect their health. Sleep disorder diagnosis and treatment programs did not appear to be used to their full potential in this population.

Key Words: *Agriculture; Farming; Health; Injury; Sleep apnea; Sleepiness*

Les répercussions de la somnolence diurne excessive sur la sécurité et la santé des agriculteurs de la Saskatchewan

HISTORIQUE : Les troubles du sommeil peuvent nuire à la santé et au bien-être des personnes qui en souffrent. La somnolence et la fonction cognitive perturbée qui en résultent peuvent également accroître les risques de blessure.
OBJECTIF : Examiner la relation entre la somnolence diurne, définie comme un indice supérieur à dix sur l'échelle de somnolence d'Epworth, et l'apnée du sommeil autodéclarée, à titre de déterminants potentiels des blessures liées à l'agriculture et à l'autoperception de santé physique.
MÉTHODOLOGIE : La phase 2 de l'étude de cohorte de la Saskatchewan sur les blessures en agriculture (2013) consistait en un sondage de départ incluant 2 849 personnes provenant de 1 216 exploitations agricoles. Un questionnaire a été distribué par la poste pour obtenir des autodéclarations sur le sommeil, la démographie, les blessures en agriculture et la santé physique générale. La régression logistique multiniveau a été utilisée pour quantifier les relations entre la somnolence diurne excessive et la santé.
RÉSULTATS : La prévalence de somnolence diurne excessive s'élevait à 15,1 %, tandis que celle d'apnée du sommeil diagnostiquée s'élevait à 4,0 %. Les groupes des 60 à 79 ans (18,7 %) et des 80 ans et plus (23,6 %) étaient plus somnolents, et les hommes (19,0 %) l'étaient davantage que les femmes (9,3 %). De plus, 8,4 % des agriculteurs ont déclaré des blessures, et 6,2 %, une santé satisfaisante ou une mauvaise santé. Après rajustement compte tenu des facteurs confusionnels, les agriculteurs qui présentaient une somnolence diurne excessive semblaient plus susceptibles de subir une blessure liée à l'agriculture (RC 1,34 [95 % IC 0,92 à 1,96]) et risquaient davantage de se déclarer en moins bonne santé physique (RC 2,19 [95 % IC 1,45 à 3,30]) que ceux qui présententaient une somnolence diurne normale.
CONCLUSION : La somnolence diurne excessive, un problème qui peut être traité, semble être courante chez les agriculteurs et nuire à leur santé. Le diagnostic de troubles du sommeil et les programmes thérapeutiques ne semblaient pas être utilisés à leur plein potentiel au sein de cette population.

Although sleep disorders are common and potentially treatable, they are frequently undiagnosed. Such disorders can be characterized by excessive daytime sleepiness, which is experienced by up to 20% of the general population (1,2). The most commonly described sleep disorder is obstructive sleep apnea (3,4), which is often associated with excessive daytime sleepiness (5) and characterized by intermittent complete and/or partial airway closure during sleep (6,7). Many individuals with obstructive sleep apnea, who could benefit from treatment, have not received a clinical diagnosis (8-10). Continuous positive airway pressure is a known efficacious therapy that can mitigate health risks (8). In the absence of sleep apnea, excessive daytime sleepiness is often treatable through addressing the underlying condition (11), making it a potentially modifiable risk factor for poor health outcomes.

Excessive daytime sleepiness and sleep apnea, frequently occurring together, are associated with several adverse health and safety consequences. These include reduced quality of life, decreased psychosocial function, cardiovascular disease and accidental injury (11,12). Cognitive impairments in the areas of attention, memory and decision making (13) leave affected individuals susceptible to motor vehicle (14) and occupational injury (1,15).

Farming populations may be at greater risk for sleep disorders because they tend to be older, male, and more likely to be overweight or obese than nonfarming groups (16), all known risk factors for sleep disorders. This group may also be vulnerable to the negative consequences associated with excessive daytime sleepiness because of the occupational hazards and long work hours associated with farming. Sleep deprivation is known to be associated with increased risk for injury in farmers (17-20). Symptoms of sleep apnea, including loud snoring (20,21) and cessation of breathing during sleep (22), have been associated with injury risk in farmers, although the evidence is inconsistent (17,23-26).

The Epworth Sleepiness Scale (ESS) is helpful in identifying individuals with excessive daytime sleepiness. Using a cut-off score of >10, the ESS is effective in distinguishing normal sleepers with healthy sleeping habits from those with sleep problems such as sleep apnea

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(3,27). Individuals with untreated sleep apnea often have ESS scores ≥11, and scores increase linearly with increasing severity, although a wide range of scores are reported (28). Although excessive daytime sleepiness is an important predictor of obstructive sleep apnea, only approximately one-half of patients with obstructive sleep apnea exhibit daytime somnolence as reflected in a high ESS score (28). These studies provide evidence that the ESS has high sensitivity, albeit moderate specificity, for identifying obstructive sleep apnea when applied to general populations. The ESS is also effective at detecting less prevalent sleep disorders, such as narcolepsy, with a sensitivity of 93.5% and specificity of 100% (29).

Farming populations are at an elevated risk for occupational injury and accidental death (30,31). Alone, educational interventions focusing on the avoidance of dangerous farm practices and tasks do not appear to be effective in reducing unsafe farm practices (32). This led us to believe that all six steps of the hierarchy of control (33) are important in the reduction of farm injury. The findings of the present study add important contributions to the literature on injury risk management and prevention in farm populations.

We had a unique opportunity to continue our study (21) investigating the prevalence of potentially undiagnosed sleep disorders and their impact on health and safety among farmers. Through the present study, we aimed to more accurately describe the extent of this problem, and its possible effects on injury risk and health status. Our specific objectives were, therefore, to: describe the prevalence of excessive daytime sleepiness in a farming cohort using the validated ESS; describe individuals with excessive daytime sleepiness and diagnosed sleep apnea in terms of quality and quantity of sleep, and daytime drowsiness; and to examine the potential impact of excessive daytime sleepiness and diagnosed sleep apnea on the injury experiences and self-perceived health status of farmers.

METHODS

Study population

The Saskatchewan Farm Injury Cohort Study (SFIC) was developed to gain increased understanding of the safety and health of farm populations. A phase 1 study was conducted from 2007 to 2012 (34), with phase 2 currently underway. The baseline sample for phase 2 includes farms from phase 1 that agreed to ongoing participation (n=588), as well as farms (n=628) from a set of municipalities that were new entrants to the cohort, yielding an overall sample size of 2849 individuals dwelling or working on 1216 farms. A mailed health and operational survey was administered during January through July 2013, and completed by a single informant on each farm. The Dillman total design method was used (35). Response rates at the rural municipality level were 93% (74 of 80) and 48.8% at the farm level. The intention was to obtain a large and heterogeneous – but not necessarily representative – sample of farmers in Saskatchewan. Informed consent was indicated by participants through completion and return of the questionnaire, as explained in the participant information letter. The study protocol was approved by the Behavioural Research Ethics Board of the University of Saskatchewan, Saskatoon, Saskatchewan.

Inclusion criteria were: participation in the Phase 2 SFIC baseline study (active operating farm in Saskatchewan as of January 1, 2013); valid responses to questionnaire items used to classify respondents based on their sleep disorder status; and provision of basic demographic information required for subgroup and regression analyses. Individuals <16 years of age were excluded because the ESS has not been validated for use in pediatric populations.

Outcome assessment

The ESS was used to identify individuals in the farm cohort with excessive daytime sleepiness, which could indicate an undiagnosed sleep disorder. The ESS has been validated as a means by which sleep disorders (27,29), primarily obstructive sleep apnea (3,36,37), may be detected. The scale has been shown to have good internal consistency (Cronbach alpha = 0.78 and 0.80) and construct validity for assessing daytime sleepiness (38). In obtaining the ESS score, participants reported how likely they were to doze off or fall asleep in eight common situations. Each item is scored on a four-point Likert scale (0 = 'would never doze'; 1 = 'slight chance of dozing'; 2 = 'moderate chance of dozing'; and 3 = 'high chance of dozing'). The individual items are summed to determine an overall score ranging from 0 to 24. An ESS score >10 was considered to be abnormal (3,27) and indicative of excessive daytime sleepiness in the present study. If ≤2 ESS items were missing (n=102), values were inputted based on their completed response means. If >2 items were missing (n=44) the participant was excluded. Participants were categorized as having 'diagnosed' sleep apnea according to previous physician diagnoses as determined on the questionnaire.

Risk factor assessment

Individual risk factors and potential confounders considered included: sex; age group (16 to 40, 41 to 50, 51 to 60, ≥61 years); calculated body mass index (BMI, 'normal' [<25 kg/m^2], 'overweight' [25 kg/m^2 to 29.9 kg/m^2], 'obese' [≥30 kg/m^2]), with age/sex-specific BMI calculated for participants <18 years of age based on Cole et al (39), in which adolescent BMI classification is mapped to the adult categories of BMI status; level of formal education completed ('less than high school', 'high school', 'university', 'technical/community college'); relationship to the farm owner-operator ('primary owner-operator', 'spouse', 'parent', 'child', 'other relative'); typical sleep duration ('>7 h', '6 h to 7 h', '<6 h'); number of comorbidities (0, 1, ≥2), medication use (0,1, ≥2 classes); current smoking status ('yes' or 'no') (40); alcohol consumption in the previous year (four categories: 'never', 'at most once a month', 'at most once a week', 'more than once a week') (40); and hours of farm and off-farm work averaged over the full year ('none', 'part-time' [<30 h/week], 'full-time' [≥30 h/week]) (41). Variables describing sleep characteristics included sleep duration, snoring, snoring volume and reported breathing cessation during sleep (42).

Farm factors considered were: total farm acreage (≤500, 501 to 1500, 1501 to 2500, >2500 total acres); commodities produced; safety conditions and practices on the farm as perceived by the farm respondent ('excellent', 'good', 'fair', 'poor'); frequency that cash flow shortages and debt were sources of worry (five categories: 'never' through 'daily') (43); and the farm operation income at the end of the most recent fiscal year ('large deficit', 'small deficit', 'break even', 'small surplus', 'large surplus').

Two safety and health indicators were modelled as outcomes: the occurrence of a farming-related injury during the previous year (44); and self-perceived physical health status (45). Farming-related injuries were defined as "unintentional injuries during the calendar year 2012 that occurred in a farm environment, whether the person was working or not, including injuries that occurred off the farm but involved farm work". General physical health was self-rated from 'poor' to 'excellent' using a five-item Likert-like scale and dichotomized for analytical purposes.

Statistical analysis

Prevalence levels of excessive daytime sleepiness and diagnosed sleep apnea were described overall, and then according to key demographic characteristics. The Rao-Scott χ^2 method was used to compare the distributions, adjusting for clustering. In cases in which categories had cell counts of 0, Pearson's χ^2 was used. Quality and quantity of sleep and daytime sleepiness was then described using cross-tabulations and associated 95% CIs.

A series of multilevel logistic regression analyses, using the SAS Procedure PROC GLIMMIX, were then conducted to study the associations between excessive daytime sleepiness and diagnosed sleep apnea, and farm injuries and worse perceived general physical health. A purposeful modelling strategy was used, with consideration of past evidence, theory and model parsimony in the selection of covariates. Backward elimination (P<0.15), followed by the change in estimate

TABLE 1
Prevalence of excessive daytime sleepiness and diagnosed sleep apnea in individuals involved in phase 2 of the Saskatchewan Farm Injury Cohort Study, 2013

		Individual categories			
		Excessive daytime sleepiness (n=376)	Diagnosed sleep apnea (n=100)	No excessive daytime sleepiness or sleep apnea (n=2018)	
Characteristic	Total (n=2494), n	n (row %)	n (row %)	n (row %)	P
Overall		376 (15.1)	100 (4.0)	2018 (80.9)	<0.001*
Sex					
Male	1483	282 (19.0)	75 (5.1)	1126 (75.9)	<0.001*
Female	1011	94 (9.3)	25 (2.5)	892 (88.2)	
Age, years					
<40	494	36 (7.3)	7 (1.4)	451 (91.3)	<0.001*
40–59	1085	170 (15.7)	40 (3.7)	875 (80.7)	
60–79	826	149 (18.0)	51 (6.2)	626 (75.8)	
≥80	89	21 (23.6)	2 (2.3)	66 (74.2)	
Education level					
Less than high school	390	83 (21.3)	17 (4.4)	290 (74.4)	0.006*
Completed high school	896	136 (15.2)	38 (4.2)	722 (80.6)	
Completed university	535	63 (11.8)	23 (4.3)	449 (83.9)	
Technical/community college	673	94 (14.0)	22 (3.3)	557 (82.8)	
Relationship					
Owner-operator	1138	253 (22.2)	67 (5.9)	818 (71.2)	<0.001†
Spouse	884	91 (10.3)	26 (2.9)	767 (86.8)	
Parent	72	17 (23.6)	2 (2.8)	53 (73.6)	
Child	342	12 (3.5)	5 (1.5)	325 (95.0)	
Other relative	58	3 (5.2)	0 (0.0)	55 (94.8)	
Hours of farm work					
None	186	22 (11.8)	4 (2.2)	160 (86.0)	<0.001*
Part-time (<30 h/week)	944	98 (10.4)	33 (3.5)	813 (86.1)	
Full-time (≥30 h/week)	1364	256 (18.8)	63 (4.6)	1045 (76.6)	

**Rao-Scott χ^2 test adjusted for individuals clustered within farms; †Pearson's χ^2 test*

approach (ORs comparing individuals with daytime sleepiness with those without diagnosed sleep apnea or daytime sleepiness changed >10%) were used to identify potential confounding variables. All individual and farm factors previously outlined were considered to be confounders, with the exception of snoring volume and breathing cessation during sleep. These were excluded because they are collinear with daytime sleepiness and part of the same underlying construct. Adjusted ORs and associated 95% CIs were estimated, with random effects at the farm level used to account for individuals being nested within farms. Because the questionnaire was designed to be completed by a single respondent per farm, it was suspected that information regarding sleep may have been acquired through proxy report for many individuals, which could result in misclassification errors. Therefore, the final analysis was conducted again for primary respondents only to examine whether the relationships of interest were similar in the entire sample versus individuals who were mostly likely to provide their own information.

RESULTS

A total of 2684 Saskatchewan farmers ≥16 years of age, from 1216 participating farms returned questionnaires; of these, complete data required for the analyses were provided for 2392 participants. At the farm level, operating arrangements of farms involved in the study (n=1170) were individual family farms (56%), family corporations (26%), partnerships (17%) and other (1%). The leading commodity types produced were grain (88% of farms reporting) and beef cattle (41%); the number of family members on the farms was modest (n=2, range one to six) and total mean acreage in production was 2341 acres (range 0 to 55,000 acres).

The cohort was predominantly male and included a wide range of age groups with varying educational backgrounds (Table 1). Individuals with excessive daytime sleepiness tended to be in the older age groups, male and owner-operators of the farm. A similar pattern was observed for individuals with diagnosed sleep apnea (Table 1). Overall, 15.1% (95% CI 13.6% to 16.5%) reported a level of daytime sleepiness compatible with an undiagnosed sleep disorder (Table 1). Prevalence estimates were highest in the 60 to 79 and ≥80 years of age groups, and were higher in men than in women. The prevalence of diagnosed sleep apnea was 4.0% (95% CI 3.2% to 4.8%), with the same sex- and age-related pattern.

With respect to the ESS (Table 2), among those with ESS scores in the abnormal range, the mean (± SD) score was 13.5±2.6, compatible with 'mild to moderate' suspected obstructive sleep apnea (3), with 78 individuals (19.9%) scoring ≥16, indicative of a significant degree of daytime somnolence. The only situations in which daytime somnolence was reported as 'low', on average, were while sitting and talking to someone, while sitting, inactive in a public place and while in a car stopped for a few minutes in traffic.

Reported durations of nighttime sleep are summarized in Table 3, with decreased estimations of hours of sleep per night among those with excessive daytime sleepiness and diagnosed sleep apnea. Snoring, snoring loudly and cessation of breathing during sleep were all more common in individuals with excessive daytime sleepiness and sleep apnea than in those with neither.

Results of the regression analyses are summarized in Table 4. Although not statistically significant, after adjustment for important confounders (age, sex, hours of farm work) individuals with excessive daytime sleepiness appeared to be at an elevated risk for experiencing a

TABLE 2
Description of daytime drowsiness in individuals involved in phase 2 of the Saskatchewan Farm Injury Cohort Study, 2013

	Excessive daytime sleepiness (n=376)		Diagnosed sleep apnea (n=100)		No excessive daytime sleepiness or sleep apnea (n=2018)	
Variable	Response, mean ± SD	≥ Moderate*, % (95% CI)	Response, mean ± SD	≥ Moderate* % (95% CI)	Response, mean ± SD	≥ Moderate* % (95% CI)
Epworth Sleepiness Scale score (range 0–24)	13.5±2.6	20 (16–24)†	8.7 (4.5)	N/A	5.1 (2.8)	N/A
Lying down to rest in the afternoon when circumstances permit	2.7±0.5	97 (96–99)	2.2 (0.9)	77 (68–85)	1.5 (1.0)	50 (48–53)
Watching television	2.5±0.7	93 (90–95)	1.8 (0.9)	66 (57–75)	1.2 (0.9)	34 (32–36)
Sitting and reading	2.2±0.8	79 (74–83)	1.4 (1.1)	40 (31–50)	0.8 (0.8)	16 (15–18)
As a passenger in a car for an hour without a break	2.0±0.9	70 (65–74)	1.2 (1.0)	37 (27–47)	0.8 (0.8)	18 (16–20)
Sitting quietly after lunch without alcohol	1.9±0.9	67 (63–72)	1.1 (1.0)	26 (16–35)	0.5 (0.7)	10 (8–11)
Sitting, inactive in a public place	1.4±0.9	44 (38–49)	0.8 (0.9)	18 (9–27)	0.2 (0.5)	2 (1–2)
Sitting and talking to someone	0.5±0.7	7 (5–10)	0.2 (0.4)	1 (0–3)	0.0 (0.2)	0 (0–0)
In a car, while stopped for a few minutes in traffic	0.3±0.7	7 (4–10)	0.1 (0.4)	3 (0–7)	0.0 (0.2)	0 (0–0)

**Respondents who answered 2 or 3 on a subscale ranging from 0 to 3 – individual item response options were: 0 = would never doze, 1 = slight chance of dozing, 2 = moderate chance of dozing, 3 = high chance of dozing (95% CI adjusted for clustering of individuals within farms); †Percentage of respondents with an Epworth Sleepiness Scale score ≥16, indicative of severe daytime somnolence. N/A Not applicable*

TABLE 3
Description of nighttime sleep characteristics in individuals involved in phase 2 of the Saskatchewan Farm Injury Cohort Study, 2013

	Excessive daytime sleepiness (n=376)		Diagnosed sleep apnea (n=100)		No excessive daytime sleepiness or sleep apnea (n=2018)	
Characteristic	n (%)	95% CI*	n (%)	95% CI*	n (%)	95% CI*
Typical hours of sleep	373 (–)	–	100 (–)	–	2008 (–)	–
>7 h	142 (38)	33–43	34 (34)	24–44	972 (48)	46–51
6 h to 7 h	199 (53)	48–58	48 (48)	38–58	927 (46)	44–49
<6 h	32 (9)	6–11	18 (18)	10–26	109 (5)	4–6
Snoring	373 (–)	–	97 (–)	–	2002 (–)	–
Yes	272 (73)	68–78	78 (80)	72–89	948 (47)	45–50
No	74 (20)	16–24	19 (20)	11–28	808 (40)	38–43
Don't know	27 (7)	4–10	0 (0)	–	246 (12)	11–14
Volume of snoring	296 (–)	–	79 (–)	–	1141 (–)	–
Louder than talking	94 (32)	26–37	23 (29)	19–39	203 (18)	15–20
Very loud, can be heard in adjacent rooms	82 (28)	22–33	40 (51)	40–62	159 (14)	12–16
Softer than talking	81 (27)	22–33	9 (11)	4–19	449 (39)	36–42
Don't know	39 (13)	9–17	7 (9)	2–15	330 (29)	26–32
Stop breathing in your sleep	366 (–)	–	97 (–)	–	1953 (–)	–
Yes	65 (18)	14–22	77 (79)	71–88	142 (7)	6–8
No	255 (70)	65–74	15 (15)	8–23	1503 (77)	75–79
Don't know	46 (12)	9–16	5 (5)	1–10	308 (16)	14–18
Regularly take sleeping pills, yes	12 (3)	1–5	3 (3)	0–6	54 (3)	2–3

**95% CI adjusted for clustering*

farming-related injury compared with individuals with normal sleepiness and no sleep apnea (OR 1.34 [95% CI 0.92 to 1.96]). After adjustment for the presence of comorbidities, individuals reporting excessive daytime sleepiness had an increased risk for self-perceived poorer physical health (OR 2.19 [95% CI 1.45 to 3.30]). Diagnosed sleep apnea was not associated with risk for injury in a statistically significant manner, but appears to have a negative impact on general physical health following adjustment for comorbidities (OR 1.76 [95% CI 0.92 to 3.38]). When examining primary respondents as a subgroup, the relationship between excessive daytime sleepiness and injury became nonsignificant; however, the relationships between both excessive daytime sleepiness and diagnosed sleep apnea and self-perceived general physical health remained consistent (Table 4). Primary respondents (n=1098) were a mean 58±12 years of age, and were predominantly male (79%) and the owner-operator of the farm (77%).

DISCUSSION

Findings of the present study extend and further clarify our previous work (21), in which we showed that primary snoring, as a surrogate for obstructive sleep apnea, was associated with reduced time to farm injury in a large cohort of Saskatchewan farmers studied prospectively. In the current analysis, we demonstrate in a large population of farmers observed in a cross-sectional study that excessive daytime sleepiness is associated with self-perceived poor health and a high likelihood of injury occurrence. These data join a growing body of evidence that sleep disorders may be significant threats to safety and well-being among farmers.

TABLE 4
Multivariable logistic regression analysis examining the effect that excessive daytime sleepiness (EDS) and diagnosed sleep apnea have on farming-related injury and general physical health

All farmers				
Farming injury	**Total, n**	**Injured, %**	**OR (95% CI) Unadjusted**	**OR (95% CI) Adjusted***
Sleep and Injury				
No EDS or sleep apnea	1921	7.9	1.00 (Reference)	1.00 (Reference)
Diagnosed sleep apnea	101	9.9	1.29 (0.65–2.57)	0.96 (0.47–1.96)
EDS	370	12.4	**1.67 (1.16–2.40)**	1.34 (0.92–1.96)
	Total, n	**Fair or poor, %**	**OR (95% CI) Unadjusted**	**OR (95% CI) Adjusted†**
Sleep and general physical health				
No EDS or sleep apnea	1921	4.8	1.00 (Reference)	1.00 (Reference)
Diagnosed sleep apnea	101	13.9	**3.32 (1.77–6.24)**	1.76 (0.92–3.38)
EDS	370	12.2	**2.79 (1.89–4.13)**	**2.19 (1.45–3.30)**
Primary respondents only				
Farming injury	**Total, n**	**Injured, %**	**OR (95% CI) Unadjusted**	**OR (95% CI) Adjusted***
Sleep and injury				
No EDS or sleep apnea	827	11.3	1.00 (Reference)	1.00 (Reference)‡
Diagnosed sleep apnea	63	14.3	1.32 (0.63–2.76)	1.18 (0.56–2.49)‡
EDS	208	11.5	1.03 (0.64–1.66)	0.96 (0.60–1.56)‡
	Total, n	**Fair or poor, %**	**OR (95% CI) Unadjusted**	**OR (95% CI) Adjusted†**
Sleep and general physical health				
No EDS or sleep apnea	827	4.4	1.00 (Reference)	1.00 (Reference)
Diagnosed sleep apnea	63	14.3	**3.66 (1.67–8.02)**	2.10 (0.93–4.72)
EDS	208	10.1	**2.47 (1.41–4.33)**	**2.12 (1.18–3.80)**

*Bolded values indicate statistical significance. *Sleep and injury adjusted for age, sex, hours of farm work; †Sleep and general physical health adjusted for number of comorbid conditions; ‡Sleep and injury adjusted for age, sex (hours of farm work removed because of convergence problems)*

The prevalence of excessive daytime sleepiness in the farm cohort was 15%, with peaks reported in older age groups and among men. We documented impairments in sleep quantity and quality among individuals with excessive daytime sleepiness and diagnosed sleep apnea. Following adjustment for important confounders, we confirmed that excessive daytime sleepiness is associated with poorer self-reported physical health in farmers. Diagnosed sleep apnea was not associated with risks for injury, but was associated with poorer physical health. The prevalence of excessive daytime sleepiness in the present study was within the range found in previous worker populations (1,2,27) and was lower than in a rural Saskatchewan population (46).

Previous studies that examined sleep behaviours and their impact on health in farm populations did not use a standard measure of daytime sleepiness in conjunction with a validated cut-off score. These studies have typically used less reliable indicators of sleep disorders, such as proxy or self-reports of sleep duration, snoring and cessation of breathing during sleep (18-20,22). One study that included a measure of daytime sleepiness ('yes' or 'no') found no association with injury in a rural Iowa (USA) population (17). Contrary to our findings, excessive daytime sleepiness (as assessed using the ESS) was not found to be a risk factor for animal-related injury (23), fall-related injury (24) or lower-back injury (25) among Iowa farmers, and has even been found to be protective for farm injury (26). In the only study that examined sleepiness as the primary exposure, it was found to increase the risk for depressive symptoms and decrease the risk for musculoskeletal pain in migrant farm workers (n=300) in North Carolina (USA) (47). Such apparently contradictory evidence may have resulted from methodological differences in the way that daytime sleepiness was assessed and the uncertainty attributable to small sample sizes.

Strengths of the present study include the novelty of the research and the practical implications of the findings for a Canadian population. We had a relatively large sample size, and the use of a standard and validated measure to assess daytime sleepiness gave us strong exposure information. Limitations include: the self-reported nature of the data, often by proxy, which was practical but may have led to misclassification errors; the cross-sectional nature of the study, which restricts our ability to infer causation; and the lack of available information regarding whether individuals with diagnosed sleep apnea were receiving treatment. The major potential limitation was our use of a high ESS score as a surrogate for undiagnosed sleep disorders because other factors, such as sleep deprivation, can result in daytime sleepiness. However, as shown in Table 3, individuals with high ESS scores tended to be more similar to participants who reported diagnosed sleep apnea with regard to hours of sleep, snoring prevalence and volume of snoring, adding additional support to the belief that daytime sleepiness with the symptoms cited increases the possibility of an undiagnosed sleep disorder.

The relationship between high ESS score and self-perceived poor overall health warrants particular attention. The strong ORs between both diagnosed sleep apnea and excessive daytime sleepiness and self-perceived fair or poor health indicates the importance of adequate or effective sleep to a sense of well-being (48). To our knowledge, the present study was the first to potentially link self-perceived health with the occurrence of injury, possibly with factors around sleep linking the two issues.

These findings raise additional issues concerning the control and prevention of the epidemic of farming-related injury and accidental death. For some time, prevention efforts have been focused on education of farmers aimed at avoidance of dangerous farm practices and tasks. Our work (32) and that of others has shown that it is difficult to find reductions in unsafe farm practices as a result of education alone. This has led to an evolution in our interpretation of the hierarchy of control (33) that we have modified into six steps and that we believe needs to be involved in the reduction of farm injury. The six steps that comprise a modified hierarchy of control are:

1. Identification of a hazard;
2. Risk assessment;
3. Elimination of the hazard;
4. Engineering controls;
5. Administrative controls such as policies and procedures; and
6. Personal protective equipment.

The findings reported in the present study suggest that fatigue and sleepiness should be addressed as part of administrative controls such as scheduling rest, job rotation out of high-vigilance tasks, allowing for recovery after long shifts and training on personal coping mechanisms for sleepiness. To date, a holistic approach to the research on and prevention of farm injuries has been elusive. By invoking a modified hierarchy of control, we are attempting to introduce principles of occupational hygiene into the study and prevention of farming injuries. The findings reported in the present study suggest that administrative controls, such as protocols and procedures, should be placed higher in importance during the planning and execution of good work practices in the agricultural industries.

Although excessive daytime sleepiness could be indicative of sleep disorders and negatively affect health, it is potentially treatable. Given the evidence generated for farmers, it is imperative that steps are taken toward better identifying these individuals and providing them with the appropriate treatment. Prevention efforts should focus on educating farmers on the seriousness and consequences of sleep disorders, what the available treatments are and making those options readily accessible. Rural physicians may also be more active in screening for sleep disorders in clinical practice. The ESS can be easily administered and should be readily available to clinicians for use in their medical practice (21). While only approximately one-half of individuals with sleep apnea demonstrate a high ESS score, the use of the ESS in rural medical practice can be a helpful adjunct to diagnosis.

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