Prevalence of sleep disordered breathing in a population of Canadian grainworkers

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OBJECTIVES: To determine the prevalence of sleep disordered breathing (SDB) in a Canadian population of industrial workers (grainworkers). To determine the clinical features that are predictive of SDB and the validity of self-reported snoring.
DESIGN: Cross-sectional, interviewer-administered questionnaire with selective recruitment of subjects for home sleep monitoring.
SETTING: Community setting, Vancouver, British Columbia.
PARTICIPANTS: All male grainworkers at grain elevators in Vancouver were approached for completion of a questionnaire. Eighty-three per cent of 524 subjects completed the questionnaire and were divided by presumed risk for SDB into four groups. All subjects in the highest risk group (group 1– frequent snoring and witnessed apneas) and a random sample of 40 subjects in the other three groups (group 2 – frequent snoring without witnessed apneas; group 3 – infrequent snoring rare; group 4 – nonsnoring) were approached for home sleep monitoring and 42% consented.
INTERVENTIONS: Interviewer-administered questionnaire and home sleep monitoring.
RESULTS: The overall prevalence of SDB in this relatively overweight group was estimated to be 25%, with a stepwise increase from group 4 to group 1 (7%, 29%, 40%, 60%). Presence of snoring and witnessed apneas, a greater body-mass index and a larger neck circumference were associated with SDB. Self-reported snoring was not found to be predictive.
CONCLUSIONS: This first study of the prevalence of SDB in Canada suggests that SDB is at least as prevalent in Canada as in other industrialized nations and may actually be more common than previously thought. Further studies are required to determine the morbidity, mortality and economic loss associated with SDB in industrial workers.

Key Words: *Home monitoring, Obstructive sleep apnea, Screening, Self-reported snoring, Sleep disordered breathing*

Prévalence des troubles respiratoires du sommeil dans une population de travailleurs du grain

OBJECTIFS : Déterminer la prévalence des troubles respiratoires du sommeil dans une population canadienne de travailleurs de l'industrie du grain. Déterminer les caractéristiques cliniques prédictives des troubles respiratoires du sommeil et la validité du ronflement signalé par les sujets eux-mêmes.
MODÈLE : Questionnaire transversal rempli par un intervieweur et recrutement sélectif de sujets pour mener des études du sommeil à domicile.
CONTEXTE : Dans la communauté de Vancouver en Colombie-Britannique.
PARTICIPANTS : On a demandé à tous les sujets de sexe masculin travaillant dans les silos à grains de répondre à un questionnaire. Quatre-vingt-trois pour cent des 524 sujets ont complété le questionnaire ; ils étaient divisés en quatre groupes selon le risque présumé de troubles respiratoires du sommeil. On a demandé à tous les sujets du groupe à risque le plus élevé (groupe 1 – ronflement fréquent et apnées observées) et un échantillon aléatoire de 40 sujets dans les trois autres groupes (groupe 2 – ronflement fréquent sans apnées observées ; groupe 3 – rare ronflement occasionnel ; groupe 4 – aucun ronflement) de subir des études de sommeil à domicile. Quarante-deux pour cent des sujets ont consenti à subir de telles études.
INTERVENTIONS : Questionnaire rempli par un intervieweur et études du sommeil à domicile.
RÉSULTATS : La prévalence globale des troubles respiratoires du sommeil dans cette population relativement obèse a été estimée à 25 %, avec une augmentation par paliers du groupe 4 jusqu'au groupe 1 (7 %, 29 %, 40 %, 60 %). Le ronflement et les apnées observées, un index de masse corporelle plus élevé et un tour du cou plus grand étaient associés à des troubles respiratoires du sommeil.

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Le ronflement signalé par les sujets eux-mêmes ne représentait pas un facteur prédictif.
CONCLUSIONS : Cette première étude sur la prévalence des troubles respiratoires du sommeil au Canada permet de croire qu'ils sont aussi fréquents dans ce pays que dans les autres pays industrialisés mais aussi que leur incidence serait en fait plus importante que celle présumée antérieurement. D'autres études sont nécessaires pour déterminer la morbidité, la mortalité et la perte économique associées aux troubles respiratoires du sommeil chez les travailleurs industriels.

Sleep disordered breathing (SDB), including obstructive sleep apnea and obstructive sleep hypopnea, is associated with significant mortality (1,2) and morbidity (3). SDB is most common in middle-aged men, but its true prevalence in this group is still being determined. While early studies estimated the prevalence of SDB to be 0.9% and 1.3%, (4,5) more recent studies from the United States and Australia (6-8) have reported prevalence rates of SDB in middle-aged men to be in the range of 10% to 15%. To date there have been no published studies of the prevalence of SDB in Canada.

The main objective of this study was to obtain an estimate of the prevalence of SDB in industrial workers, using a population of men working at grain elevators in Vancouver, British Columbia as a model. To achieve this objective we studied subjects with all levels of risk for SDB. A secondary objective was to determine which clinical features and anthropometric data were predictive of SDB. We also examined the relationship between self-reported snoring and recorded snoring.

PATIENTS AND METHODS

Subjects: The target population was men working in grain terminals. The sample frame, for the purpose of this study, consisted of men working at the grain terminals in the Vancouver area.

Questionnaire administration: Subjects completed a questionnaire administered by trained interviewers that included questions concerning demographic data, sleep disturbance (snoring, witnessed apneas, daytime sleepiness), smoking history and included the American Thoracic Society Respiratory Disease Questionnaire (9). All subjects had their height, weight, blood pressure and neck circumference measured. The subjects were divided into four groups based on the reported presence of snoring and witnessed apneas: group 1, frequent snoring and witnessed apneas; group 2, frequent snoring without witnessed apneas; group 3, infrequent snoring or rare; group 4, nonsnoring.

All subjects in group 1 and a random sample of 40 subjects in groups 2 to 4 were approached about overnight home sleep monitoring. Subjects who consented formed the sample population for determining SDB prevalence.

Home sleep monitoring: Home sleep was monitored using the Mesam 4 (Madaus Medizin Elektronik, Freiburg, Germany) (10). The Mesam 4 is a four-channel digital recording device. The Mesam system has been validated in two previous studies (10,11). A polysomnographic technologist, trained in the use of the Mesam 4, set up the device at the subject's home on the study night and retrieved it the next morning. Heart rate was monitored through a single-lead electrocardiogram (modified V2) and R-R intervals were measured in milliseconds. Snoring sounds were monitored through an electric subminiature microphone, type MCE 2,000 (frequency range, 30 to 20,000 cycles/s ± 2dB, sensitivity 0.6 mV/microbar at 1000 cycles/s ± 4 dB; Conrad Electronics, Hirschau, Germany), taped above the larynx. Arterial oxygen saturation was measured continuously with a finger probe. The body position sensor, a flat cylinder 18 mm high with a diameter of 50 mm, was placed on the lower part of the sternum.

Automated scoring software is available with the Mesam that provides a respiratory disturbance index. However, previous research has shown that hand scoring provides results that are more closely related to the results of simultaneous polysomnography than the automated analysis results (11). The Mesam recordings were therefore hand scored in 5 min epochs. This was done independently and in a blinded fashion by two physicians trained in SDB and familiar with the Mesam 4. Interobserver variability was determined using the Kappa statistic (12). Snoring was scored as absent, present during less than 50% of the recording, or present during 50% or more of the recording. A respiratory event was scored if at least two of the following three parameters were present: pauses in snoring of at least 10 s; heart rate deceleration and acceleration of at least 10 beats/min; and an associated arterial oxygen desaturation of at least 2%. If recurrent episodes were present during the majority of a 5 min epoch, the epoch was defined as positive for SDB. The subjects' records were then classified based on the following criteria: normal – events less than 10% of the recording; possible SDB – events 10% to 30% of the recording; definite SDB – events greater than 30% of the recording. The Mesam 4 does not record sleep; therefore, the total study time is not equivalent to a total sleep time. Using a total study time rather than a total sleep time tends to underestimate the degree of SDB. This approach was adopted to avoid concerns that the prevalence of SDB would be overestimated in this population.

Calculation of prevalence: The prevalence of both suspected and definite SDB was calculated but the conservative latter definition was used for the primary analysis. The prevalence of SDB was calculated in each sample group by the equation:

$$\text{Prevalence} = (\text{number of subjects with definite SDB} \times 100\%) / \text{total number of subjects}$$

To estimate the overall prevalence of definite SDB in the entire group of grainworkers the prevalence obtained from each sample groups was projected to their respective total groups.

$$\begin{aligned}\text{Overall prevalence} = &[(\text{sample group 1})(\text{number of subjects in total group 1}) + \\ &(\text{sample group 2})(\text{number of subjects in total group 2}) + \\ &(\text{sample group 3})(\text{number of subjects in total group 3}) + \\ &(\text{sample group 4})(\text{number of subjects in total group 4})] \\ &\times 100\%/\text{total number of grainworkers}\end{aligned}$$

TABLE 1
Demographic data on the four groups of grainworkers studied for sleep disordered breathing

	Group 1 frequent snoring, apneas	Group 2 frequent snoring, no apnea	Group 3 frequent snoring or rare	Group 4 nonsnorers	Total
n	19 (4%)	98 (22%)	185 (42%)	135 (31%)	437
Age (years)	42±10	44±11	43±10	40±10*	42±10
Body mass index (kg/m^2)	30±6	30±5	29±4	27±4**	29±5
Neck circumference (cm)	42±4	41±3	41±3	39±2**	40±3

** P<0.05; **P<0.0001*

where sample group refers to the prevalance of SDB in the sample group specificed.

Before this calculation, subjects approached for home sleep monitoring who did not participate (refused or could not be contacted) were compared with their respective total groups in terms of age, body mass index (BMI) and neck circumference. If no significant difference was found between the sample group and total group, then the previously described formula was used to calculate prevalence. If a significant difference was found between a sample group and either those who did not participate or the group as a whole then the above formula was modified such that the respective group prevalence was multiplied by only the number of subjects in the sample group and not by the entire total group.

Statistics: One-way ANOVA was used to to compare the anthropometric data and a χ^2 test was used to compare the questionnaire data (categorical) among the four total groups and among the three home sleep monitoring derived diagnostic groups (normal, possible SDB, definite SDB). The sample groups and the total groups were compared by an unpaired Student's *t* test. Prevalence was calculated as described above, and the interobserver variability was calculated using the Kappa statistic (a Kappa score greater than 0.7 is indicative of minimal interobserver variability).

RESULTS

Questionnaire data: Four hundred and thirty-seven men of the 524 men approached completed the questionnaire and had a limited physical examination (83% response rate). Nineteen (4.3%) admitted to snoring often and had a history of witnessed apneas (group 1), 98 (22.3%) snored often without witnessed apneas (group 2), 185 (42.3%) snored sometimes or rarely (group 3) and 135 (31.1%) were nonsnorers (group 4). These groups differed significantly in the distribution of neck circumference (P<0.0001), BMI (P<0.0001) and age (P<0.05) (Table 1). The nonsnorers were younger and less obese, and had smaller neck circumferences than group 1 subjects. In addition, the smoking history differed between groups with a greater prevalence of current and exsmokers than nonsnorers among subjects who snored often, with or without associated witnessed apneas (P<0.01).

Prevalence of SDB: Fifteen of the 19 subjects in group 1 who were approached agreed to undergo home sleep monitoring. Of the 40 subjects randomly selected in groups 2 to 4, nine, 10, and 11, respectively, could not be contacted. Of the remaining men, 15, 14 and 14 agreed to home sleep monitoring representing response rates of 48%, 47%, and 48%, respectively.

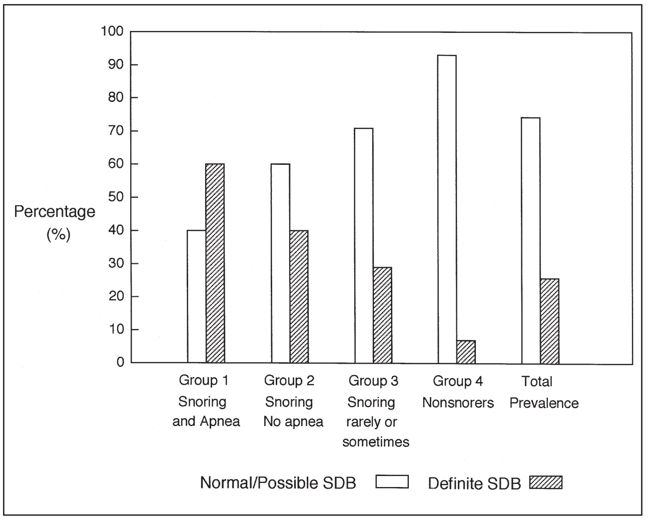

Figure 1) *Prevalence of definite sleep disordered breathing in the sample groups and the total population*

The distribution of diagnoses from home sleep monitoring differed among the four groups (Figure 1). The prevalence of definite SDB was greatest in group 1: 60% (nine of 15). The prevalence of definite SDB decreased in a stepwise manner in groups 2 through 4 with values of 40% (six of 15), 29% (four of 14) and 7% (one of 14), respectively. Possible and definite SDB were found in most subjects with a history of snoring while those classified as normal were found predominantly in group 4 (Figure 1). One subject from group 1 (snoring and witnessed apneas) was classified as normal from home sleep monitoring.

By projecting the prevalence of definite SDB found in the four sample groups to their respective total group the overall prevalence of SDB was estimated to be 25% in this group of grainworkers:

$$\text{Prevalence} = [(0.60)(15) + (0.40)(98) + (0.29)(185) + (0.07)(135)][100\%]/433 = [111][100\%]/433 = 25.6\%$$

In group 1 the prevalence of the sample group was multiplied by the number of subjects in the sample group rather than the total group. There was a significant difference in BMI between those studied (heavier) and those who were not studied (P<0.02, Table 2), although those who were studied were similar to the total group. There were no significant differences between those subjects studied and those that did not participate in sample groups 2 to 4 (P>0.05, Table 2).

TABLE 2
Demographic features of the grainworkers approached and those who underwent home sleep monitoring to determine the prevalence of sleep-disordered breathing

	Approached	Sample group	Not studied	Total group
Group 1 – Frequent snoring and witnessed apneas				
Number (%)	19 (100)	15 (79)	4 (21)	19
Age (years)	42±10	43±10	39±10	42±10
Body mass index (kg/m^2)	30±6	31±6	26±3*	30±6
Neck circumference (cm)	42±4	42±4	40±3	42±4
Group 2 – Frequent snoring often, no witnessed apnea				
Number (%)	40 (41)	15 (15)	25	98
Age (years)	43±12	45±11	42±12	44±11
Body mass index (kg/m^2)	30±4	30±4	30±5	30±5
Neck circumference (cm)	41±2	41±3	41±2	41±3
Group 3 – Infrequent snoring or rare				
Number (%)	40 (22)	14 (8)	26	185
Age (years)	44±10	40±9	46±9	43±10
Body mass index (kg/m^2)	29±4	29±5	29±3	29±4
Neck circumference (cm)	40±3	41±3	40±2	41±3
Group 4 – Nonsnoring				
Number (%)	40 (30)	14 (10)	26	135
Age (years)	40±9	38±8	41±10	40±10
Body mass index (kg/m^2)	27±3	27±3	27±4	27±4
Neck circumference (cm)	39±2	39±1	39±2	39±2

*Mean ± SD. * P<0.05 body mass index higher in subjects from the sample group than those not studied*

TABLE 3
Comparison of self-reported snoring with recorded snoring in grainworkers

	Absence of Snoring	Snoring <50% of recording	Snoring >50 % of recording	Total
Group 1– Snoring/apnea	0	1	14	15
Group 2 – Frequent snoring	1	1	12	14
Group 3 – Infrequent snoring or rare	1	1	12	14
Group 4 – Nonsnorers	5	5	4	14

There were no differences among the total groups and their respective sample groups in age, BMI or neck circumference.

The two physicians scoring the Mesam studies agreed on categorization of the studies 85% of the time. In the studies in which there was not complete agreement, the two physicians were never more than one category removed. The interobserver variability, as calculated by the Kappa statistic, was 0.7.

Factors associated with SDB: Among grainworkers who underwent home sleep monitoring, the presence of snoring (P<0.005) and witnessed apneas (P<0.04), a greater BMI (P<0.040) and a larger neck circumference (P<0.02) were found to be predictive of definite SDB. However, the presence of daytime sleepiness, history of hypertension (patient reported) and smoking history were not associated with the presence of SDB. There was no difference in measured blood pressure between the patients with and those without SDB. The relatively small sample size in each group may limit the power to detect true differences among the groups.

Validity of self-reported snoring: Fifty-eight subjects underwent home sleep monitoring. Fourteen of these subjects denied snoring but home sleep monitoring revealed that five did not snore, five snored for less than 50% of the night and four snored for more than 50% of the night (Table 3). Of the 44 subjects who admitted to snoring, three showed no evidence of snoring, five snored occasionally and 36 snored throughout most of the night.

DISCUSSION

In this first study of the prevalence of SDB in Canada, we found that 25% of a population of male grainworkers had SDB. The known risk factors of male sex and higher than average BMI in the study population are probably responsible for a higher prevalence of SDB than previously reported. A history of snoring and witnessed apneas as well as greater BMI and larger neck circumference were found to be useful predictors of SDB, a finding consistent with previous studies (6,13-15). Smoking was more common in subjects who reported snoring (with or without witnessed apneas) but we did not find a previously reported association between smoking history and SDB (7). Furthermore, self-reported snoring was not found to be a reliable guide to the presence of recorded snoring.

A number of factors could have contributed to our finding of a greater prevalence of SDB in our study than that reported by others. Certain assumptions were made in previous prevalence studies, the most common of which is that self-reported snoring and daytime sleepiness were reliable symptoms of SDB (4,5,16). This assumption, which is not supported by this study or another (16), would result in an underestimation of the true prevalence of SDB. In a number of studies, men were initially screened by a questionnaire, and only those with symptoms suggestive of SDB were approached for overnight polysomnography (4,5,16). Patients with milder symptoms were not approached, contributing to estimates of prevalence of SDB of approximately 1%.

The recognition of obstructive breathing associated with neurological arousal without accompanying arterial oxygen desaturation has expanded the definition of SDB. It is now apparent that there is a continuum of SDB associated with progressively more clinical consequences, from chronic snoring to obstructive sleep hypopnea to severe obstructive sleep apnea. The diagnostic threshold to define SDB within this continuum directly affects the measured prevalence. For example, the initial study by Lavie (4) used a diagnostic threshold of an apnea index greater than 10/h; however, if one uses an apnea index more than five/h the prevalence moves from 1% to nearly 16% in a group of male industrial workers.

The use of home oximetry to define cases of SDB, a less sensitive monitoring system than conventional overnight, in-hospital polysomnography, has also contributed to the underestimation of prevalence rates. Stradling and Crosby (17) studied 893 men with overnight oximetry and found that 45 (5%) had more than five desaturations of 4% per hour. Thirty-one of these men had overnight polysomnography, and three had severe, nonpositional SDB (0.3%) and 18 had mild to moderate, positional apnea (2.4%). Men with clinically significant SDB with apneas and hypopneas without associated desaturations of 4% would have been missed using this methodology.

More recent studies conducted in the United States and Australia using expanded definitions of SDB have found prevalence rates similar to our study (10% to 20%). In a recent study from the United States, 40% of middle-aged men and 30% of middle-aged women were found to be habitual snorers (6). Significant SDB was defined as the presence of an apnea-hypopnea index (AHI) greater than five/h (from polysomnography) and symptoms of excessive daytime sleepiness. About 4% of middle-aged men and 2% of middle-aged women met these criteria. When they defined SDB based only on AHI, 24% of middle-aged men had an AHI greater than five/h, 15% had an AHI greater than 10 per hour, and 9% had an AHI greater than 15/h. These prevalence rates are similar to those found in our study. Bearpark and colleagues (7) reported the prevalence of SDB in a population of middle-aged Australian men who were part of a large health survey. They also used the Mesam 4 to assess SDB in those subjects who returned their questionnaires. The respiratory disturbance index was greater than five/h in 26% and greater than 10/h in 10% of the men. Olson and colleagues (8) recruited subjects from a general community in Australia using a questionnaire and overnight portable monitoring. The minimum prevalence in men was 5.7% and varied based on the threshold of respiratory disturbance index used as a diagnostic cut-off.

Obesity is a significant risk factor for SDB. We examined a relatively healthy, nonhypertensive population of middle-aged, working men who had a higher average BMI (29±5 kg/m^2) than the national average for Canada. Approximately 35% of Canadian adult men have a BMI 27 kg/m^2 or greater but roughly 60% of our population had a BMI 27 kg/m^2 or greater (18). Many of the grainworkers had sedentary jobs with minimal physical activity. The grainworkers we studied may be representative of industrial or blue collar workers in Canada as a whole. Obesity declines with increasing income and education (19), and Canadian industrial workers may have a significantly greater prevalence of SDB than white collar workers such as government employees (6). Our subjects were more obese than the workers studied by Lavie (4) and Gislason and colleagues (5), and more obese than the population averages for the United States (33% of Caucasian males ages 20 to 74 years had a BMI greater than 27.8 kg/m^2 in 1988 to 1991) (20) and Australia (44% of males were defined to be overweight or obese in 1989 to 1990) (21). This may partly explain the higher prevalence of SDB found in our study than in previous studies (6,7).

We did not study men working in Vancouver grain terminals because we considered them to be at an increased risk for SDB. Rather, our goal was to study a group of men whom we considered representative of the average male industrial worker. It is possible that exposure to large amounts of grain dust results in increased nasal congestion and hence predisposes a subject to SDB. However, while exposure to dust can exacerbate nasal congestion, it is possible that those most troubled by these symptoms would seek employment elsewhere as has been shown to be the case in men with symptoms of bronchial hyperreactivity (22). Furthermore, although nasal obstruction may predispose to SDB by increasing upstream resistance, rarely is it a major contributing factor (23-25). Furthermore, treatment of nasal obstruction either medically or surgically rarely results in a significant improvement in either snoring or obstructive apnea (26-28). Even if nasal congestion was increased in this population it would not explain the high prevalence of SDB that we found. The high level of obesity appears to be the most significant risk factor.

An ideal study of prevalence involves assessment of each subject in a large population with a gold standard diagnostic test (ie, overnight polysomnography). Due to the great expense and time this would involve, most studies have elected to study a portion of the population of interest and then estimate the prevalence of the entire population. There is a potential for bias when patients are sampled from a larger population and the results extrapolated back to the total group. A limitation of the present study is that we only studied 58 of 139 patients (42%) chosen either at random from the sample group (in groups 2, 3 and 4) or all patients in group 1. There was a potential for bias in our study in that the subjects who volunteered may have been more likely to have SDB, resulting in an overestimate of the true prevalence for this group. However, other prevalence studies have been subject to the same potential for volunteer bias, with approximately 40% to 45% of patients undergoing overnight recordings (6,8).

Another potential concern is the use of a portable home monitoring system rather than conventional laboratory polysomnography. Many studies have used a home monitoring device rather than polysomnography because of the ease and availability of home monitoring systems (7,8,17). The home monitoring unit used in this study has also been used in another large population study in Australia (7). This case selection device records snoring and heart rate and arterial oxygen saturation. It generates both a continuous tracing for the entire night as well as computer-generated indexes for snoring, heart rate and arterial oxygen saturation. Although, the computer-generated indexes have been previously validated (10,11), hand scoring is more accurate (11). The interobserver variability achieved was in an acceptable range. In order to prevent overestimation of the prevalence of SDB we assigned the lower score to a subject if differences in the scoring remained after discussion of the original results. Advantages of home sleep monitoring are a greater acceptability by subjects to being studied at home and the ability to monitor subjects in their normal surroundings.

The results of prevalence studies are influenced by the character of the study population. Because the prevalence found in the study group can only be generalized to a population with similar characteristics, the study group must be representative of the total population. Most studies of prevalence have focused on middle-aged men (4,5,17) but more recent work has shown that SDB is common in women (6). The prevalence rates obtained by studying high risk groups, such as patients with systemic hypertension (29-33), erectile dysfunction (29,34) or the elderly (35-37), are only representative of subjects with similar risk factors. We studied healthy working men in order to determine a prevalence rate that would be more representative of an average male middle-aged population. In retrospect, the greater rate of obesity in this group suggests that other groups of industrial workers, if similarly overweight, may also be at increased risk of SDB.

Is there a role for screening specific populations for SDB? To justify screening for a specific condition, the cost of screening must be weighed against the projected benefits of case detection. The benefit from screening can be measured in terms of both number of individuals identified (prevalence) and the degree of harm averted by their detection. Screening for systemic hypertension has been justified on the grounds that screening is relatively inexpensive, prevalence is relatively high, and treatment decreases the likelihood of adverse vascular sequelae. Although SDB is common and has significant consequences, and effective therapies exist, there is no evidence of the cost effectiveness of screening the general population for SDB (38). However, it may be appropriate to target specific high risk groups such as obese men with reported snoring with or without witnessed apneas.

The overall prevalence of SDB in our group of grainworkers was estimated to be 25%. The prevalence of SDB in this population of men is quite high and is in large part explained by the high rate of obesity. If these workers are representative of other industrial workers in Canada and elsewhere, the prevalence of SDB may be higher in this vocational group than expected, and as such, may be a significant public health issue. Further studies are required to define the burden of SDB in industrial workers and its long term impact if left untreated in terms of quality of life, morbidity, mortality and economic loss. Public health strategies may be needed to detect and treat SDB as its prevalence and clinical consequences are more widely recognized.

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