Sleep laboratory test referrals in Canada: Sleep Apnea Rapid Response Survey

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BACKGROUND: An estimated 5.4 million Canadian adults have been diagnosed with sleep apnea or are at high risk of experiencing obstructive sleep apnea (OSA). There are no recent Canadian data regarding access to and predictors of referral for diagnostic testing in these populations.
METHODS: The Sleep Apnea Rapid Response survey sampled 8647 Canadian adults and captured information about risk, testing, diagnosis and treatment of sleep apnea. Predictors of sleep laboratory test referrals were assessed using log-linked binomial regression modelling. Information regarding sleep testing facilities was updated at the provincial and regional levels.
RESULTS: Approximately 76.8% (95% CI 70.1% to 83.6%) of adult Canadians with sleep apnea and 5.1% (95% CI 3.4% to 6.7%) of those at high risk for OSA reported being referred to a sleep laboratory. Significant predictors of sleep laboratory referral in the general population were male sex, middle age, overweight or obese, a chronic condition, having a regular medical doctor and reporting symptoms of sleep apnea. Region of residence was also a predictor of reported sleep laboratory referral, with individuals from Ontario being more likely to report being referred to a sleep laboratory versus individuals from other regions.
CONCLUSION: Individuals reporting risk factors and symptoms associated with OSA were more likely to report a sleep laboratory testing referral compared with those without risk factors or symptoms. However, Canada's diagnostic sleep laboratory testing capacity varies across regions and is believed to be inadequate given the number of individuals at high risk for OSA who did not report testing referral.

Key Words: *Diagnostic testing referral; Sleep apnea; Sleep laboratory testing capacity*

Les aiguillages vers des tests en laboratoire du sommeil au Canada : sondage sur la réponse rapide à l'apnée du sommeil

HISTORIQUE : On estime que 5,4 millions d'adultes canadiens ont un diagnostic d'apnée du sommeil ou sont très vulnérables à une apnée obstructive du sommeil (AOS). Aucunes données canadiennes récentes ne portent sur l'accès aux tests diagnostiques et sur les prédicteurs d'aiguillage vers ces tests au sein de ces populations.
MÉTHODOLOGIE : Le sondage sur la réponse rapide à l'apnée du sommeil a sondé 8 647 adultes canadiens et permis de saisir de l'information sur le risque, les tests, le diagnostic et le traitement de l'apnée du sommeil. Les chercheurs ont évalué les prédicteurs d'aiguillage vers des tests en laboratoire du sommeil au moyen de la modélisation de régression binomiale liée au logarithme. L'information sur les laboratoires de tests du sommeil ont été mises à jour sur les scènes provinciale et régionale.
RÉSULTATS : Environ 76,8 % (95 % IC 70,1 % à 83,6 %) des adultes canadiens ayant de l'apnée du sommeil et 5,1 % (95 % IC 3,4 % à 6,7 %) de ceux très vulnérables à une AOS ont déclaré avoir été aiguillés vers un laboratoire du sommeil. Les prédicteurs significatifs d'aiguillage vers un laboratoire du sommeil dans la population générale étaient le sexe masculin, l'âge mûr, l'embonpoint ou l'obésité, une maladie chronique, le fait d'avoir un médecin traitant et des symptômes déclarés d'apnée du sommeil. La région de résidence était également un prédicteur d'aiguillage déclaré vers un laboratoire du sommeil, les habitants de l'Ontario étant plus susceptibles de recevoir un tel aiguillage que ceux des autres régions.
CONCLUSION : Les personnes qui déclarent des facteurs de risque et des symptômes associés à l'AOS étaient plus susceptibles de déclarer un aiguillage vers des tests en laboratoire du sommeil que celles qui ne présentaient pas de facteurs de risque ou de symptômes. Cependant, la capacité des tests diagnostiques en laboratoire du sommeil au Canada varie selon les régions et semble insuffisante compte tenu du nombre de personnes très vulnérables à l'AOS qui n'ont pas déclaré avoir été aiguillés pour des tests.

Obstructive sleep apnea (OSA) is a common chronic condition; its prevalence, estimated to be 3% to 7% among adult males and 2% to 5% among adult females in Western countries, along with the prevalence of its risk factors, such as obesity and aging, are increasing (1). A recent Public Health Agency of Canada (PHAC) survey indicated that 22% (5.4 million) of adult Canadians report either being diagnosed with sleep apnea (3%) or are at high risk for OSA (19%) (2). The exact proportion of high risk for OSA cases that are true cases of OSA remains unknown; however, if one conservatively assumes that only 15% of the high-risk cases have OSA (3% of the overall population), in addition to the 3% who report being diagnosed with sleep apnea, the prevalence of OSA approaches that of reported diagnosed diabetes (6%) (3).

With the growing awareness of OSA and its associated outcomes, such as increased risk of systemic hypertension (4), atherosclerosis and cardiovascular events (5), and motor vehicle collisions (6) and, with evidence demonstrating the effectiveness of therapy (7-8), there has been a progressive increase in sleep laboratory tests for OSA. Sleep laboratory tests in Australia increased from 123 per 100,000 in 1995 to 308 per 100,000 in 2004 (9). In Canada, increases in sleep laboratory test rates have been correlated with increases in obesity prevalence rates over a nine-year period among patients referred to a sleep laboratory in Winnipeg, Manitoba (10). During 2001, it was estimated that at least 1.17 million people in the United States were examined for sleep disorders in 1292 sleep laboratories (11). Only one study has characterized access to in-laboratory polysomnography (PSG) in Canada and reported an overall sleep laboratory test rate of 370.4 per 100,000 Canadians, and revealed wide discrepancies in per-capita testing and wait times among provinces (12). There are no recent data regarding access to and predictors of referral for sleep laboratory diagnostic tests for OSA in Canada.

The objectives of the present study were to determine the number of Canadian adults with sleep apnea or at high risk for OSA who were referred for sleep laboratory testing; determine the number of sleep

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laboratory beds per capita in Canada; and to examine the predictors of sleep laboratory testing in the adult Canadian population.

METHODS

The Sleep Apnea Rapid Response, 2009 Canadian Community Health Survey

The Sleep Apnea Rapid Response (SARR) questionnaire was developed and funded by PHAC, and was conducted by Statistics Canada as a component of the 2009 Canadian Community Health Survey (CCHS). The CCHS is a cross-sectional survey that annually samples 65,000 respondents ≥12 years of age and provides estimates at the health region level. Residents of Indian reserves, Crown lands, institutions and the Territories, as well as full-time members of the Canadian Forces are not included. The CCHS uses three sampling frames to select the sample of households and generate a sample representative of the Canadian population. The area frame is a complex, two-stage stratified design in which each stratum is formed of clusters. The clusters are selected using a sampling method with a probability proportional to size; the final sample is generated by a systematic sampling of dwellings stratified according to health regions within the clusters. In addition, random household telephone numbers were selected using a list frame of telephone numbers and a random digit dialling sampling frame that complemented the area frame and that were also stratified according to health region. The selection of a household member was made at the time of contact for data collection. Household members ≥12 years of age were listed and chosen using various selection probabilities based on age and household composition. During January and February 2009 (the sampling frame of the SARR module), a total sample of 9523 individuals was obtained, with an overall response rate of 73%. The weighted sample represents approximately 98% of the Canadian population. Due to sample size limitations associated with reported diagnosed sleep apnea among individuals 12 to 17 years of age, the current study focused on adults ≥18 years of age (n=8647).

Analysis

The analyses were performed using SAS Enterprise Guide version 4.1 (SAS, USA). Estimates were weighted to the Canadian population by applying sampling weights that accounted for the unequal probability of being selected into the survey. SDs and 95% CIs were estimated using the bootstrap technique (13). The bootstrap method allows for variance estimation while accounting for the complex multistage survey design. The process involves drawing repeated random samples, with replacement, from the observations to obtain a set of estimates. Estimates associated with a coefficient of variation >33.3 or a cell size <10 were not reported due to high sampling variability. Statistical significance was defined at $P<0.05$.

Potential predictors of reported sleep laboratory test referral were identified a priori. Bivariate log-linked binomial modelling was used to assess the relationship between the variables of interest and reported sleep laboratory test referral; prevalence rate ratios (PRR) were subsequently estimated. All variables found to be significant in the bivariate regression model, as well as all confounders were included in the final adjusted multivariable log-linked binomial regression models. Potential confounders were identified as such if they resulted in a 10% change in the relative risk for the association between the exposure and outcome (14). Potential effect modification was explored by including multiplicative interaction terms into the model; however, none of the interactions assessed were significant. Variance inflation factors were also assessed, and multicollinearity was not observed in any of the models (variance inflation factor <10) (15).

Defining select covariates

Individuals with self-reported diagnosed sleep apnea were identified as those who responded 'yes' to the following question: 'Have you been told by a health professional that you have sleep apnea?' Individuals with self-reported sleep laboratory testing referral were identified as those who responded 'yes' to the following question: 'Have you ever been referred to a sleep lab for overnight testing?' Individuals at high risk for OSA, excluding those who reported diagnosed sleep apnea, were identified using the STOP tool, which screens patients for OSA based on Snoring, Tiredness, Observed apneas and high blood Pressure (16). Given specific length and time guidelines for the CCHS Rapid Response modules, which dictated restrictions on the number and length of questions, the use of the STOP tool for estimating risk of OSA was a logistical decision.

Sleep laboratory testing capacity data

Data regarding numbers of sleep laboratories and numbers of sleep laboratory beds for each province was provided by a Canadian Sleep Society (CSS) database, which included data from provincial regulatory bodies and home care companies. Confirmation of the data was performed by telephone survey conducted in late 2010 and early 2011, and was additionally verified by members of the CSS and the Canadian Thoracic Society. Facilities that only performed home-based sleep testing with portable monitors (ie, level 3 testing) were excluded from the list.

RESULTS

Population characteristics

Population distributions according to various characteristics are presented in Table 1 for the total population and for individuals reporting having been referred to a sleep laboratory. The proportion of individuals who reported a sleep laboratory test referral was similar among the total population (4.8%) and those at high risk for OSA (5.1%) (Table 2). Nearly one in four individuals with diagnosed sleep apnea had not been referred to a sleep laboratory for overnight testing.

Predictors of referral for overnight sleep laboratory testing

The prevalence of reported referral to a sleep laboratory according to various population characteristics and the associated rate ratios are presented in Table 3 and Figure 1.

In the adjusted model, significant predictors of reported sleep laboratory test referral were body mass index (BMI), number of chronic conditions, regular medical doctor, age, sex and region (Figure 1). Individuals who were male, 45 to 64 years of age, were overweight or obese, had one or more of the five chronic conditions of interest, had a regular medical doctor and resided in Ontario were more likely to report sleep laboratory test referral.

The PRRs of sleep laboratory test referral for symptoms of sleep apnea, including those of the STOP tool, are reported in Table 4. Reported testing referral was greater among individuals reporting symptoms of sleep apnea – loud snoring, tiredness and observed apnea – compared with those not reporting these symptoms. Observed apnea was the strongest symptom predictor for sleep laboratory test referral. The proportion of individuals at high risk for OSA who were referred for sleep laboratory testing was nearly two times greater than in those who were not at high risk for OSA.

Chronic conditions and sleep laboratory test referral

The prevalence of high risk for OSA as well as the proportion reporting sleep laboratory test referral according to chronic condition is presented in Table 5. Compared with the prevalence of high risk of OSA (19.0% [95% CI 17.6% to 20.4%]) and the proportion reporting sleep laboratory test referral (4.8% [95% CI 4.1% to 5.5%]) in the general population, the prevalence of high risk for OSA and proportion reporting sleep laboratory test referrals was significantly higher for individuals with chronic conditions, except for migraine headaches (Table 5).

The prevalence of high risk for OSA was greatest among individuals with hypertension, chronic obstructive pulmonary disease (COPD), heart disease and diabetes, while the largest proportion reporting a sleep laboratory test was among respondents with COPD, diabetes, heart disease, and mood or anxiety disorder. Reporting sleep

TABLE 1
Study population characteristics

Population characteristic	Proportion reporting various population characteristics*	
	Total population (n=8647)	Individuals reporting sleep lab testing referral (n=422)
Sex		
Male	49.1 (48.8–49.4)	60.5 (53.5–67.5)
Age, years		
18–44	47.7 (47.4–47.9)	28.0 (21.4–34.7)
45–64	35.6 (35.4–35.8)	53.7 (46.7–60.7)
≥65	16.7 (16.7–16.8)	18.3 (13.9–22.6)
Ethnicity		
White	80.6 (78.8–82.4)	86.7 (81.6–91.8)
Body mass index, kg/m^2		
<25	48.2 (46.4–50.0)	17.4 (11.6–23.2)‡
≥25 to <30	34.2 (32.6–35.9)	46.8 (39.0–54.6)
≥30 to <35	13.2 (12.0–14.4)	22.0 (16.3–27.6)
≥35	4.4 (3.9–5.1)	13.9 (9.1–18.7)‡
Smoking status		
Never smoker	37.1 (35.3–38.9)	27.1 (20.3–33.9)
Former smoker	41.8 (40.1–43.4)	54.2 (46.5–61.8)
Current smoker	21.1 (19.7–22.6)	18.7 (13.6–23.9)
Marital status		
Ever married/common-law	77.1 (75.9–78.3)	86.2 (80.7–91.6)
Educational attainment		
<Secondary school	8.4 (7.6–9.2)	6.1 (2.6–9.7)‡
Secondary school graduation	16.0 (14.7–17.4)	14.7 (9.4v20.0)‡
Postsecondary school graduation	75.6 (74.0–77.2)	79.2 (73.1–85.3)
Total annual household income, $		
<30,000	14.5 (13.3–15.7)	15.4 (11.2–19.5)
30,000 to 99,999	47.4 (45.7–49.2)	52.7 (45.5–59.9)
≥100,000	24.6 (23.0–26.2)	32.0 (24.5–39.4)
Not stated	13.5 (12.3–14.8)	11.9 (5.2–18.6)‡
Chronic conditions†		
0 of 5 conditions	70.1 (68.5–71.7)	47.9 (39.7–56.0)
1–2 of 5 conditions	27.9 (26.4–29.4)	45.0 (37.5–52.5)
3–5 of 5 conditions	2.0 (1.6–2.3)	7.2 (4.4–9.9)‡
Medical doctor		
Has a regular medical doctor	84.6 (83.3–85.9)	95.9 (93.2–98.5)

*Data presented as % (95% CI). *Estimates weighted to the Canadian population; †Includes hypertension, heart disease, diabetes, stroke and mood disorder; ‡Interpret with caution – estimate associated with high sampling variability. lab Laboratory*

laboratory testing among individuals with hypertension was relatively low given the large proportion at high risk for OSA in this group. The proportion reporting a test referral did not differ significantly according to chronic condition.

Geography and sleep laboratory testing referral

Geographical region region was a strong predictor of reported sleep laboratory test referrals (Table 3). The prevalence according to geographical region of reported diagnosed sleep apnea, high risk for OSA and the proportion reporting sleep laboratory test referrals are presented in Table 6. After adjustment for confounders, the proportion reporting sleep laboratory referral was significantly less in the Prairie region, Quebec and the Atlantic regions compared with Ontario. The nonsignificance of the adjusted PRR for British Columbia was potentially due to limited sample power, as indicted by the degree of variability associated with the estimate as well as the strength of the association represented by the unadjusted and adjusted point PRR estimate.

TABLE 2
Proportion reporting sleep laboratory testing referral among adults ≥18 years of age

	Proportion reporting sleep laboratory testing referral*, % (95% CI)
Total Canadian population	4.8 (4.1–5.5)
Individuals with reported diagnosed sleep apnea	76.8 (70.1–83.6)
Individuals at high risk for OSA†	5.1 (3.4–6.7)
Individuals not reporting diagnosed sleep apnea and not at high risk for OSA	1.4 (0.9–1.8)

**Estimates weighted to the Canadian population; †High risk for obstructive sleep apnea (OSA) excludes individuals who reported diagnosed sleep apnea and is defined by the STOP tool (see text)*

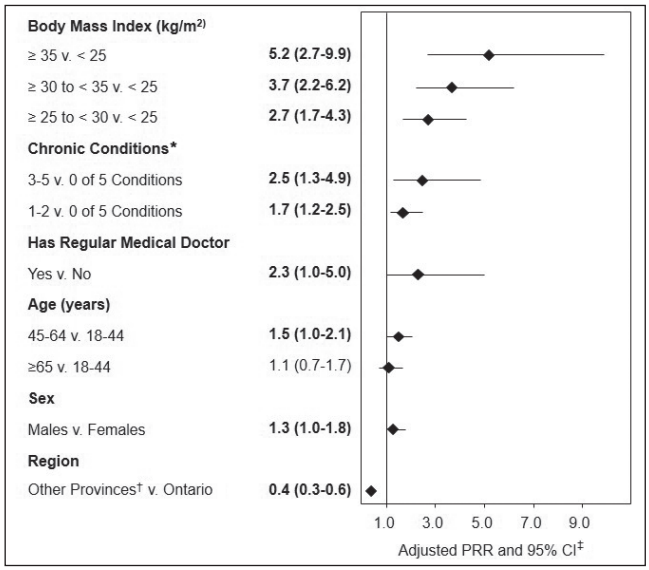

Figure 1) *Adjusted prevalence rate ratios (PRR) for reported sleep laboratory testing referrals among adults ≥18 years of age and older. Estimates are weighted to the Canadian population; *Includes hypertension, heart disease, diabetes, stroke and mood disorder; †Excludes the Territories; ‡Adjusted for sex, age, ethnicity, body mass index, smoking, marital status, educational attainment, household income, chronic conditions, having a regular medical doctor and region. Bolded values indicate P<0.05. v Versus*

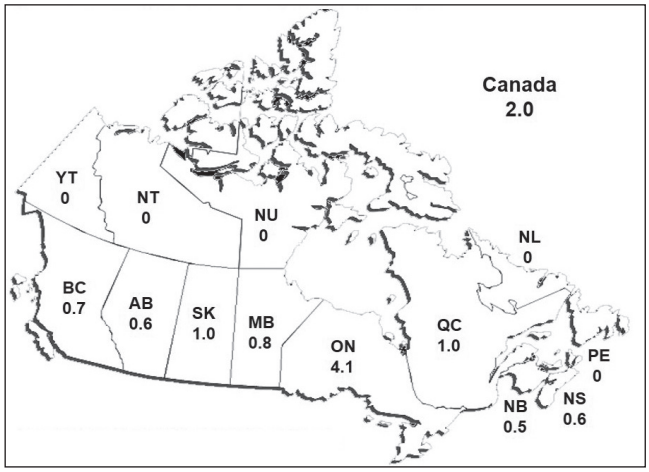

Figure 2) *Number of sleep testing beds per 100,000 population in Canada, 2010. Estimates do not include level 3 or pediatric testing facilities. AB Alberta; BC British Columbia; MB Manitoba; NB New Brunswick; NL Newfoundland and Labrador; NS Nova Scotia; NT Northwest Territories; NU Nunavut; ON Ontario; PE Prince Edward Island; QC Quebec; SK Saskatchewan; YT Yukon Territory*

TABLE 3
Prevalence and rate ratios for reported overnight sleep laboratory testing referrals among adults ≥18 years of age

	Proportion reporting sleep laboratory testing referral*, % (95% CI)	Prevalence rate ratio for reported sleep lab testing referral* (95% CI)	
		Unadjusted	Adjusted†
Sex			
Female	3.7 (2.9–4.5)	1.0	1.0
Male	5.9 (4.7–7.2)	**1.6 (1.2–2.1)**	**1.3 (1.0–1.8)**
Age, years			
18–44	2.8 (2.0–3.6)	1.0	1.0
45–64	7.2 (5.7–8.7)	**2.6 (1.8–3.7)**	**1.5 (1.0–2.1)**
≥65	5.5 (4.2–6.8)	**1.9 (1.3–2.8)**	1.1 (0.7–1.7)
Ethnicity			
Other	5.3 (4.5–6.2)	1.0	1.0
White	2.9 (1.7–4.1)‡	**1.8 (1.2–2.8)**	1.2 (0.7–2.0)
Body mass index, kg/m^2			
<25	1.7 (1.1–2.4)‡	1.0	1.0
≥25 to <30	6.6 (5.0–8.2)	**3.8 (2.4–6.0)**	**2.7 (1.7–4.3)**
≥30 to <35	8.0 (5.7–10.3)	**4.6 (3.0–7.1)**	**3.7 (2.2–6.2)**
≥35	15.0 (10.1–19.8)‡	**8.6 (5.1–14.5)**	**5.2 (2.7–9.9)**
Smoking			
Never smoker	3.5 (2.5–4.6)	1.0	1.0
Former smoker	6.3 (5.0–7.6)	**1.8 (1.2–2.5)**	1.3 (0.9–1.9)
Current smoker	4.3 (3.0–5.5)	1.2 (0.8–1.8)	1.4 (0.9–2.3)
Marital status			
Never married/common law	5.4 (4.5–6.3)	1.0	1.0
Ever married/common law	2.9 (1.7–4.1)‡	**1.9 (1.2–3.0)**	1.0 (0.6–1.7)
Educational attainment			
<Secondary school	3.7 (1.5–5.9)‡	1.0	1.0
Secondary school graduation	4.7 (2.8–6.6)‡	1.2 (0.6–2.5)	1.2 (0.6–2.5)
Postsecondary school graduation	5.1 (4.2–6.0)	1.4 (0.7–2.6)	1.2 (0.6–2.4)
Total household income			
Lowest income quintile	4.6 (3.3–5.9)	1.0	1.0
Middle three income quintiles	4.7 (3.7–5.6)	1.0 (0.7–1.4)	0.9 (0.6–1.3)
Upper income quintile	5.5 (3.9–7.2)	1.2 (0.8–1.8)	1.0 (0.7–1.6)
Chronic conditions§			
0 of 5 conditions	3.2 (2.4–4.1)	1.0	1.0
1–2 of 5 conditions	7.8 (6.3–9.3)	**2.4 (1.7–3.3)**	**1.7 (1.2–2.5)**
3–5 of 5 conditions	18.0 (11.2–24.9)‡	**5.6 (3.5–8.9)**	**2.5 (1.3–4.9)**
Regular medical doctor			
Has a regular doctor	5.5 (4.6–6.3)	1.0	1.0
Does not have a regular doctor	1.3 (0.5–2.1)‡	4.2 (2.1–8.5)	2.3 (1.0–5.0)
Region			
Ontario	7.7 (6.3–9.2)	1.0	1.0
Other provinces¶	2.9 (2.3–3.6)	**0.4 (0.3–0.5)**	**0.4 (0.3–0.6)**

*Bolded values indicate P<0.05, 1.0 represents the reference category. *Estimates weighted to the Canadian population; †Adjusted for sex, age, ethnicity, body mass index, smoking, marital status, educational attainment, household income, chronic conditions, having a regular medical doctor and region; ‡Interpret with caution, estimate associated with high sampling variability; §Includes hypertension, heart disease, diabetes, stroke and mood disorder; ¶Excludes the Territories*

Distribution of sleep laboratories across Canada

Current estimates of number of sleep laboratories and per 100,000 population sleep testing beds according to province and region are presented in Table 7 and Figure 2. The number of sleep laboratory beds per 100,000 population varies greatly across Canada, ranging from 0 in several provinces/territories to 4.1 beds per 100,000 in Ontario. The number of sleep laboratory beds in Ontario is twice the national estimate for Canada. Overall, the number of sleep laboratory beds per 100,000 population in Canada has increased to 2.0 in 2010 from the 1.4 estimated in 2004. The largest relative increase in the number of beds was observed in the Prairie region, followed by Quebec, Ontario and British Columbia. In the Atlantic region, the number of beds per 100,000 population decreased slightly, while estimates for the Territories remained at 0. Within the regions, a high degree of provincial variability exists in the number of sleep laboratory beds per 100,000 population.

DISCUSSION

Approximately 4.8% of the total population and 76.8% of individuals with reported diagnosed sleep apnea reported having been referred to a sleep laboratory for overnight testing. Significant predictors of sleep laboratory referral included male sex, middle age, overweight, having a chronic condition, having a regular medical doctor and reporting symptoms of sleep apnea. Our data are consistent with previous findings that male sex, increased BMI and multiple comorbid chronic conditions are associated with OSA. Seventy one per cent of the individuals referred to a sleep laboratory were diagnosed with sleep apnea or were at high risk for OSA, suggesting that of the potential sleep disorders being investigated, suspicion of sleep apnea is likely the most common reason for referral to sleep laboratory.

While several sleep apnea symptoms and risk factors were associated with sleep laboratory test referral, systemic hypertension, a key clinical

TABLE 4
Prevalence rate ratios of sleep laboratory testing referral according to symptoms of obstructive sleep apnea (OSA) among adults ≥18 years of age

	Proportion reporting sleep laboratory testing referral*, % (95% CI)	Prevalence rate ratio for sleep laboratory testing referral* (95% CI)	
		Unadjusted	Adjusted†
Does not snore	3.1 (2.3–3.9)	1.0	1.0
Snores slightly louder than heavy breathing or as loud as talking	4.2 (3.0–5.4)	0.8 (0.6–1.2)	0.9 (0.6–1.4)
Snores louder than talking or loud enough to be heard through closed doors‡	11.4 (8.4–14.3)	**3.2 (2.3–4.4)**	**1.5 (1.0–2.3)**
Does not often feel tired, fatigued, or sleepy during the daytime	3.0 (2.2–3.8)	1.0	1.0
Often feels tired, fatigued, or sleepy during the daytime‡	7.0 (5.8–8.3)	**2.4 (1.7–3.3)**	**2.2 (1.5–3.1)**
Not observed to stop breathing during sleep	2.9 (2.3–3.5)	1.0	1.0
Observed to stop breathing during sleep‡	26.7 (21.5–31.9)	**9.3 (7.0–12.4)**	**6.6 (4.7–9.4)**
Does not have hypertension	4.0 (3.1–4.8)	1.0	1.0
Has or is being treated for hypertension‡	8.3 (6.4–10.2)	**2.1 (1.5–2.9)**	1.3 (0.9–2.0)
Has difficulty falling or staying asleep none, some, or a little of the time	4.0 (6.5–11.7)	1.0	1.0
Has difficulty falling or staying asleep most or all of the time	9.1 (6.5–11.7)	**2.3 (1.6–3.2)**	**2.0 (1.4–2.8)**
Awakens with the feeling of gasping or choking never, rarely, or sometimes	4.5 (14.0–31.6)	1.0	1.0
Awakens with the feeling of gasping or choking often or very often	22.8 (14.0–31.6)	**5.1 (3.3–7.8)**	**2.9 (1.9–4.6)**
Not diagnosed with sleep apnea and not at high risk for OSA	1.4 (0.9–1.8)	1.0	1.0
At high risk of OSA§	5.1 (3.4–6.7)	**3.2 (2.1–5.0)**	**1.9 (1.1–3.3)**

*Bolded values indicate P<0.05, 1.0 represents the reference category. *Estimates weighted to the Canadian population; †Adjusted for sex, age, ethnicity, body mass index, smoking, marital status, educational attainment, household income, chronic conditions, regular medical doctor and region (note: ratio for hypertension not adjusted for chronic conditions due to colinearity issues); ‡Components of the STOP tool for estimating high risk for OSA (16); §High risk for OSA excludes individuals who reported diagnosed sleep apnea and is defined by the STOP tool (see text)*

feature of sleep apnea, was not a significant predictor of referral. Although 60.3% of the respondents with systemic hypertension were at high risk for OSA, only 8.3% of this population reported being referred for sleep laboratory testing, which was lower than the proportion referred for testing among several other chronic disease categories (eg, COPD, diabetes, heart disease, mood or anxiety disorder). These results suggest that patients with systemic hypertension are not being sufficiently identified at risk for OSA, despite the relationship between OSA and hypertension (4). On the other hand, use of the STOP criteria could lead to an overestimation of the prevalence of high risk for OSA among individuals with hypertension, and perhaps the discrepancy between proportion referred for testing and those at high risk for OSA among those with hypertension is not as great (although likely still present) as has been estimated (16). Several provinces perform unattended portable sleep monitoring or overnight oximetry to diagnose OSA; we are aware that publicly funded portable sleep monitoring exists in at least three provinces (British Columbia, Manitoba and Saskatchewan). Our data indicate that nearly one-quarter (23.2%) of Canadians with reported diagnosed sleep apnea were potentially diagnosed by methods other than sleep laboratory testing (76.8% of individuals with sleep apnea had been referred to sleep laboratories). Some of these individuals may not have been tested at all. Because the sleep laboratory referral question specified 'overnight testing', we cannot exclude the possibility that some individuals may have been diagnosed with sleep apnea based on portable sleep monitoring or overnight oximetry. Moreover, our survey asked whether individuals had ever been 'referred' for a sleep test, but not if such testing had ever been performed; thus, we may have captured individuals who were still waiting to undergo a sleep laboratory test.

The CSS database of level 1 sleep laboratories was generated using provincial regulatory databases and was supplemented by national home care company lists in which level 1 laboratory activity is not regulated. Database accuracy was verified in each province by Canadian Thoracic Society and CSS members from those regions, and all laboratories on the list were called to confirm their operation and the number of beds. It is estimated that >90% of in-laboratory (level-1) testing activity has been captured using this methodology. Conversely, unattended portable sleep monitoring (level-3 testing; excluded from the analysis) remains unregulated; it is currently difficult to ascertain the availability of portable testing in Canada. Regional discrepancies in the number of beds per 100,000 population were observed, with estimates being four to 10 times greater in Ontario compared with other provinces where sleep laboratory beds exist. The regional differences in beds per 100,000 population estimates and, subsequently, rates of sleep laboratory test referral and diagnosed sleep apnea, may reflect different practice models and public coverage among the provinces. The potential underdiagnosis of OSA is a Canada-wide issue, as is suggested by the large differences observed between the prevalence of individuals at high risk for OSA and diagnosis of sleep apnea across all provinces. The ratio of individuals at

TABLE 5
Proportion reporting sleep laboratory testing referral according to chronic condition

Self-reported health professional-diagnosed chronic condition	Proportion at high risk for OSA*†	Proportion reporting sleep laboratory testing referral*
Mood or anxiety disorder‡	28.9 (23.8–34.0)	11.2 (8.1–14.3)
Arthritis or back problems (excluding fibromyalgia)	29.5 (26.7–32.4)	7.7 (6.2–9.3)
Asthma	28.8 (23.2–34.5)	9.2 (5.9–12.6)§
COPD (COPD, chronic bronchitis, or emphysema)¶	51.0 (42.4–59.7)	13.1 (7.8–18.3)§
Diabetes	48.0 (41.2–54.8)	12.1 (8.6–15.7)
Heart disease	50.0 (43.4–56.5)	11.9 (7.1–16.6)§
Hypertension	60.3 (56.0–64.6)	8.3 (6.4–10.2)
Migraine headaches	24.3 (19.6–29.0)	5.5 (3.5–7.5)§
Urinary incontinence**	45.7 (36.9–54.4)	10.1 (6.0–14.2)§

*Data presented as % (95% CI). *Estimates weighted to the Canadian population; †High risk for obstructive sleep apnea (OSA) excludes individuals who reported diagnosed sleep apnea and is defined by the STOP tool; ‡Includes phobia, obsessive compulsive disorder, panic disorder, depression, bipolar, mania and dysthymia; §Interpret with caution, estimate associated with high sampling variability; ¶Asked of individuals ≥35 years of age, respondents <35 years of age were coded as not having the condition; **Asked of individuals ≥25 years, respondents <25 years of age were coded as not having the condition. COPD Chronic obstructive pulmonary disease*

TABLE 6
Prevalence and rate ratios of reported diagnosed obstructive sleep apnea (OSA) and sleep laboratory testing referral according to region among adults ≥18 years of age

	Prevalence* (95% CI)				Prevalence rate ratio for sleep laboratory testing referral* (95% CI)	
	Reported sleep laboratory testing referral	Reported diagnosed sleep apnea	At high risk for OSA†	At high risk for OSA† and no reported sleep laboratory testing referral	Unadjusted	Adjusted‡
Canada	4.8 (4.1–5.5)	3.4 (2.8–4.0)	19.0 (17.6–20.4)	18.0 (16.6–19.4)	–	–
Ontario	7.7 (6.3–9.2)	4.6 (3.4–5.8)	18.3 (15.9–20.8)	17.1 (14.7–19.5)	1.0	1.0
British Columbia	3.9 (2.1–5.7)§	3.8 (2.2–5.3)§	16.9 (13.8–20.1)	16.1 (12.9–19.2)	**0.5 (0.3–0.9)**	0.6 (0.4–1.1)
Prairies¶	3.4 (1.8–4.9)§	2.5 (1.4–3.6)§	20.0 (16.8–23.2)	18.7 (15.6–21.9)	**0.4 (0.3–0.7)**	**0.4 (0.3–0.7)**
Quebec	2.0 (1.2–2.8)§	1.9 (1.0–2.7)§	19.1 (16.0–22.2)	18.7 (15.6–21.8)	**0.3 (0.2–0.4)**	**0.3 (0.2–0.5)**
Atlantic**	3.4 (1.4–5.3)§	3.3 (1.7–4.8)§	23.7 (20.7–26.6)	22.6 (19.6–25.6)	**0.4 (0.2–0.8)**	**0.3 (0.2–0.6)**

*Bolded values indicate P<0.05, 1.0 represents the reference category. *Estimates weighted to the Canadian population; †High risk for OSA excludes individuals who reported diagnosed sleep apnea and is defined by the STOP tool; ‡Adjusted for sex, age, ethnicity, body mass index, smoking, marital status, educational attainment, household income, chronic conditions and regular medical doctor; §Interpret with caution, estimate associated with high sampling variability; ¶Includes Alberta, Saskatchewan and Manitoba; **Includes New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador*

TABLE 7
Number of overnight sleep laboratories and number of sleep testing beds according to province and region, Canada, 2004 and 2010

	2004 (Flemons et al [17])				2010*			
	Sleep laboratories, n	Beds, n	Population	Beds/100,000	Sleep laboratories, n	Beds, n	Population†	Beds/100,000
Canada	100	440	31,413,990	1.4	131	698	34,108,800	2.0
British Columbia	5	18	4,141,272	0.4	8	31	4,531,000	0.7
Prairies	9	24	5,276,242	0.5	9	44	6,001,900	0.7
Alberta	5	14	3.113,586	0.4	6	24	3,720,900	0.6
Saskatchewan	2	6	1,011,808	0.6	2	10	1,045,600	1.0
Manitoba	2	4	1,150,848	0.3	1	10	1,235,400	0.8
Ontario	69	340	12,068,301	2.8	87	537	13,210,700	4.1
Quebec	12	44	7,455,208	0.6	24	76	7,907,400	1.0
Atlantic	4	11	2,372,925	0.5	3	10	2,346,300	0.4
New Brunswick	1	3	756,652	0.4	1	4	751,800	0.5
Nova Scotia	2	6	944,765	0.6	2	6	942,500	0.6
Prince Edward Island	0	0	139,913	0.0	0	0	142,300	0.0
Newfoundland and Labrador	1	2	531,595	0.4	0	0	509,700	0.0
Territories	0	0	100,042	0.0	0	0	111,500	0.0
Yukon	0	0	29,924	0.0	0	0	34,500	0.0
Northwest Territories	0	0	41,403	0.0	0	0	43,800	0.0
Nunavut	0	0	28,715	0.0	0	0	33,200	0.0

**Estimates do not include level 3 or pediatric testing facilities or data for the Territories; †Statistics Canada, 2010 (18)*

high risk for OSA to diagnosed sleep apnea was largest in Quebec (10:1) and smallest in Ontario (4:1); the ratio for Canada overall was 6:1.

Assuming that the estimated 698 sleep laboratory beds in Canada operate for 365 days of the year, current sleep laboratories can perform a maximum of 254,770 tests per year. If one conservatively assumes that only one of four individuals at high risk for OSA requires a sleep laboratory test, we can estimate, using a more reasonable testing capacity estimate (5 days/week × 50 weeks/year × operational capacity of 80%), that it would take nearly eight years to test these individuals. This estimate does not take into account treatment follow-up requirements for sleep apnea or other sleep disorders, nor do they take into account testing requirements for children with sleep apnea and other sleep disorders.

Recent Canadian guidelines recommend that portable sleep monitoring studies can be used to confirm the diagnosis of OSA and institute appropriate treatment in patients with a moderate to high pretest probability of OSA (19). As such, portable monitoring is likely a viable and cost-effective option for increasing access to sleep testing in Canada. However, portable sleep monitoring has limited application in patients with medical or psychiatric comorbid diseases as well as for the diagnosis of other forms of sleep apnea. In the majority of these patients, level-1 overnight sleep testing is required. Moreover, patients with obesity-hypoventilation currently require overnight PSG in a sleep laboratory for treatment to be initiated. Thus, even if portable monitoring becomes more widely available, the need for overnight sleep laboratory facilities is still apparent, particularly when one considers the trend of increasing obesity prevalence (and associated comorbidities). OSA management pathways should focus on early identification at the primary care level, with proper risk stratification and triaging to either in-laboratory PSG or home portable monitoring with management based on a validated ambulatory pathway protocol.

The STOP tool was validated in an older, preoperative population with higher average BMI measures as compared with the general population (16). Thus, our use of the tool for estimating the prevalence of high risk for OSA may have limited generalizability to the Canadian population. Furthermore, by using male-oriented OSA symptom criteria (eg, snoring), the tool may have been biased toward

male selection. Women may present with different OSA symptoms compared with men, and are more likely to report insomnia, fatigue, to have hypothyroidism, to be treated for depression and be more overweight than men (20,21).

The SARR questionnaire asked individuals if they had 'diagnosed sleep apnea' and, as such, we have no information regarding the type of sleep apnea. In our interpretation of the data, we assumed that the majority of these individuals had OSA. A few studies have demonstrated that the prevalence of central sleep apnea among individuals referred for sleep laboratory tests is <5% (22,23).

In the majority of provinces, sleep laboratory tests are covered by provincial heath plans; however, in some (eg, Alberta, British Columbia, Nova Scotia and Quebec), privately funded sleep laboratories exist. We included privately funded sleep laboratories in our sleep laboratory survey recognizing that, for many Canadians, the costs of such testing constitutes a significant barrier to access.

Of the estimated 5.4 million Canadian adults who have either been diagnosed with sleep apnea or who are estimated to be at high risk for OSA, 4.5 million did not report having been referred for sleep laboratory testing. Canada currently has 131 diagnostic sleep laboratories, which is inadequate given the number of individuals at high risk for OSA, and the proportion of these individuals who would potentially benefit from testing and appropriate treatment.

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