

Respiratory health, occupation and the healthy worker effect

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Background	Workers are exposed to physical, chemical and other hazards in the workplace, which may impact their respiratory health.
Aims	To examine the healthy worker effect in the Canadian working population and to identify the association between occupation and respiratory health.
Methods	Data from four cycles of the Canadian Health Measures Survey were utilized. The current occupation of employed participants was classified into 10 broad categories based on National Occupation Category 2011 codes. Data relating to 15 400 subjects were analysed.
Results	A significantly lower proportion of those in current employment than those not in current employment reported respiratory symptoms or diseases or had airway obstruction. Similarly, those currently employed reported better general health and had greater mean values for percent-predicted forced vital capacity (FVC), forced expiratory volume in one second (FEV ₁), forced expiratory flow between 25% and 75% of FVC (FEF _{25–75%}) and FEV ₁ /FVC ratio. Among males, females and older age groups, significant differences were observed for almost all the respiratory outcomes for those in current employment. Those in ‘Occupations unique to primary industry’ had a significantly greater likelihood of regular cough with sputum and ever asthma and had lower mean values of percent-predicted FEV ₁ /FVC and FEF _{25–75%} than those in ‘Management occupations’. Those in ‘Health occupations’ had the highest proportion of current asthma.
Conclusions	Participants in current employment were healthier than those not in current employment providing further support for the healthy worker effect. Those in ‘Occupations unique to primary industry’ had an increased risk of adverse respiratory outcomes and reducing workplace exposures in these occupations has the potential to improve their respiratory health.
Key words	Airway obstruction; employment; healthy worker effect; occupation; respiratory symptoms.

Introduction

Working populations are exposed to physical, chemical and other hazards in the workplace. Exposure to hazards can cause respiratory symptoms and diseases [1]. However, as unhealthy people are more likely to leave employment, the working population tends to be healthier than the non-working population. This phenomenon is referred to as the ‘healthy worker effect’ and introduces selection bias in occupational epidemiological studies [2]. Factors associated with the healthy worker effect include age, gender and race [3,4].

In a cross-sectional survey of an urban population in Wellington, New Zealand, cumulative life-long occupational exposure determined using a job matrix was not associated with self-reported respiratory symptoms, percent-predicted forced expiratory volume in one second (FEV₁) and chronic obstructive pulmonary disease (COPD), raising the possibility of the healthy worker effect [5]. A healthy worker effect has similarly been reported in farming populations [6].

Asthma and COPD have been identified as the leading occupational lung diseases [7]. Studies conducted in the USA and UK have examined the association between occupation and respiratory disease [8–14]. Associations

Key learning points

What is already known about this subject:

- Several studies have examined the association between occupation and respiratory health using self-reported symptoms. However, only a limited number of studies have used spirometric measures to determine airway obstruction.

What this study adds:

- A significantly lower proportion of those in current employment had respiratory symptoms or diseases or had airway obstruction. Those in current employment also reported better general health and had greater mean values for some of the lung function parameters in males, females and older age groups.
- Participants employed in 'Occupations unique to primary industry' had a significantly greater likelihood of reporting regular cough with sputum or ever asthma, were more likely to have airway obstruction and had lower mean values for some of the lung function parameters than those employed in 'Management occupations'.
- The highest prevalence of current asthma was observed in 'Health occupations'.

What impact this may have on practice or policy:

- The healthy worker effect must be taken into consideration in occupational epidemiology studies.
- Reduced exposure to workplace air contaminants has the potential to improve the respiratory health of those employed in 'Occupations unique to primary industry'.

between occupation and respiratory symptoms and lung function measures were also reported in a case-control study from the Netherlands [12] and in a large population-based study from the USA [13]. Being able to investigate these associations allowing for the healthy worker effect is important.

In this study, we examined first the healthy worker effect and respiratory outcomes by comparing the respiratory outcomes between those in current employment and those not in current employment. And secondly, the association between 10 broad occupational categories and respiratory outcomes among those in current employment in a Canadian population using data from the four cycles of the Canadian Health Measures Survey (CHMS).

Methods

Each cycle of the CHMS comprised a cross-sectional survey, and cycles were conducted every 2 years, with the sample in each cycle being representative of the Canadian population [14]. Details of the sampling design, data collection and data description are seen elsewhere [15]. The CHMS included completion of an interviewer-administered household questionnaire at home and a visit to the mobile examination centre (MEC) to complete a clinic questionnaire and provide spirometry and other measures [16]. The first four cycles of CHMS were conducted from 2007 to 2009 (Cycle 1, number of participants: 5604), 2009 to 2011 (Cycle 2, number of participants: 6395), 2012 to 2013 (Cycle 3, number of participants: 5785) and 2014 to 2015 (Cycle 4, number of participants: 5794) [17]. Participants in an earlier survey were not considered for inclusion in later surveys. Data for subjects aged 6–79 years from the four

CHMS cycles were appended, and the appended data were merged with design and bootstrap weights provided by Statistics Canada. The records of the respondents <15 years (the minimum age for employment) and >75 years were excluded. After exclusions, the appended data file contained approximately 15 400 records. Information on current employment status and spirometry measurements were available for approximately 15 330 and 14 580 subjects, respectively.

Information about employment in the last 12 months was obtained from the response to the question: 'Have you worked at a job or business at any time in the past 12 months?' Subjects who answered 'yes' were considered to be in current employment. The job description fields of those currently employed were then extracted to classify the occupation of the individual using the National Occupational Classification—Statistics (NOC) 2011 codes [18]. The first character of the NOC 2011 codes was used to classify the occupations into 10 broad occupational categories [18]. There were enough details recorded to code the occupation of 10 730 of the 11 140 in current employment.

Age at the time of the visit to the MEC was considered and was categorized into 15–29, 30–59 and 60–75 years. After excluding pregnant women, obesity was classified, based on body mass index (BMI), into underweight (BMI <18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.9–29.9 kg/m²) and obese (≥30.0 kg/m²). Smoking habit was categorized into never, former and current smokers.

The responses to the following questions in the clinic questionnaire administered at the MEC were used to determine regular cough, regular cough with phlegm, shortness of breath and wheeze: 'Do you cough regularly?' 'Do you cough up phlegm regularly?' 'Do even

simple chores make you short of breath?’ and ‘Do you wheeze when you exert yourself, or at night?’, respectively. The general health of the participant was determined from the question: ‘In general, would you say that your health is excellent? very good? good? fair or poor?’. Information on COPD, asthma, chronic bronchitis and emphysema was obtained using the response to the question on long-term conditions which were expected to last or had already lasted ≥ 6 months and were diagnosed by a health professional. Information on current asthma was obtained from the response to the question: ‘Have you had any asthma symptoms or asthma attacks in the past 12 months?’.

The details of the methods used for the spirometry measurements are reported in detail elsewhere [19]. Briefly, subjects who had health issues and women who were pregnant for >27 weeks were excluded from the spirometry. A Koko pneumotach spirometer (Koko; nSpire Health, Longmont, CO) was used for the spirometry. Trained technicians performed the spirometry using American Thoracic Society/European Respiratory Society guidelines [20]. Spirometric measures of lung function included forced vital capacity (FVC), FEV_1 , forced expiratory flow between 25% and 75% of FVC ($FEF_{25-75\%}$) and FEV_1/FVC ratio. Percent-predicted lung function values and lower limit of normal (LLN) values were obtained using the reference equations for the Canadian population, which were derived using the data from the first three CHMS cycles that were part of this study [19]. Typically, post-bronchodilator spirometry measurements are used to define the Global Initiative for Chronic Obstructive Lung Disease (GOLD) staging criteria for COPD. However, only pre-bronchodilator spirometry measurements were obtained in CHMS, and consequently a modification of GOLD staging criteria for COPD based on pre-bronchodilator values was used to classify subjects into different stages: severe COPD (GOLD Stage III or IV; $FEV_1/FVC < 0.70$ and $FEV_1 < 50\%$ predicted), moderate COPD (GOLD Stage II; $FEV_1/FVC < 0.70$ and $50\% \leq FEV_1 < 80\%$ predicted), mild COPD (GOLD Stage I; $FEV_1/FVC < 0.70$ and $FEV_1 \geq 80\%$ predicted) and no airflow limitation ($FEV_1/FVC \geq 0.70$) [21]. This modification has been used previously in population-based studies [22–24]. The severity of airflow obstruction was also classified using LLN into two criteria: (i) $FEV_1/FVC < LLN$ and (ii) $FEV_1/FVC < LLN$ and $FEV_1 < LLN$, hereafter referred to as non-GOLD criteria [25,26]. This study was approved by the University of Alberta Health Research Ethics Board.

Design weights provided by Statistics Canada were incorporated in all the statistical analyses. Standard error, *P*-value and 95% confidence interval of the regression coefficients were obtained using 500 bootstrap weights provided by Statistics Canada. Chi-squared statistics were used to test for overall significant differences in the general

characteristics between those in current employment and those not in current employment, and between the 10 broad occupational categories. Simple and multinomial logistic regression analyses were used to determine significant differences in the proportion of respiratory symptoms and of airway obstruction defined by GOLD and non-GOLD criteria between those in current employment and those not in current employment, and between the 10 broad occupational categories, after controlling for potential confounders. Multiple linear regression analyses were used to determine significant differences in the mean lung function parameters and mean percent-predicted lung function parameters between current workers and non-workers, and the 10 broad occupational categories, after controlling for potential confounders. The procedures for the analysis of complex survey data in STATA were used in the statistical analyses [27].

Results

As given in Table 1, the majority of those in current employment were in the middle-age group whereas the majority of those not in current employment were in the older age group with the difference between the distribution of the age groups being statistically significant. The proportion of females was significantly lower among those in current employment than in those not. There was also a statistically significant difference in the distribution of smoking status and obesity between those in current employment and those not in current employment (Table 1).

After adjusting for age group, sex and smoking, the proportion reporting respiratory symptoms including regular cough, regular cough with phlegm, wheeze and shortness of breath was significantly lower among those in current employment than those not in current employment (Table 2). The proportion reporting respiratory diseases including ever asthma, chronic bronchitis and COPD was significantly lower among those in current employment than those not in current employment after adjusting for age group, sex and smoking. As given in Table 2, there was almost a 2-fold significant increase in self-reported poor health among those not in current employment in comparison to those in current employment after adjusting for age, sex and smoking.

After adjusting for age, sex, height and smoking status, mean values of FVC, FEV_1 and $FEF_{25-75\%}$ were significantly greater in those in current employment than in those not after adjusting for smoking status (Table 3). The proportion with airway obstruction based on non-GOLD or GOLD criteria was significantly lower among those in current employment than those not in current employment after adjusting for smoking.

Stratified analyses within male and female groups and age groups were carried out to determine whether the

Table 1. Distribution of the demographic and personal characteristics by current employment status^a

Characteristic	Current employment status		P-value ^b
	Employed, n = 11 140, n (%)	Not employed, n = 4190, n (%)	
Age group (years)			
15–29	3050 (28)	950 (18)	<0.001
30–59	6600 (62)	1030 (33)	
60–75	1480 (10)	2220 (49)	
Sex			
Female	5370 (47)	2550 (62)	<0.001
Male	5770 (53)	1640 (38)	
Ethnicity			
Caucasians	9120 (80)	3290 (76)	0.04
Others	2010 (20)	900 (24)	
Education			
Secondary or below	1590 (16)	1200 (29)	<0.001
Some post-secondary	390 (3)	120 (3)	
Post-secondary	8820 (81)	2720 (68)	
Marital status			
Married	6440 (61)	2110 (60)	<0.001
Divorced/widowed	1260 (9)	860 (17)	
Single	3440 (31)	1220 (23)	
Province			
Atlantic	1300 (6)	520 (7)	<0.001
Quebec	2710 (23)	1080 (26)	
Ontario	3850 (39)	1490 (39)	
Prairies	1690 (19)	500 (13)	
British Columbia	1590 (13)	600 (14)	
Smoking status			
Never	6100 (53)	2140 (49)	0.01
Current smoker	2210 (22)	760 (21)	
Former smoker	2810 (26)	1280 (30)	
Obesity			
Underweight or normal weight	4620 (41)	1590 (37)	0.006
Overweight	3790 (35)	1340 (34)	
Obese	2620 (24)	1210 (29)	

^aThe number of observations in those in current employment and those not in current employment were rounded to the nearest 10.

^bP-value from chi-squared statistics for overall comparison between those in current employment and those not in current employment.

differences in respiratory outcomes between those in current employment and those not in the current employment were consistent across groups. Significant differences between those in current employment and those not in current employment were observed in the

majority of respiratory outcomes among both males and females with the differences in airway obstruction determined by non-GOLD criteria being significant only in females. No significant differences were observed in the respiratory outcomes between those in current employment and those not in the current employment in the youngest age group, 15–29 years. However, in the older age groups, 30–59 years and 60–75 years, significant differences were observed for almost all the respiratory outcomes between those in current employment and those not in the current employment. The exception was for airway obstruction determined by both non-GOLD criteria, regular cough and cough with phlegm.

Among the group in current employment, the largest group was in the sales and service occupations followed by business, finance and administrative occupations. The percentage in each group is given in Table 4. The distribution of demographic and personal characteristics of those in current employment for the 10 broad occupational categories is also given in Table 4. As given in Table 4, there were significant differences between the 10 broad occupational categories in the distribution of all the characteristics. The largest proportion of the workers was in the middle-aged group and the majority had post-secondary education in all the 10 broad occupational categories (Table 4). The majority of workers were females in five broad occupational categories: ‘Business, finance and administrative occupations’, ‘Health occupations’, ‘Occupations in social science, education, government service and religion’, ‘Occupations in art, culture, recreation and sport’ and ‘Sales and service occupations’. There was a greater proportion of current smokers in ‘Trades, transport and equipment operators and related occupations’, ‘Occupations unique to primary industry’ and ‘Occupations unique to processing, manufacturing and utilities’. The lowest proportion of current smokers was in the ‘Health occupations’ category followed by the ‘Occupations in social science, education, government service and religion’. The greatest proportion of obese workers was in the ‘Occupations unique to primary industry’ and the lowest was in the ‘Occupations in art, culture, recreation and sport’.

There was an overall significant difference between the 10 broad occupational categories in the distribution of regular cough with phlegm, wheeze, ever asthma and general health after adjusting for age group, sex and smoking (data not shown). The highest proportion of regular cough, regular cough with phlegm, wheeze and ever asthma was in the ‘Occupations unique to primary industry’ category with the proportion of regular cough with phlegm and ever asthma being significantly different from those in the ‘Management occupations’ category after adjusting for age group, sex and smoking status. In comparison to the ‘Management occupations’ category, there was a significantly greater

Table 2. Distribution of respiratory and general health by current employment status^a

Characteristic	Total (<i>n</i> = 15, 400), <i>n</i> (%)	Current employment status		<i>P</i> -value ^b
		Employed (<i>n</i> = 11 140), <i>n</i> (%)	Not employed (<i>n</i> = 4190), <i>n</i> (%)	
Regular cough	2180 (14)	1341 (13)	720 (17)	0.03 ^b
Regular cough with phlegm	1490 (10)	960 (9)	530 (12)	0.005 ^b
Wheeze	1360 (9)	870 (8)	490 (12)	<0.001 ^b
Shortness of breath	1310 (9)	680 (6)	630 (16)	<0.001 ^b
Current asthma	740 (5)	540 (5)	200 (4)	0.28 ^b
Ever asthma	1460 (10)	1020 (9)	440 (11)	0.03 ^b
Chronic bronchitis	290 (2)	150 (1)	140 (3)	0.003 ^b
COPD	150 (1)	50 (1)	100 (3)	0.01 ^c
Emphysema	(1)	(0)	(2)	<0.001 ^c
General health				
Poor or fair	1710 (11)	880 (8)	830 (21)	<0.001 ^d
Good	5470 (37)	3950 (36)	1520 (38)	
Very good or excellent	8140 (52)	6300 (56)	1840 (42)	

Frequencies of emphysema were suppressed to be compliant with the Statistic Canada confidentiality guidelines for reporting the data.

^aThe number of observations among those in current employment and those not in current employment were rounded to the nearest 10.

^b*P*-value for comparison between those in current employment and those not in current employment from logistic regression analysis after adjusting for age, sex and smoking.

^cDue to small cell frequencies, *P*-value from logistic regression after adjusting for age and sex only.

^d*P*-value from multinomial logistic regression after adjusting for age, sex and smoking.

Table 3. Distribution of spirometry measurements, percent-predicted lung function values, modified GOLD criteria and non-GOLD criteria by current employment status^a

Characteristic	Current employment status		<i>P</i> -value
	Employed (<i>n</i> = 10 710), mean (SE)	Not employed (<i>n</i> = 3870), mean (SE)	
FVC (litres)	4.31 (0.02)	3.55 (0.02)	<0.001 ^b
Percent-predicted FVC (%)	98.17 (0.36)	95.92 (0.41)	<0.001 ^c
FEV ₁ (litres)	3.38 (0.02)	2.72 (0.02)	<0.001 ^b
Percent-predicted FEV ₁ (%)	96.77 (0.31)	93.76 (0.43)	<0.001 ^c
FEV ₁ /FVC (%)	78.45 (0.14)	76.41 (0.22)	0.39 ^b
Percent-predicted FEV ₁ /FVC (%)	98.04 (0.18)	97.79 (0.25)	0.44 ^c
FEF _{25–75%} (litres/second)	3.10 (0.02)	2.40 (0.03)	<0.001 ^b
Percent-predicted FEF _{25–75%} (%)	94.57 (0.53)	92.22 (0.83)	<0.001 ^c
	<i>n</i> (%)	<i>n</i> (%)	
Modified GOLD criteria			
No airway limitation	9690 (91)	3230 (83)	<0.001 ^c
Stage I	630 (5)	310 (9)	
Stage II	(4)	(7)	
Stage III and IV	(0)	(1)	
Non-GOLD staging criteria			
FEV ₁ /FVC < LLN	500 (5)	260 (8)	<0.001 ^c
FEV ₁ /FVC < LLN and FEV ₁ < LLN	260 (3)	170 (5)	0.004 ^c

Frequencies of Stage II and Stage III and IV were suppressed to be compliant with the Statistic Canada confidentiality requirements for reporting the results.

^aThe number of observations among those in current employment and those not in current employment are rounded to the nearest 10.

^b*P*-values were adjusted for age group, height, sex and smoking status.

^c*P*-values were adjusted for smoking status.

proportion of shortness of breath and current asthma in the ‘Sales and service occupations’ category after adjusting for age group, sex and smoking status. There

was also a significant difference in the proportion of those reporting poor or fair general health between the ‘Trades, transport and equipment operators and

Table 4. Distribution of the demographic and personal characteristics by broad occupational categories^a

Characteristics	A	B	C	D	E	F	G	H	I	J	P-value ^b
	(n = 900) n (%)	(n = 1720) n (%)	(n = 850) n (%)	(n = 670) n (%)	(n = 1040) n (%)	(n = 510) n (%)	(n = 2880) n (%)	(n = 1410) n (%)	(n = 310) n (%)	(n = 470) n (%)	
Age group (years)											
15–29	60 (9)	300 (24)	120 (21)	90 (24)	150 (20)	170 (3)	1430 (43)	360 (28)	110 (36)	100 (19)	<0.001
30–59	690 (78)	1160 (66)	630 (70)	500 (67)	750 (68)	270 (65)	1160 (50)	830 (61)	130 (51)	330 (74)	
60–75	150 (14)	260 (10)	100 (9)	80 (9)	140 (12)	70 (9)	290 (7)	220 (11)	70 (14)	40 (7)	
Sex											
Female	330 (39)	1160 (67)	200 (21)	520 (80)	710 (64)	280 (54)	1680 (55)	90 (7)	50 (13)	140 (32)	<0.001
Male	570 (61)	560 (33)	650 (79)	150 (20)	330 (35)	230 (46)	1200 (45)	1320 (93)	260 (87)	330 (68)	
Ethnicity											
Caucasians	(77)	(82)	(77)	(76)	(86)	(87)	(74)	(84)	(95)	(79)	<0.001
Others	(23)	(14)	(24)	(24)	(14)	(13)	(26)	(16)	(5)	(21)	
Education											
Secondary or below	(12)	(12)	(5)	(5)		(4)	(20)	(25)	(35)	(34)	<0.001
Some post-secondary	(1)	(4)	(2)	(4)		(5)	(5)	(4)	(5)	(3)	
Post-secondary	(87)	(85)	(94)	(92)	(96)	(91)	(75)	71	(61)	(63)	
Marital status											
Married	690 (74)	1070 (66)	610 (67)	460 (69)	720 (68)	240 (54)	1120 (48)	910 (66)	160 (52)	300 (64)	<0.001
Divorced/widowed	100 (8)	260 (9)	80 (6)	90 (9)	130 (8)	60 (14)	280 (8)	120 (8)	40 (16)	50 (10)	
Single	110 (18)	380 (25)	160 (26)	120 (22)	190 (25)	210 (32)	1480 (45)	380 (27)	110 (32)	120 (26)	
Smoking status											
Never	480 (49)	910 (54)	520 (60)	430 (63)	630 (63)	310 (54)	1670 (54)	550 (38)	160 (47)	230 (48)	<0.001
Current smoker	140 (22)	290 (18)	110 (17)	80 (12)	130 (13)	70 (17)	670 (24)	440 (31)	70 (26)	120 (28)	
Former smoker	280 (29)	510 (28)	220 (23)	160 (25)	280 (24)	130 (29)	540 (22)	420 (31)	70 (26)	120 (24)	
Obesity											
Underweight or normal weight	300 (32)	660 (39)	320 (42)	310 (52)	410 (38)	270 (52)	1390 (45)	460 (33)	120 (37)	200 (49)	<0.001
Overweight	350 (40)	580 (35)	350 (36)	200 (27)	360 (35)	140 (32)	850 (33)	560 (41)	110 (22)	170 (30)	
Obese	250 (28)	450 (26)	180 (23)	160 (21)	250 (27)	90 (15)	620 (22)	380 (26)	70 (41)	100 (21)	

Frequencies of ethnicity and education were suppressed to be compliant with the Statistic Canada confidentiality requirements for reporting the results.

A: Management occupations; B: Business, finance and administrative occupations; C: Natural and applied sciences and related occupations; D: Health occupations; E: Occupations in social science, education, government service and religion; F: Occupations in art, culture, recreation and sport; G: Sales and service occupations; H: Trades, transport and equipment operators and related occupations; I: Occupations unique to primary industry; J: Occupations unique to processing, manufacturing and utilities.

^aFrequencies were rounded off to the nearest 10 to meet the confidentiality requirements of the Statistics Canada.

^bP-values obtained using chi-squared test indicate the overall significant differences between the 10 groups.

related occupations' category and the 'Management occupations' category after adjusting for age group, sex and smoking status. The prevalence of current asthma was highest in the 'Health occupations' category and was significantly different from that observed for the 'Management occupations' category (8% versus 4%, $P < 0.05$).

There was an overall significant difference between the 10 broad occupational categories in the adjusted mean values of $FEF_{25-75\%}$ and percent-predicted FEV_1/FVC (Table 5). Mean values of FEV_1 , FEV_1/FVC and $FEF_{25-75\%}$ among those in the 'Occupations unique to primary industry' category were significantly lower than those for the 'Management occupations' category after adjusting for age, height, sex and smoking. In addition, mean values of percent-predicted FEV_1/FVC and $FEF_{25-75\%}$ among those in the 'Occupations unique to primary industry' category were significantly lower than those for

the 'Management occupations' category after adjusting for smoking.

Discussion

In this study, a healthy worker effect related to respiratory outcomes was observed in a Canadian population aged 15–75 years. This healthy worker effect was observed independently in both males and females and in the age groups 30–59 years and 60–75 years. Among those who were in current employment, the proportion of regular cough, regular cough with phlegm, wheeze, shortness of breath, ever asthma, chronic bronchitis, COPD, emphysema, general health and airway obstruction were significantly lower and adjusted mean values of FVC, FEV_1 and $FEF_{25-75\%}$ were significantly greater in comparison to those who were not in current employment and adjusted

Table 5. Distribution of spirometry measurements, percent-predicted lung function values, modified GOLD criteria and non-GOLD criteria by broad occupational categories

Characteristics	A	B	C	D	E	F	G	H	I	J	P-value
	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	
FEV ₁ (litres)	3.31 (0.04)	3.16 (0.04)	3.64 (0.04)	3.04 (0.03)	3.23 (0.04)	3.44 (0.07)	3.37 (0.03)	3.74 (0.04)	3.54 (0.13)*	3.46 (0.10)	0.17 ^a
Percent-predicted FEV ₁ (%)	96.54 (0.68)	96.90 (0.62)	97.48 (0.54)	97.21 (0.73)	97.91 (0.73)	98.56 (1.07)	96.32 (0.51)	96.91 (0.82)	93.48 (1.88)	97.19 (1.32)	0.45 ^b
FVC (litres)	4.31 (0.06)	4.02 (0.05)	4.67 (0.07)	3.85 (0.05)*	4.15 (0.05)	4.44 (0.09)	4.24 (0.04)*	4.83 (0.05)	4.66 (0.15)	4.42 (0.13)	0.02 ^a
Percent-predicted FVC (%)	97.72 (0.60)	97.63 (0.58)	98.47 (0.62)	98.08 (0.77)	99.41 (0.77)*	100.71 (0.93)**	97.72 (0.53)	99.04 (0.86)	97.61 (2.02)	98.02 (1.13)	0.09 ^b
FEV ₁ /FVC (%)	77.13 (0.39)	78.66 (0.29)	78.35 (0.49)	78.98 (0.46)	78.12 (0.32)	78.10 (0.77)	79.63 (0.26)	77.36 (0.29)	75.92 (0.79)**	78.06 (0.68)	0.10 ^a
Percent-predicted FEV ₁ /FVC	97.74 (0.48)	98.50 (0.31)	98.28 (0.54)	98.61 (0.59)	97.79 (0.36)	97.30 (0.84)	98.48 (0.33)	97.25 (0.31)	95.40 (0.89)*	98.22 (0.76)	0.03 ^b
FEF _{25-75%} (l/s)	2.95 (0.06)	2.93 (0.05)	3.33 (0.05)	2.87 (0.06)	2.94 (0.05)	3.09 (0.11)	3.16 (0.05)	3.36 (0.06)	3.07 (0.15)*	3.23 (0.15)	0.25 ^a
Percent-predicted FEF _{25-75%}	94.01 (1.65)	95.58 (1.26)	95.68 (1.40)	97.26 (1.81)	95.64 (1.46)	94.85 (2.73)	94.13 (1.00)	93.04 (1.14)	86.04 (2.59)*	97.35 (3.04)	0.13 ^b

A: Management occupations; B: Business, finance and administrative occupations; C: Natural and applied sciences and related occupations; D: Health occupations; E: Occupations in social science, education, government service and religion; F: Occupations in art, culture, recreation and sport; G: Sales and service occupations; H: Trades, transport and equipment operators and related occupations; I: Occupations unique to primary industry; J: Occupations unique to processing, manufacturing and utilities.

^aAdjusted for age, height, sex and smoking status.

^bAdjusted for smoking status.

* $P \leq 0.05$, ** $P < 0.01$ for comparison with the management group after adjusting age, height, sex and smoking.

mean values of FEV₁/FVC and FEF_{25-75%} were significantly lower among those in the 'Occupations unique to primary industry' category than among those in the 'Management occupations' category.

This study provided further support for the healthy worker effect based on respiratory and general health in the Canadian general population. Similar to our study, subjects reporting poor health were more likely to be out of the workforce than those reporting excellent health in a large population study from the USA [3]. There were significant differences between those currently employed and those not currently employed in all the demographic and personal characteristics that were considered in this study. This finding provides further support for the recommendation that 'control' subjects or comparison groups should not be chosen from the non-working population in occupational epidemiological studies without allowing for this important difference [4].

In this study, a greater proportion of people employed in the 'Occupations unique to primary industry' reported regular cough with phlegm, ever having had asthma and airway obstruction than those employed in management occupations. The 'Occupations unique to primary industry' category included jobs with tasks such as operating farms and supervising or doing farm work, operating fishing vessels and doing specialized fishing work and in doing supervision and production

work in oil and gas production and forestry and logging (Table 4). The increased risk of adverse respiratory outcomes in this occupational category may be related to exposure to respiratory hazards in the workplace including gases, dust and chemicals [28]. In a large population-based study conducted in four US communities, an elevated risk of respiratory symptoms and diseases, and airway obstruction, was found in mechanical and repair occupations and construction and extractive trades, and cleaning and building services [13]. The differences in findings between the latter study and this study may be related to the timing of data collection impacting workplace exposures. The data for the US study were collected in 1987–89 whereas data for this study were collected in 2005–15.

In this study, the highest prevalence of current asthma was observed in the group employed in 'Health occupations' (8%), which was more than twice that observed in the group employed in 'Management occupations' (4%). Similar to this study, the highest prevalence of current asthma was observed in health-related occupations in a number of studies conducted in the USA [8–10]. This higher prevalence of current asthma in health occupations may be related to workplace exposures that are recognized to include a number of respiratory allergens and other hazards including detergents, latex, glutaraldehyde, formaldehyde, cleaning products and aerosolized medications [29].

This study has several strengths and limitations. The sample in each CHMS cycle was selected to be representative of the Canadian population and similar questionnaires and the same spirometric instruments were used in all the four cycles to minimize inter-cycle variability. However, the presence of respiratory symptoms and diseases including COPD and asthma was determined simply from a self-report by the participants and no clinical examination was conducted. As this study is cross-sectional, it was not possible to determine whether currently unemployed subjects with respiratory disease left their employment because of their illness or did not enter employment because of pre-existing respiratory disease. In a cross-sectional study conducted in 44 sites, mainly from low- and middle-income countries, chronic airflow obstruction was associated with unemployment in the preceding year [30]. Although some of the broad occupational categories were associated with respiratory outcomes, the reasons for these associations cannot be determined from this cross-sectional study and further studies are required to validate the findings of this study.

In conclusion, those in current employment were healthier than those not in current employment providing further support for a healthy worker effect. Workers in the category 'Occupations unique to primary industry' had an increased risk of self-reported respiratory diseases and airway obstruction. The healthy worker effect must be taken into consideration in epidemiological studies comparing those in employment with those not. Reducing exposure to workplace air contaminants for those employed in 'Occupations unique to primary industry' has the potential to improve their respiratory health.

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Competing interests

The authors report no competing interests. The authors alone are responsible for the content and writing of the paper.

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