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Chronic bronchitis: High prevalence in never smokers and underdiagnosis—A population-based study in Colombia

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Abstract

The objective of the article was to establish the prevalence, underdiagnosis, and risk factors of chronic bronchitis (CB) in a general population in five Colombian cities. Cross-sectional study using a probabilistic sampling technique in five Colombian cities was adopted. The CB definition was "cough and expectoration for three or more months per year for at least two consecutive years." Underdiagnosis was considered in subjects with clinical definition without previous medical diagnosis. Univariate χ^2 or Student's *t*-test and logistic regression analysis were used. The study included 5539 subjects. The prevalence was 5.5%, the underdiagnosis 50.3%, and 33.7% of the cases were in nonsmokers (53.6% in women vs. 16.9% in men, $p < 0.001$). The adjusted risk factors were living in Bogota, current smoking, male, age $\geq$ 64 years, low education, indoor wood smoke exposure, and occupational exposure to vapors, gases, dust, and fumes. CB is a common disease among adults in Colombia. The underdiagnosis was high and there were a large proportion of cases in nonsmokers, particularly in women. Our findings support the association of CB with indoor wood smoke and occupational exposures.

Keywords

Chronic bronchitis, biomass, indoor air pollution, occupational exposure, prevalence, risk factors, underdiagnosis

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Introduction

Chronic bronchitis (CB) is an accepted clinical phenotype of chronic obstructive pulmonary disease (COPD) that can also occur in subjects without airflow obstruction and is associated with an increased risk of exacerbations, accelerated decline in lung function, poor quality of life, and increased mortality.[1–5] There are regional differences in the prevalence of CB reported around the world that vary between 3.4% and 22%.[6]

The clinical definition of CB "cough and expectoration for three or more months per year for at least two consecutive years" is widely used in epidemiological studies allowing the comparison of the prevalence between populations and following the trends. Although this definition is easily used, previous studies demonstrated that CB is clearly underdiagnosed in the general population.[7]

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The main risk factor for CB is smoking, but it is known that the disease can occur in nonsmokers. Many other factors have been associated with CB, including air pollution and occupational or indoor exposures.[6,8,9] The regional variation in the prevalence of these risk factors could explain the wide range of the reported CB prevalence.

PREPOCOL was a large population-based study to establish the COPD prevalence by spirometry in Colombia. In this study, the prevalence of CB by medical diagnosis was 2.7%, but the prevalence by the clinical definition of CB and their risk factors were not addressed.[10] In Colombia, a middle-income country, the risk factors for CB could be different from more developed countries, particularly the indoor wood smoke exposure, occupational exposure, or previous history of tuberculosis. Due to the absence of population-based studies that determine the prevalence, underdiagnosis, and the risk factors associated with CB, we used the PREPOCOL study data to analyze the epidemiological situation in adults over 40 years in Colombia.

Methods

The PREPOCOL study was an observational analytic cross-sectional study in 5539 participants over 40 years in five Colombian cities (Barranquilla, Bogotá, Bucaramanga, Cali, and Medellin) located at different altitudes above sea level (18–2640 m).[10] The sample size in PREPOCOL was calculated using a 1.0 adjustment for design effects, an accepted 5% for type I error, and an expected prevalence of COPD from 9.1 to 12.7, similar to the reported BC prevalence around the world. Participants were selected by a probabilistic, bi-stage clustered sampling technique; randomization of sectors was done using the official maps from the Colombian National Statistics Department. This protocol was approved by the Ethics Research Committee of the Institution (approval number 201503-20804) and the participants signed an informed consent.

Measurement and instruments

Each subject answered a Spanish version of the adult ATSDLD-78 respiratory symptoms and risk factors questionnaire,[11] with additional questions about wood smoke exposure, passive smoking, and tuberculosis history. Additional information can be found in the PREPOCOL paper.[10]

Response variables according to questionnaire answers

We used three definitions for CB: (a) Symptoms: affirmative answer to the question "Have you ever had cough and expectoration for three or more months a year for at least two consecutive years?" (b) Self-reported medical diagnosis: affirmative answer to the question "Have you ever had a diagnosis of CB confirmed by a physician?" (c) Underdiagnosis: subjects with clinical definition without self-reported medical diagnosis of CB.

Predictor variables

The risk factors included in the analysis were age, sex, level of education, history of pulmonary tuberculosis, smoking, indoor wood smoke exposure, and occupational exposure. A history of pulmonary tuberculosis was defined as an affirmative answer to the question "Have you ever had pulmonary tuberculosis confirmed by a doctor?" Smoking was defined as active exposure to more than one cigarette per day for at least one year and passive smoking as frequent exposure to other smokers at work or home. The exposure to biomass indoor combustion in stoves was assessed by the question: "Have you ever used wood for cooking?" Occupational exposure to vapors, gases, dust, and fumes (VGDF) was defined as an affirmative answer to the questions: "Have you ever been exposed to vapors, gases or fumes in your work?" or "Have you ever had a workplace for one or more years with much dust in the air?"

Statistical analysis

The prevalence of CB and underdiagnosis were calculated in the total group, by age and sex, and expressed as a percentage and 95% confidence interval (CI). The association of the clinically defined CB with the variables of interest was examined in a multivariate logistic regression model. All variables with a p value < 0.1 in the univariate analysis were included in the final model. Estimated crude odds ratios (OR) and adjusted OR with their corresponding 95% CI were calculated. To describe the contributions to the burden of CB due to smoking, wood smoke, and occupational exposures, we calculated the population attributable fractions (PAFs). The SPSS 16 statistical software was used for the analysis.

Table 1. Participants characteristics ($n = 5539$).[a]

Variables	*n*	%
City of residence (altitude above sea level, m)		
Barranquilla (18)	1102	19.9
Bogota (2640)	1106	20.0
Bucaramanga (960)	1103	19.9
Cali (995)	1100	19.8
Medellin (1538)	1128	20.4
Sex		
Male	1838	33.2
Female	3701	66.8
Age, years		
<64	4108	74.2
≥64	1431	25.8
Body mass index		
<30	4400	80.5
≥30	1067	19.5
Educational level		
No education	1432	25.9
Some level of education	4107	74.1
Respiratory disease before 16 years		
No	4434	80.1
Yes	1105	19.9
First-degree relative with asthma		
No	4246	76.7
Yes	1293	23.3
Smoking status		
Never smokers	2853	51.5
Past smokers	1672	30.2
Current smokers	1014	18.3
History of tuberculosis		
No	5477	98.9
Yes	62	1.1
Indoor wood smoke exposure		
No	2175	39.3
Yes	3364	60.7
Occupational exposure to VGDF		
No	3129	56.5
Yes	2410	43.5

VGDF: vapors, gases, dust and fumes.
[a]Values expressed as *N* and %.

Results

Participants

We included 5539 participants from 40 to 93 years, 66.8% women and 19.5% obese. From this population, 48.5% were current or past smokers, 60.7% exposed to indoor wood smoke from cooking, and 43.5% exposed to occupational VGDF. Table 1 shows other characteristics of the population and the distribution by city.

CB prevalence and underdiagnosis

The prevalence of CB by symptoms was 5.5% and by medical diagnosis 2.7%. The prevalence was higher in Bogota and Medellin than in other cities ($p < 0.001$), in men ($p < 0.001$), in people 64 years or older ($p < 0.001$), and in current smokers. The higher prevalence in men was found in both age groups (<64 years and in older) and with the two CB definitions (symptoms and medical diagnosis, Table 2 and 3).

Using the definition of CB by symptoms and the patient self-reported diagnosis of CB, the underdiagnosis was 50.3% in the whole group, with no difference by sex (49.4% in males and 51.4% in females, $p = 0.723$), smoking history (54.4% in nonsmokers and 48.3 in smokers, $p = 0.314$), or age (54.4% in <64 years old vs. 44.4% in the older, $p = 0.085$).

CB risk factors

In the univariate analysis, there was a significant association between CB and age, male, current smoking, no education, indoor wood smoke exposure, and occupational exposure to VGDF. There was no association with body mass index, respiratory disease before 16 years, family history of asthma, and history of tuberculosis. The non-adjusted ORs for CB are shown in Table 4. In the multivariate analysis, the variables related to CB were living in Bogota or Medellin, male, age ≥ 64years, no education, current smoking, indoor wood smoke exposure, and occupational exposure to VGDF (Table 5). The stronger associations were found with (OR [95% CI]) living in Bogota (2.71 [1.83–4.02]), male (2.13 [1.63–2.79]), age ≥ 64 (1.85 [1.43–2.41]), and current smoking (2.71 [1.83–3.95]).

The proportion of patients with CB who never smoked was 33.7%, higher in women than in men (53.6% vs. 16.9%, $p < 0.001$). The PAFs for CB were 22.5% for current smoking, 21.0% for indoor wood smoke exposure, and 16.2% for occupational exposure (VGDF).

Discussion

Summary of main findings

In this population-based study among adults aging from 40 to 93 years, the prevalence of CB was 5.5%, which confirms that it is a common disease in adults in Colombia. It should be noted that the

Table 2. Prevalence of CB by diagnosis criteria, age and sex ($N = 5539$).[a]

	Diagnosis by symptoms			Medical diagnosis		
Age, years	Men	Women	Total	Men	Women	Total
<64	95 (7.4)[b]	87 (3.1)	182 (4.4)[c]	41 (3.2)[b]	42 (1.5)	83 (2.0)[c]
≥64	71 (12.9)[b]	53 (6.0)	124 (8.7)	43 (7.8)[b]	26 (3.0)	69 (4.8)
Total	166 (9.0)[b]	140 (3.8)	306 (5.5)	84 (4.6)[b]	68 (1.8)[b]	152 (2.7)

CB: chronic bronchitis.
[a]Values as *N* (%).
[b]$p < 0.001$ value for differences of CB prevalence by sex in people <64 years or older and in the whole group.
[c]$p < 0.001$ value for differences of CB prevalence by age groups.

Table 3. Prevalence of CB by selected variables[a].

Variables	Categories	*N*	%	95% CI
City of residence	Cali	39	3.5	3.1–4.0
	Bucaramanga	54	4.9	4.3–5.5
	Barranquilla	33	3.0	2.5–3.4
	Medellin	85	7.5	6.8–8.2
	Bogota	95	8.6	7.9–9.3
Sex	Male	166	9.0	8.3–9.8
	Female	140	3.8	3.3–4.3
Age ≥ 64 years	No	182	4.4	3.9–5.0
	Yes	124	8.7	7.9–9.4
Body mass index ≥ 30	No	241	5.5	4.9–6.1
	Yes	61	5.7	5.1–6.3
Educational level	Some level of education	189	4.6	4.1–5.2
	No education	117	8.2	7.4–8.9
Respiratory disease before 16 years	No	254	5.7	5.1–6.3
	Yes	52	4.7	4.1–5.3
First-degree relative with asthma	No	235	5.5	4.9–6.1
	Yes	71	5.5	4.9–6.1
Smoking status	Nonsmokers	103	3.6	3.1–4.1
	Past smokers	103	6.2	5.5–6.8
	Current smokers	100	9.9	9.1–10.6
History of tuberculosis	No	299	5.5	4.9–6.1
	Yes	7	11.3	10.5–12.1
Indoor wood smoke exposure	No	85	3.9	3.4–4.4
	Yes	221	6.6	5.9–7.2
Occupational exposure to VGDF	No	125	4.0	3.5–4.5
	Yes	181	7.5	6.8–8.2

VGDF: vapors, gases, dust, and fumes; CB: chronic bronchitis.
[a]Values expressed as *N*, %, and CI.

Table 4. Risk factors for CB—Univariate analysis.[a]

Variables	Categories	OR	95% CI	*p* Value
City of residence	Cali	1.00		
	Bucaramanga	1.40	0.92–2.13	0.117
	Barranquilla	0.84	0.52–1.35	0.468
	Medellin	2.22	1.50–3.27	<0.001
	Bogota	2.56	1.74–3.75	<0.001
Sex	Female	1.00		
	Male	2.53	2.00–3.19	<0.001
Age ≥ 64 years	No	1.00		
	Yes	2.05	1.62–2.59	<0.001
Body mass index ≥ 30	No	1.00		
	Yes	1.05	0.78–1.40	0.759
Educational level	Some level of education	1.00		
	No education	1.84	1.45–2.34	<0.0001
Respiratory disease before 16 years	No	1.00		
	Yes	0.81	0.60–1.10	0.184
First degree relative with asthma	No	1.00		
	Yes	0.99	0.75–1.30	0.952
Smoking status	Never smokers	1.00		
	Past smokers	1.75	1.32–2.32	<0.001
	Current smokers	2.92	2.20–3.88	<0.001
History of tuberculosis	No	1.00		
	Yes	2.20	1.00–4.88	0.051
Indoor wood smoke exposure	No	1.00		
	Yes	1.73	1.34–2.23	<0.001
VGDF exposure	No	1.00		
	Yes	1.95	1.54–2.47	<0.001

VGDF: vapors, gases, dust and fumes; OR: odds ratio; CI: confidence interval.
[a]Estimated crude OR and 95% CI.

underdiagnosis was very high and there was a big proportion of the cases of CB in nonsmokers. Although we found a strong association between CB and current smoking, one-third of the cases occurred in subjects who never smoked; this proportion increased to more than half in women. Besides the smoking, the other risk factors of CB were male, older age, low educational level, and environmental factors such as wood smoke and occupational exposures.

Table 5. Risk factors for CB—Multivariate analysis.[a]

Variables	Categories	OR	95% CI		*p* Value
Sex	Female	1.00			
	Male	2.09	1.61	2.73	<0.001
Age $\geq$ 64 years	No	1.00			
	Yes	1.84	1.42	2.39	<0.001
City of residence	Cali	1.00			
	Bucaramanga	1.52	0.99	2.33	0.055
	Barranquilla	0.93	0.58	1.51	0.776
	Medellin	2.11	1.41	3.14	<0.001
	Bogota	2.66	1.80	3.95	<0.001
Educational level	No education	1.00			
	Some level of education	1.48	1.14	1.93	0.004
History of tuberculosis	No	1.00			
	Yes	1.58	0.69	3.61	0.283
Smoking status	Nonsmokers	1.00			
	Past smokers	1.09	0.81	1.48	0.569
	Current smokers	2.36	1.73	3.21	<0.001
Indoor wood smoke exposure	No	1.00			
	Yes	1.44	1.09	1.90	0.011
Occupational exposure VGDF	No	1.00			
	Yes	1.44	1.12	1.86	0.005

VGDF: vapors, gases, dust and fumes; CB: chronic bronchitis; OR: odds ratio; CI: confidence interval.
[a]Estimated adjusted OR and 95% CI. Adjusted ORs were obtained by simultaneously adjusting all other variables in the model.

Disease-specific findings and relations to the literature

The CB prevalence in our study of 5.5% is in the lower range of 3.4–22% reported in worldwide studies using the clinical definition[6,12] but was similar to the PLATINO study in five Latin-American countries of 7.4% in COPD and 2.5% in no COPD subjects.[13]

There are many studies showing higher prevalence of CB in males, but others have found that CB affects women more than men.[14,15] In our study using the clinical and medical definitions of CB, the prevalence was higher in males, in the total population, and in the two age groups.

In this study, there was a high proportion of subjects with underdiagnosed CB (50.3%): people who fulfilled the symptomatic definition of CB without a patient self-reported diagnosis of CB. There were no differences in underdiagnosis by sex, age group, or smoking status. Although the underdiagnosis was high in this study, it was lower than reported in two studies in France.[7,16] An international survey in North America and Europe showed a lower prevalence of underdiagnosis of 14.5%.[17]

Although in our study the primary risk factor for CB was smoking, as on other studies,[13–16,18–21] it should be noted that 33.7% of cases of CB were in nonsmokers. This proportion is similar to previous studies in Europe[22,23] but lower than a study in South Africa.[14] While one-third of the cases in the whole group were nonsmokers, in women, the proportion was more than half. This higher proportion of CB in nonsmoking females has been observed in the other studies[14,22,23] and could be related to a higher exposure to indoor biomass fuels in females.

In the previous studies, the low educational level has been associated to CB.[14,18,19] Similarly, in this study, the low educational level was significantly associated with CB in the multivariate analyses. The mechanism of increase in the risk due to low education is unclear, since smoking, occupational and indoor wood smoke exposure were controlled in the analysis. Although the education itself cannot cause CB directly, the effect may be mediated through other mechanisms such as low socioeconomic status, other exposures, or previous diseases. Even though there is evidence that respiratory infections during childhood could be responsible for respiratory disease in adults and specifically CB in a study in Brazil,[18] we did not find association between CB and respiratory disease before 16 years.

Although our study was based on an urban area population, a significant proportion of participants were exposed to wood smoke for many years while living in rural areas. Similar to our results, there are many studies that confirm the association between wood smoke indoor pollution and COPD, using the clinical definition of CB or the functional definition of air flow obstruction.[8,24–26] Interestingly, the PAF for CB due to wood smoke indoor pollution was very similar to current smoking.

Our results also support the association between self-reported occupational exposures to VGDF with CB. Occupational exposure to VGDF has been related to CB in other population-based, cross-sectional, and cohort studies.[8,21,27–29] Although we did not assess a specific inhalation or job exposure, it was shown that the self-reported exposure to VGDF delineates risk exposure as well as the other methods.[30] The PAF for CB from occupational exposure to VGDF in our study (15.8%) was very similar to previous studies where

the calculated PAF ranged between 4% and 29% with a median of 15%.[27,28]

The history of tuberculosis has been associated to a decline in pulmonary lung function and with airflow obstruction, including the PREPOCOL study[10,31–33] but the association with CB is less clear. Although in a previous study the strongest predictor of CB was a history of tuberculosis,[14] we found no association between CB and tuberculosis. It should be noted that the study is underpowered to detect this association due to the few cases of subjects with a history of tuberculosis and CB.

The fact that differences in the risk for CB among Colombian cities remained significant in the multivariate analyses, after adjusting for many factors, suggests that there are other potential risk factors not included in our study. Because socioeconomic and cultural status are similar in these cities, environmental factors may play a significant role. The higher prevalence of CB in Bogota and Medellin could be related to environmental pollution because these two cities, the biggest in Colombia, have higher levels of particulate matter (PM) than the other three cities included.[34] Even though the association between air pollution with CB has not been supported in some studies, in a recent meta-analysis of five cross-sectional studies in Europe, a statistically significant association was found between air pollution (PMcoarse) and CB in never smokers.[35]

Strengths and limitations

The strengths of this study are the large representative sample of participants aged ≥40 years and the analysis of many risk factors for CB, including occupational and indoor exposures. The probabilistic sampling technique using official maps assured that was a representative sample of the general population. Since the clinical definition of CB is widely used in epidemiological studies, this allows the comparison of the prevalence between populations. We think that our results enhance the existing literature about CB prevalence and risk factors because there are limited population studies in Latin America.

There are some limitations in our study. For the definition of the underdiagnosis we used, as in other epidemiological studies, the self-reported diagnosis of CB, and not the confirmed diagnosis in a clinical record, may lead to incorrect classification. Although we did not include the years of indoor wood smoke exposure or the pack years of smoking, the association of these risk factors with CB in our study was consistent and similar to those found in previous studies. A possible source of bias is that the participants with CB symptoms may have been more likely to report risk factors, such as occupational or wood smoke exposure than those without symptoms. With the inclusion of older people, it is possible that the memory bias and the presence of symptoms due to other common conditions, such as heart failure, could affect the results. Finally, the cross-sectional design of this study precluded establishing temporal relationships or causality.

In conclusion, the prevalence of CB of 5.5% in this population-based study among adults confirms that it is a common disease in Colombia, although the underdiagnosis was very high. Even if we found a strong association between CB and current smoking, one-third of the cases were in subjects who never smoked—a proportion that increases to more than half in women. Our findings support an association of CB with indoor wood smoke and occupational exposures.

Declaration of conflicting interests

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References

1. Vestbo J, Prescott E and Lange P. Association of chronic mucus hypersecretion with FEV1 decline and chronic obstructive pulmonary disease morbidity. Copenhagen city heart study group. *Am J Respir Crit Care Med* 1996; 153(5): 1530–1535.
2. Miravitlles M, Guerrero T, Mayordomo C, et al. Factors associated with increased risk of exacerbation and hospital admission in a cohort of ambulatory COPD patients: a multiple logistic regression analysis. *Respiration* 2000; 67(5): 495–501.
3. Guerra S, Sherrill DL, Venker C, et al. Chronic bronchitis before age 50 years predicts incident airflow limitation and mortality risk. *Thorax* 2009; 64(10): 894–900.

4. Pelkonen M, Notkola IL, Nissinen A, et al. Thirty-year cumulative incidence of chronic bronchitis and COPD in relation to 30-year pulmonary function and 40-year mortality: a follow-up in middle-aged rural men. *Chest* 2006; 130(4): 1129–1137.
5. Kim V, Han MK, Vance GB, et al. The chronic bronchitic phenotype of COPD: an analysis of the COPDGene Study. *Chest* 2011; 140(3): 626–633.
6. Kim V and Criner GJ. The chronic bronchitis phenotype in chronic obstructive pulmonary disease: features and implications. *Curr Opin Pulm Med* 2015; 21(2): 133–141.
7. Huchon GJ, Vergnenegre A, Neukirch F, et al. Chronic bronchitis among French adults: high prevalence and underdiagnosis. *Eur Respir J* 2002; 20(4): 806–812.
8. Eisner MD, Anthonisen N, Coultas D, et al. An official American thoracic society public policy statement: novel risk factors and the global burden of chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2010; 182(5): 693–718.
9. Salvi SS and Barnes PJ. Chronic obstructive pulmonary disease in non-smokers. *Lancet* 2009; 374(9691): 733–743.
10. Caballero A, Torres-Duque CA, Jaramillo C, et al. Prevalence of COPD in five colombian cities situated at low, medium, and high altitude (PREPOCOL Study). *Chest* 2008; 133(2): 343–349.
11. Ferris BG. Epidemiology standardization project (American Thoracic Society). *Am Rev Respir Dis* 1978; 118(6 Pt 2): 1–120.
12. Halbert RJ, Natoli JL, Gano A, et al. Global burden of COPD: systematic review and meta-analysis. *Eur Respir J* 2006; 28(3): 523–532.
13. Montes de Oca M, Halbert RJ, Lopez MV, et al. The chronic bronchitis phenotype in subjects with and without COPD: the PLATINO study. *Eur Respir J* 2012; 40(1): 28–36.
14. Ehrlich RI, White N, Norman R, et al. Predictors of chronic bronchitis in South African adults. *Int J Tuberc Lung Dis* 2004; 8(3): 369–376.
15. Harmsen L, Thomsen SF, Ingebrigtsen T, et al. Chronic mucus hypersecretion: prevalence and risk factors in younger individuals. *Int J Tuberc Lung Dis* 2010; 14(8): 1052–1058.
16. Ferre A, Fuhrman C, Zureik M, et al. Chronic bronchitis in the general population: influence of age, gender and socio-economic conditions. *Respir Med* 2012; 106(3): 467–471.
17. Rennard S, Decramer M, Calverley PM, et al. Impact of COPD in North America and Europe in 2000: subjects' perspective of confronting COPD international survey. *Eur Respir J* 2002; 20(4): 799–805.
18. Menezes AM, Victora CG and Rigatto M. Prevalence and risk factors for chronic bronchitis in Pelotas, RS, Brazil: a population-based study. *Thorax* 1994; 49(12): 1217–1221.
19. Cerveri I, Accordini S, Verlato G, et al. Variations in the prevalence across countries of chronic bronchitis and smoking habits in young adults. *Eur Respir J* 2001; 18(1): 85–92.
20. Mahesh PA, Jayaraj BS, Chaya SK, et al. Variation in the prevalence of chronic bronchitis among smokers: a cross-sectional study. *Int J Tuberc Lung Dis* 2014; 18(7): 862–869.
21. Dijkstra AE, de Jong K, Boezen HM, et al. Risk factors for chronic mucus hypersecretion in individuals with and without COPD: influence of smoking and job exposure on CMH. *Occup Environ Med* 2014; 71(5): 346–352.
22. Hardie JA, Vollmer WM, Buist AS, et al. Respiratory symptoms and obstructive pulmonary disease in a population aged over 70 years. *Respir Med* 2005; 99(2): 186–195.
23. Lindstrom M, Kotaniemi J, Jonsson E, et al. Smoking, respiratory symptoms, and diseases: a comparative study between northern Sweden and northern Finland: report from the FinEsS study. *Chest* 2001; 119(3): 852–861.
24. Hu G, Zhou Y, Tian J, et al. Risk of chronic obstructive pulmonary disease from exposure to biomass smoke: a meta-analysis. *Chest* 2010; 138(1): 20–31.
25. Kurmi OP, Semple S, Simkhada P, et al. COPD and chronic bronchitis risk of indoor air pollution from solid fuel: a systematic review and meta-analysis. *Thorax* 2010; 65(3): 221–228.
26. Po JYT, FitzGerald JM and Carlsten C. Respiratory disease associated with solid biomass fuel exposure in rural women and children: systematic review and meta-analysis. *Thorax* 2011; 66(3): 232–239.
27. Balmes J, Becklake M, Blanc P, et al. American thoracic society statement: occupational contribution to the burden of airway disease. *Am J Respir Crit Care Med* 2003; 167(5): 787–797.
28. Blanc PD and Toren K. Occupation in chronic obstructive pulmonary disease and chronic bronchitis: an update. *Int J Tuberc Lung Dis* 2007; 11(3): 251–257.
29. Marchetti N, Garshick E, Kinney GL, et al. Association between occupational exposure and lung function, respiratory symptoms, and high-resolution computed tomography imaging in COPDGene. *Am J Respir Crit Care Med* 2014; 190(7): 756–762.

30. Blanc PD, Eisner MD, Balmes JR, et al. Exposure to vapors, gas, dust, or fumes: assessment by a single survey item compared to a detailed exposure battery and a job exposure matrix. *Am J Ind Med* 2005; 48(2): 110–117.
31. Willcox PA and Ferguson AD. Chronic obstructive airways disease following treated pulmonary tuberculosis. *Respir Med* 1989; 83(3): 195–198.
32. Hnizdo E, Singh T and Churchyard G. Chronic pulmonary function impairment caused by initial and recurrent pulmonary tuberculosis following treatment. *Thorax* 2000; 55(1): 32–38.
33. Menezes AMB, Hallal PC, Perez-Padilla R, et al. Tuberculosis and airflow obstruction: evidence from the PLATINO study in Latin America. *Eur Respir J* 2007; 30(6): 1180–1185.
34. WHO Global Urban Ambient Air Pollution Database. World Health Organization (WHO). 2016. http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/ (accessed 31 March 2018).
35. Cai Y, Schikowski T, Adam M, et al. Cross-sectional associations between air pollution and chronic bronchitis: an ESCAPE meta-analysis across five cohorts. *Thorax* 2014; 69(11): 1005–1014.