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CHEST

Original Research

COPD

Prevalence of COPD in Five Colombian Cities Situated at Low, Medium, and High Altitude (PREPOCOL Study)*

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Background: **The prevalence of COPD in Colombia is unknown. This study aimed to investigate COPD prevalence in five Colombian cities and measure the association between COPD and altitude.**

Methods: **A cross-sectional design and a random, multistage, cluster-sampling strategy were used to provide representative samples of adults aged ≥ 40 years. Each participant was interviewed (validated Spanish version of the Ferris Respiratory Questionnaire) and performed spirometry before and after 200 μg of inhaled salbutamol, using a portable spirometer according to American Thoracic Society recommendations. COPD definitions were as follows: (1) spirometric: fixed ratio (primary definition): $FEV_1/FVC < 70\%$ after bronchodilator; (2) medical: a diagnosis of chronic bronchitis, emphysema, or COPD made by a physician; (3) clinical: cough and phlegm ≥ 3 months every year during ≥ 2 consecutive years (chronic bronchitis). Analysis was performed using statistical software.**

Results: **A total of 5,539 subjects were included. The overall COPD prevalence using the primary definition (spirometric) was 8.9%, ranging from 6.2% in Barranquilla to 13.5% in Medellín. The prevalence measured by the spirometric definition was higher than medical (2.8%) and clinical (3.2%) definitions. After the logistic regression analysis, the factors related with COPD were age ≥ 60 years, male gender, history of tuberculosis, smoking, wood smoke exposure ≥ 10 years, and very low education level. There was a nonsignificant tendency toward larger prevalence with higher altitude.**

Conclusion: **COPD is an important health burden in Colombia. Additional studies are needed to establish the real influence of altitude on COPD prevalence.** ***(CHEST 2008; 133:343–349)***

Key words: airflow obstruction; altitude; chronic bronchitis; COPD; emphysema; prevalence; tuberculosis; wood smoke

Abbreviations: CI = confidence interval; GOLD = Global Initiative for Chronic Obstructive Lung Disease; OR = odds ratio; PLATINO = Proyecto Latinoamericano de Investigación en Obstrucción Pulmonar; PREPOCOL = Prevalencia de EPOC en Colombia; TB = tuberculosis

COPD is a frequent, preventable, and treatable pathologic condition.[1,2] The World Health Organization estimated that in 2020 COPD will be the fifth-worldwide cause of disability adjusted life-years lost and the third-worldwide cause of mortality.[3] Male gender, advanced age, cigarette smoking, occupational exposure, and low socioeconomic status are well-known independent risk factors for COPD. An increasing COPD prevalence in developing countries is expected due to cigarette smoking and environmental pollution.[4,5] Furthermore, the use of wood and other biomass fuels by > 50% of population is an additional burden.[6]

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COPD is characterized by non-fully reversible airflow limitation that can be demonstrated by a postbronchodilator FEV_1/FVC ratio < 70% ("fixed ratio").[1,2] COPD prevalence varies according to the epidemiologic definition[7,8] and the local variability of risk factors and other unknown conditions[9,10]; there-

fore, the extrapolation of COPD prevalence from one geographic area to another is not recommended. Local studies using validated questionnaires and spirometry are the most valid technique to assess COPD prevalence in a particular region.

Colombia is a developing Latin-American country where the smoking rate (19%) is lower than the observed in many developed countries[11]; however, using wood for cooking is frequent and there is a high prevalence of tuberculosis, a disease known to cause airway obstruction.[12] Because of its mountainous conditions, the cities are located at significantly different altitudes that could influence COPD prevalence, a point brought up by the PLATINO (Proyecto Latinoamericano de Investigación en Obstrucción Pulmonar) study in five Latin-American cities[13] that suggested a negative association between altitude and COPD prevalence. The primary objective of the PREPOCOL (Prevalencia de EPOC en Colombia) study was to establish COPD prevalence and assess the related risk factors in five Colombian cities situated at significantly different altitudes.

Materials and Methods

Design and Sampling Technique

PREPOCOL was a cross-sectional, population-based, observational, and analytical study done in urban areas of five Colombian cities (Barranquilla, Bogotá, Bucaramanga, Cali, and Medellín) located at different altitudes (18 to 2,640 m). Using an expected COPD prevalence from 9.1 to 12.7% obtained from two Latin-American studies,[14,15] a 1.0 adjustment for design effects, and an accepted 5% for type I error, it was estimated a sample of 1,100 subjects in each city. Subjects were selected by a probabilistic, bistage clustered sampling technique; randomization of sectors was done using the official maps from the Colombian National Statistics Department.

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Inclusion Criteria

The study included civilian, noninstitutionalized adults of both genders ≥ 40 years old, who signed the informed consent and were able to perform an acceptable spirometry. The subjects with mental alterations or contraindication to salbutamol were excluded and replaced using the same sampling technique.

Measurement and Instruments

Each subject answered a Spanish version of Ferris Respiratory Symptoms and Risk Factors Questionnaire,[14,16] with additional questions on wood smoke exposure, and performed spirometry before and after 200 μg of inhaled salbutamol, using a portable spirometer (MicroLoop; Micro Medical; Rochester, Kent, UK) according to American Thoracic Society recommendations[17]; calibration was checked daily with a 3-L syringe. Participants performed up to eight forced expiratory maneuvers to obtain three acceptable maneuvers (FEV_1 and FVC variation ≤ 150 mL). During data collection, spirometry results were sent weekly to Bogotá and analyzed by the principal investigators for each individual technician. Spirometry results that did not fulfill quality criteria (5%) were repeated, and 0.2% of them were finally excluded. Predicted values were calculated using the Perez-Padilla data for the Latin-American population.[18]

COPD Definitions

COPD definitions are as follows: (1) spirometry (functional): postbronchodilator FEV_1/FVC ratio < 70%; (2) medical definition: an affirmative response to: "Have you ever had chronic bronchitis, emphysema, or COPD confirmed by a doctor?"; and (3) clinical definition (chronic bronchitis): a positive criteria for the standard definition of chronic bronchitis. Primary criteria for establishing COPD prevalence was the spirometric definition. The severity of the COPD was determined by Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria.[1]

Bias and Quality Control

To evaluate the reliability of the portable spirometers, a concordance study was performed using, as reference, a fixed, calibration-certified spirometer (Vmax; Sensor Medics; Yorba Linda, CA). One hundred sixty-three measurements were obtained with the flow meters connected in-line, finding an excellent agreement for each spirometric parameter: FVC, $\rho = 0.97$; FEV_1, $\rho = 0.99$; FEV_1/FVC, $\rho = 0.98$; and κ index = 0.91 for diagnosing obstruction by a FEV_1/FVC ratio < 70%.[19] The spirometers were calibrated daily. All the questionnaires and spirometric tracings were revised twice, and the data were entered by two different persons; any inconsistence was resolved by inspection of source documents.

Field Work

The field work was done from February 2003 to May 2004 by 14 chest physiotherapists, after a pilot study of 106 subjects done in Bogotá.

Statistical Analysis

The analysis addressed the overall COPD prevalence, the prevalence by city, age, gender, and severity of the disease, and the prevalence of risk factors and its associations with other variables such as altitude and COPD prevalence using the χ^2 or Fisher exact test for categorical variables and the Student *t* test or

the Mann Whitney parametric test for continuous variables. Following a univariate analysis, a logistic regression model was constructed using the variables that showed $p < 0.1$ in the univariate analysis. Bilateral two-tailed hypotheses were formulated (95% confidence interval [CI]; $p < 0.05$). Statistical software (STATA version 7.0; StataCorp; College Station, TX) was used.

Ethics, Sponsoring, and Conflicts of Interest

The protocol was approved by the Ethics Research Committee of the Fundación Neumológica Colombiana and the Colombian Drug and Food Surveillance Institute. PREPOCOL was sponsored by an educational contribution from the Colombian offices of Boehringer-Ingelheim and Pfizer (Bogotá, Colombia), which did not participate in study design, sample collection, data analysis, or publication. None of the investigators has or has had any contractual relation with the sponsoring companies.

Results

From a total of 7,149 households visited in the five cities, 5,539 subjects were included (3,701, women; 66.8%). Table 1 shows the demographic characteristics. The highest rates of contact household failures and refusals (15.4% and 20.7%, respectively) were found in Bogotá.

Table 1—*Demographic Characteristics, Smoking, and Wood Smoke Exposure*

Characteristics	Subjects, No.	%
Gender		
Male	1,838	33.2
Female	3,701	66.8
Age, yr*		
40–49	1,978	35.7
50–59	1,600	28.9
60–69	1,182	21.3
≥ 70	779	14.1
Cities (altitude in above sea level, m)		
Barranquilla (18)	1,102	19.9
Bogotá (2,640)	1,106	20.0
Bucaramanga (960)	1,103	19.9
Cali (995)	1,100	19.8
Medellín (1,538)	1,128	20.4
Smoking status		
Never-smokers	2,853	51.5
Ex-smokers	1,672	30.2
Current smokers	1,014	18.3
Female	565	15.3
Male	449	24.4
< 15 pack-yr	571	10.3
≥ 15 pack-yr	443	8.0
Wood smoke exposure		
Not exposed	2,175	39.3
Exposed < 10 yr	1,185	21.4
Exposed ≥ 10 yr	2,179	39.3
Total	5,539	100

*Average, 55.8 ± 11.2 (SD).

COPD Prevalence

Table 2 shows the overall COPD prevalence according to altitude and each definition criteria in the five cities and Table 3 according to age and gender. The overall COPD prevalence defined by the spirometric functional criteria was 8.9%, higher in men (13.6%) than in women (6.6%); the prevalence was significantly higher in subjects aged ≥ 60 years ($p < 0.001$) [Table 3]. Figure 1 shows COPD prevalence defined by spirometric criteria by age and gender. COPD prevalence by GOLD classification of severity[1] was distributed as follows: mild, 68.9%; moderate, 26.3%; severe, 3.4%; and very severe, 0.5%.

Prevalence of Risk Factors

Smoking: The overall prevalence of active smoking was 18.3%, higher in men (24.4%) than in women (15.3%). The highest prevalence was observed in Medellín (29.9%), followed by Bogotá (17.5%), Cali (17%), Barranquilla (13.9%), and Bucaramanga (13.0%). The smoking prevalence in Medellín was significantly higher compared with the other cities ($p < 0.001$). The COPD prevalence defined by any criteria was significantly higher in smokers than in nonsmokers and in smokers of ≥ 15 pack-years ($p < 0.001$) [Table 4]. Never-smokers had a COPD prevalence of 5.2% (149 of 2,853 subjects), representing 30% of the subjects with COPD (149 of 494 subjects).

Wood Smoke: A large proportion of the subjects (60.7%) had used wood for cooking at some time, 39.3% for > 10 years (Table 1). COPD prevalence by any definition was significantly higher in people exposed to wood smoke, particularly in those exposed for > 10 years ($p < 0.001$).

Risk Factors and Other Variables Related to COPD: Table 5 shows the univariate analysis of the

Table 2—*COPD Prevalence According to Altitude and Definition Criteria**

City	Altitude, m	Subjects, No.	COPD Prevalence		
			Spirometric	Medical	Clinical
Barranquilla	18	1,102	68 (6.2)	17 (1.5)	21 (1.9)
Bogotá	2,640	1,106	94 (8.5)	36 (3.3)	38 (3.4)
Bucaramanga	960	1,103	87 (7.9)	37 (3.4)	23 (2.1)
Cali	995	1,100	93 (8.5)	25 (2.3)	20 (1.8)
Medellín	1,538	1,128	152 (13.5)	65 (5.8)	50 (4.4)
Total (%)		5,539	494 (8.9)	180 (3.3)	152 (2.7)
95% CI			8.2–9.7	2.8–3.8	2.3–3.2

*Data are presented as No. (%) unless otherwise indicated.

Table 3—*COPD Prevalence According to Age, Gender, and COPD Definition Criteria***

	COPD Definition Criteria								
	Spirometry: Postbronchodilator $FEV_1/FVC < 70\%$			Medical: Prior Medical Diagnosis			Clinical: Chronic Bronchitis		
Age, yr	Male	Female	Total	Male	Female	Total	Male	Female	Total
40–49	22 (3.6)	34 (2.5)	56 (2.8)	5 (0.8)	19 (1.4)	24 (1.2)	14 (2.3)	16 (1.2)	30 (1.5)
50–59	49 (9.7)	45 (4.1)	94 (5.9)	12 (2.4)	29 (2.6)	41 (2.6)	19 (3.8)	16 (1.5)	35 (2.2)
60–69	78 (19.3)†‡	69 (8.9)†	147 (12.4)†	13 (3.2)	38 (4.9)	51 (4.3)	22 (5.4)†	26 (3.3)	48 (4.1)
≥ 70	101 (32.1)†‡	96 (20.7)†	197 (25.3)†	24 (7.6)	40 (8.6)	64 (8.2)	29 (9.2)†	10 (2.2)	39 (5.0)
Total	250 (13.6)†	244 (6.6)	494 (8.9)	54 (2.9)	126 (3.4)	180 (3.2)	84 (4.6)†	68 (1.8)	152 (2.7)
95% CI	12.1–15.3	5.8–7.4	8.2–9.7	2.2–3.8	2.8–4.0	2.8–3.8	3.6–5.6	1.4–2.3	2.3–3.2

*Data are presented as No. (%) unless otherwise indicated.
†Men had greater COPD prevalence than women according to spirometric and clinical criteria ($p < 0.001$).
‡COPD prevalence was greater in the population > 60 years old ($p < 0.001$).

factors associated with COPD (spirometric definition). The multiple logistic regression analysis was adjusted by age, gender, smoking, altitude, history of tuberculosis (TB), and work-related exposure to dust, gas, or smoke; the variables significantly associated with the COPD prevalence were age ≥ 60 years, male gender, history of TB, active and passive smoking, wood smoke exposure > 10 years, and very low education level (Table 6). Relatives' COPD history and respiratory diseases in childhood were not associated with COPD.

Altitude: The logistic regression analysis comparing Barranquilla (18 m above sea level) and Medellín (1,538 m) showed a positive association between altitude and COPD prevalence (the higher altitude, the larger prevalence; odds ratio [OR], 2.13; 95% CI, 1.55 to 2.94). However, when Bogota, the highest city (2,640 m), was compared with Barranquilla, the association was not significant, although there was an increase in relative risk of 39% (OR, 1.39; 95% CI, 0.98 to 1.96; $p = 0.062$).

History of Pulmonary TB: Of 72 subjects who had a history of TB confirmed by a physician, 16 subjects (25.8%) had obstruction in the postbronchodilator spirometry. The logistic regression analysis (Table 6) revealed an association between the history of TB and airflow obstruction (OR, 2.94; 95% CI, 1.58 to 5.49).

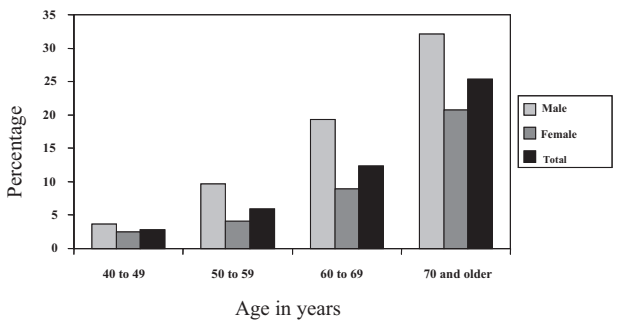

FIGURE 1. COPD prevalence (FEV_1/FVC postbronchodilator < 0.7) by gender and age group.

DISCUSSION

As far as we know, PREPOCOL is the first probabilistic population study done in Colombia and the second in Latin America[15] that use a spirometric definition (postbronchodilator $FEV_1/FVC < 70\%$) as the primary criterion for establishing the COPD prevalence. Although this fixed ratio may underestimate the prevalence of obstruction in young people and overestimate it in older individuals, we selected it to facilitate the comparison of the prevalence with that determined by other studies.[1,2,20] The highest rates of contact household failures and refusals were found in Bogotá, the biggest city; refusals can be related to personal security. The other cities had significantly lower rates of contact failures and refusals. The smoking rate of 18.3% found in our study, very similar to the rate found in the National Study of Risk Factors[11] (19%) done in 1998, and the educational level distribution, comparable with that found by the National Census in 2005,[21] support that subjects not included because of contact failures and refusals were not significantly different from those included in our study.

The greater percentage of women in the study (66.8%) can be partially explained by the composition of the population in Colombia that is skewed toward the female gender (52% in urban areas)[21] and, mainly, by the cultural feature that women stay more time at home than men. However, we found that the sample size was representative of the general male population and comparable with that population in terms of smoking rates and age distribution.

Table 4—*COPD Prevalence According to Smoking Intensity

Definition Criteria	Never-Smokers	Current Smokers		Ex-Smokers	Total
		< 15 Pack-Years	≥ 15 Pack-Years		
Spirometry	149 (5.2); 4.4–6.1	45 (7.9); 5.8–10.4	91 (20.5); 16.9–24.6	209 (12.5); 11.0–14.2	494 (8.9); 8.2–9.7
Medical	69 (2.4); 1.9–3.1	6 (1.1); 0.4–2.3	18 (4.1); 2.4–6.3	87 (5.2); 4.2–6.4	180 (3.3); 2.8–3.8
Clinical	47 (1.6); 1.2–2.2	14 (2.5); 1.3–4.1	40 (9.0); 6.5–12.1	51 (3.1); 2.3–4.0	152 (2.7); 2.3–3.2

*Data are presented as No. (%); 95% CI.

COPD prevalence in Colombia of 8.9% is within the range found in other studies.[7,22,23] It is lower than the prevalence of 17.2% observed in Korea[24] and 10.6% in Spain,[25] and similar to the 8.4% in Greece.[26] The overall COPD prevalence in the five Colombian cities (Table 2) is lower than that observed in the five Latin-American cities studied in PLATINO.[13] Montevideo (19.7%), Santiago de Chile (16.9%), and Sao Paulo (15.8%) had a COPD prevalence higher than that of all of the Colombian cities (8.9%). However Medellín (13.5%) had a higher prevalence compared to Caracas (12.1%), and Cali (8.5%) and Bogotá (8.5%) had a higher prevalence than Mexico City (7.8%).

The prevalence defined by prior medical diagnosis or clinical criteria (chronic bronchitis) was very low: 3.3% and 2.7%, respectively. Chronic bronchitis prevalence was significantly lower than that found in other studies[16,27–29] and only similar to that reported in a study for adults < 45 years of age.[30]

Of 492 people with the study COPD criteria, only 62 subjects (12.6%) had received a diagnosis of COPD previously by a doctor, indicating a high rate of underdiagnosis (87.4%). GOLD[1] and others[31] have brought up this concern noticing a rate of underdiagnosis of 63.3% in the Third National Health and Nutrition Examination Survey,[32] 78.2% in a study of the prevalence of respiratory symptoms and chronic airflow limitation in Spain,[25,33] and higher than 50% in other studies.[26,34,35]

The prevalence of active smoking of 18.3% is lower than the 24% reported by PLATINO.[13] Excluding age, smoking was the main risk factor for COPD (Tables 5, 6) and explained the difference in COPD prevalence in men (COPD prevalence, 13.6%; smoking rate, 24%) and women (COPD prevalence, 6.6%; smoking rate, 15.3%). Medellín had the higher COPD prevalence (13.5%) and the higher smoking rate (29.8%) compared with the other cities ($p < 0,001$), confirming that the higher the cigarette smoking the higher COPD prevalence. In never-smokers, COPD prevalence was 5.2%, suggesting that other risk factors could be involved. The logistic regression analysis demonstrated that exposure to wood smoke for > 10 years is one of those factors (Table 6). Similar findings suggesting that wood smoke exposure independently increase the risk of COPD have been described in other studies.[36–38]

Table 5—*COPD Risk Factors: Univariate Analysis*

Variables	Frequency of COPD, No. (%)	OR	95% CI	p Value
Age ≥ 60 yr	344 (17.5)	4.86	4.0–5.9	< 0.001
History of TB*	62 (25.8)	4.80	4.0–5.9	< 0.001
Current smoking	136 (13.4)	2.81	2.20–3.59	< 0.001
Former smoking	345 (12.8)	2.67	2.18–3.28	< 0.001
Wood smoke exposure ≥ 10 yr	292 (13.4)	2.42	2.00–2.92	< 0.001
Male gender	250 (13.6)	2.23	1.84–2.70	< 0.001
Occupational gases, fumes > 10 yr	104 (14.2)	1.88	1.49–2.37	< 0.001
Coal > 10 yr	29 (13.1)	1.57	1.05–2.34	0.027
Passive smoking	91 (6.2)	1.53	1.08–2.15	0.013
Occupational dust > 10 yr	203 (11.0)	1.43	1.19–1.74	< 0.001
Childhood respiratory disease	99 (8.9)	1.01	0.80–1.27	0.958
History of COPD in the family	55 (7.9)	0.87	0.65–1.58	0.331

*As a specific disease, TB cannot be considered a risk factor for COPD but for airways obstruction.

Table 6—*COPD Risk Factors: Multiple Logistic Regression Analysis*

Variables	OR	95% CI	p Value
Age ≥ 60 yr vs < 60 yr	3.80	3.01–4.72	< 0.001
History of TBs*	2.94	1.58–5.49	0.001
Ever vs never smoking	2.56	1.89–3.46	< 0.001
Male vs female gender	1.91	1.55–2.36	< 0.001
Passive smoking	1.66	1.17–2.35	0.004
Wood smoke exposure ≥ 10 yr vs < 10 yr	1.50	1.22–1.86	< 0.001
Education level Very low vs higher	1.49	1.20–1.84	< 0.001
Cali altitude, 995 m†	1.24	0.88–1.74	0.216
Bucaramanga altitude, 960 m†	1.28	0.91–1.81	0.164
Medellín altitude, 1,538 m†	2.13	1.55–2.94	< 0.01
Bogotá altitude, 2,640 m†	1.39	0.98–1.96	0.062

*As a specific disease, TB cannot be considered a risk factor for COPD but for airways obstruction.
†Barranquilla (altitude, 18 m) was used for comparison level.

The PLATINO study[13] found a negative association between altitude and COPD prevalence (the greater the altitude, the lower the prevalence). Our study did not support this hypothesis. Using the classification of altitude in low (< 1,500 m), medium (1,500 to 2,500 m), and high (> 2,500 m), proposed by Barry and Pollard,[39] we included cities situated at low, medium, and high altitudes. The multivariate analysis comparing Medellín (1,538 m) with Barranquilla (18 m) showed an opposite hypothesis to PLATINO findings: the higher the altitude, the larger the prevalence. However, this apparent association was not significant when we compared Barranquilla (18 m) with Bogotá, the highest city (2,640 m), although there was an increase in relative risk of 39% (OR, 1.39; 95% CI, 0.98 to 1.96; p = 0.062), suggesting a nonsignificant tendency toward larger prevalence with higher altitude (Table 6). This finding, in five cities in the same country, with similar geographic conditions (excepting altitude) and ethnic conformation, is at odds with the "protective" association of altitude suggested by the PLATINO study.[13] In an analysis done in our subjects without airways obstruction, we found that both FVC and FEV_1 were significantly higher at higher altitude,[40] but FEV_1 proportionally increased a little more than FVC, which could increase the FEV_1/FVC ratio and decrease its ability to define the population with obstruction at a greater altitude. Additional studies are needed to establish the real influence of altitude on COPD prevalence.

Sixteen of the 62 people (25.8%) with TB history confirmed by a doctor had airflow obstruction. Pulmonary TB is a frequent cause of bronchial obstruction,[12,41–43] and *vice versa* individuals with airways obstruction, wheezing, asthma, or COPD frequently had have TB.[44,45] The logistic regression analysis established a strong association between history of TB and obstruction (OR, 2.97; p = 0.001); furthermore, the association was higher than smoking. Being that TB is a specific infectious disease, we do not consider it as a risk factor for COPD but a risk factor for airways obstruction. TB should be considered in people with respiratory symptoms and obstructive airways disease, particularly in countries with a high prevalence of TB.

The COPD prevalence in never-smokers was 5.2% (142 of 2,853 subjects) and in never-smokers never exposed to wood smoke was 3.1% (35 of 1,140 subjects), indicating that 30.2% of our cases (142 of 494 subjects) were not related to smoking, and 7.1% (35 of 494 subjects) were not related to both smoking and wood smoke exposure. This finding supports the hypothesis that other factors might be related to COPD. Several studies[46–50] have stressed the importance of genetic, ethnic, climatic, and sociocultural factors, and the exposure to pollutants different from cigarette smoking.

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Prevalence of COPD in Five Colombian Cities Situated at Low, Medium, and High Altitude (PREPOCOL Study)

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