ORIGINAL ARTICLE

Symptoms of chronic bronchitis in individuals without chronic obstructive pulmonary disease: prevalence, burden, and risk factors in southern Poland

Filip Mejza[1], Paweł Nastałek[2], Zbigniew Doniec[3], Wojciech Skucha[4]

1 Centre for Evidence Based Medicine, 2nd Department of Internal Medicine, Jagiellonian University Medical College, Kraków, Poland
2 Department of Pulmonology, 2nd Department of Internal Medicine, Jagiellonian University Medical College, Kraków, Poland
3 Department of Pneumonology, Institute of Tuberculosis and Lung Diseases, Rabka-Zdrój Branch, Rabka-Zdrój, Poland
4 Pulmonology Ward, County Hospital in Proszowice, Proszowice, Poland

KEY WORDS

chronic bronchitis, epidemiology, Poland, prevalence

ABSTRACT

INTRODUCTION Chronic bronchitis (CB) symptoms are commonly reported in individuals without chronic obstructive pulmonary disease (COPD), but CB is rarely diagnosed in this population.

OBJECTIVES We aimed to determine the prevalence and burden of CB, as well as its risk factors, in a population of patients without COPD.

PATIENTS AND METHODS Data from the "Health Action" program (a lung cancer prevention and health care improvement program conducted in Proszowice County, Poland) were used. All county inhabitants aged 40 years or older without COPD were invited to participate. As part of the program, a questionnaire was administered to assess CB symptoms and risk factors. Spirometry at baseline and after the bronchodilator test was also performed.

RESULTS CB symptoms were present in 9.1% of the 3558 participants. The prevalence of CB in the study population was 7.12% (95% CI, 6.70–7.56). Patients with CB had more dyspnea and more often received medical treatment for lung disease or were hospitalized for respiratory disorders than patients without CB. CB was associated with worse lung function and a worse score in the modified Medical Research Council Dyspnea Scale even after adjustment for possible confounders. In a multivariate analysis, male sex, age over 70 years, current smoking, passive exposure to tobacco smoke, gas or wood heating, occupational exposure to chemical agents, lower forced expiratory volume in 1 second, and asthma correlated with an increased risk of CB.

CONCLUSIONS CB symptoms are common in individuals without COPD aged 40 years or older and are associated with more dyspnea irrespective of lung function and comorbidities.

Correspondence to:
Filip Mejza, MD, PhD,
Centre for Evidence Based Medicine,
2nd Department of Internal Medicine,
Jagiellonian University Medical
College, ul. Skawińska 8,
31-066 Kraków, Poland,
phone: +48 12 430 51 58,
email: filipmejza@hotmail.com
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INTRODUCTION Chronic cough and sputum production are among the most commonly reported medical symptoms.[1] Cough and sputum expectoration for most days for at least 3 months during at least 2 consecutive years are considered the epidemiological criteria of chronic bronchitis (CB).[2] Clinical diagnosis requires exclusion of common diseases causing CB symptoms, especially asthma and heart failure. CB was originally recognized as a stand-alone condition,[3] but since the term chronic obstructive pulmonary disease (COPD) became popular, it has been commonly, yet incorrectly, viewed solely as a COPD phenotype and hence rarely diagnosed in individuals without COPD. In fact, CB is common in the general population, including people over 40 years of age as well as younger ones, many of whom do not have COPD.[4-7] Contrary to older reports,[8,9] the results of recent longitudinal studies suggest that CB symptoms in the general population are associated with an increased rate of lung function decline as well as a higher risk of COPD

and death.[10-12] It has been suggested that in patients with normal lung function CB symptoms may also be associated with worse quality of life as well as an increased risk of lung function impairment and respiratory exacerbations.[4] However, this issue has not received adequate attention in clinical practice or scientific research.

Recently, a large health promotion program has been implemented in Proszowice County in southern Poland, aiming to improve the respiratory health status of the local population.[13] The program consisted of a series of educational initiatives and active prevention measures aimed at identification of individuals with respiratory symptoms among the county population. We have used the data from this program to determine the prevalence and burden of CB symptoms, as well as their risk factors, in a population of patients without irreversible airway obstruction.

PATIENTS AND METHODS We used data from "Action Health," a health program promoting lung cancer prevention and health care improvement implemented in Proszowice County, Poland, between 2014 and 2016. The details and main results of the program were published elsewhere.[13] In brief, all county inhabitants aged 40 years or older were invited to participate. The program was based on a questionnaire composed of questions on respiratory symptoms (including detailed questions on cough and sputum production as well as the modified Medical Research Council [mMRC] Dyspnea score), previous medical diagnoses, and exposure to known and potential respiratory risk factors (including occupational risk factors). The questionnaires were administered at participants' homes by trained staff supervised by the medical coordinator of the program (WS). Questionnaire data were analyzed based on prespecified rules. Individuals with respiratory symptoms or exposure to risk factors or both were offered spirometry, chest x-ray, and further diagnostic management, as clinically indicated, at a respiratory clinic at County Hospital in Proszowice. Spirometry was performed in the office by experienced technicians, using LungTest 1000 spirometers (MES, Kraków, Poland), before and after bronchodilator administration (400 μg of inhaled salbutamol). All spirometry results were reviewed by the medical coordinator (WS), and those of acceptable quality were included in further analyses.[14] COPD was excluded based on the postbronchodilator ratio of forced expiratory volume in 1 second (FEV_1) to forced expiratory capacity (FVC) equal to or higher than the lower limit of normal.[15] CB symptoms were considered to be present when a participant: 1) provided affirmative answer to the following questions on chronic cough and chronic sputum production: "Do you cough for most days for at least 3 month each year?" and "Do you cough up phlegm on most days for at least 3 months each year?"; and 2) confirmed that both chronic cough and chronic sputum production lasted for at least 2 years. Asthma and other medical diagnoses were assessed based on self-reported previous medical diagnoses.

Statistical analysis Within-group comparisons were made using the χ^2 test and the *t* test or the Mann–Whitney test, as appropriate. Regression analysis was used to evaluated the relationship of CB symptoms with specific negative outcomes. Postbronchodilator FEV_1, FVC, FEV_1/FVC, and mMRC Dyspnea Scale score were used as dependent variables in separate regression models, along with CB, sex, age, smoking status, and self-reported asthma (and FEV_1 in a model with the mMRC Dyspnea Scale score as a dependent variable) as potential predictors. Multiple logistic regression was used to assess potential risk factors for CB symptoms. The presence of CB symptoms was used as a dependent variable. The following parameters were used as independent variables: age, sex, education, smoking status, e-cigarette use (vaping), exposure to passive smoke, occupational exposure (working in mining and metallurgy industry, welding, farming, using pesticides or fertilizers during farm work, exposure to chemical agents), household heating (with coal, coke gas, or wood), household cooking (using gas oven, electric oven, or wood or coal stove), self-reported medical diagnoses of asthma and bronchiectasis, as well as postbronchodilator lung function (FEV_1). All the above analyses were repeated after excluding asthma-reporting participants from the dataset. Similarly, risk factor analysis was repeated after excluding asthma-reporting participants from the dataset, and it was carried out separately in nonsmoking individuals without asthma. All analyses were performed with R statistical software, version 3.3.1 (https://www.R-project.org). The results with a *P* value of less than 0.05 were considered significant.

RESULTS Approximately 70% of county inhabitants aged 40 years or older gave their consent to participate in the study. Good-quality questionnaire data were obtained from 14 323 respondents (98.4%), and appropriate-quality prebronchodilator and postbronchodilator spirometry data, from 4105 respondents (~20%). Based on postbronchodilator spirometry, COPD was excluded in 3558 of participants (86.7%). All these individuals were subjected to further analyses, unless stated otherwise, as outlined in FIGURE 1.

CB symptoms were present in 9.1% of respondents (n = 323), whereas chronic cough and chronic sputum production, in 16% (n = 569) and 10.6% (378), respectively. The prevalence of CB symptoms decreased to 7.6% (n = 271) after exclusion of individuals who reported asthma diagnosis. CB symptoms were present in 1.6% of lifetime nonsmokers without asthma (n = 57). The population prevalence of CB symptoms was estimated at 7.12% (95% CI, 6.70–7.56) in the whole studied population and 6.31% (95% CI, 5.9–6.74) in those without asthma.

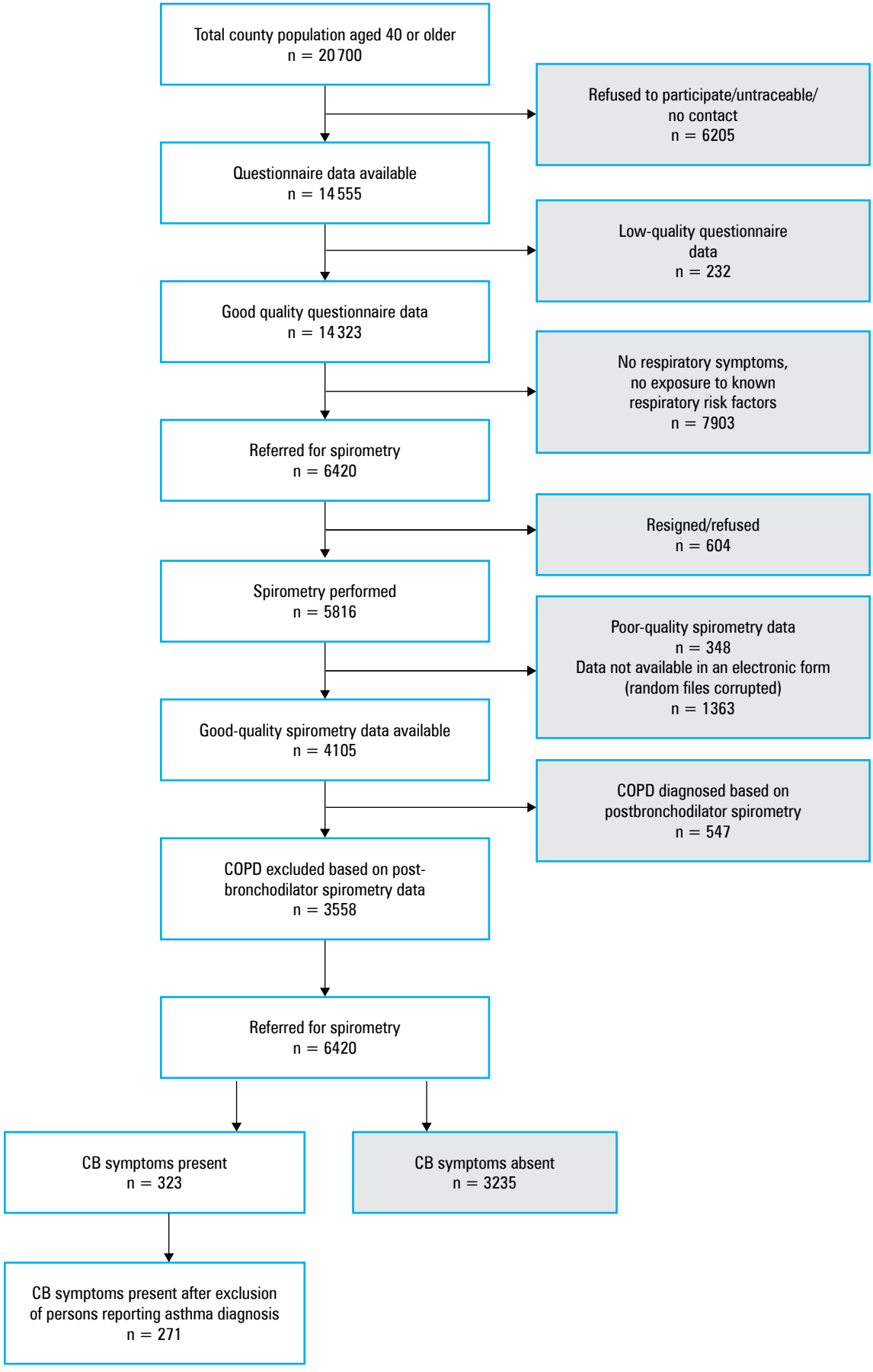

FIGURE 1 Flowchart for selection of study participants
Abbreviations: CB, chronic bronchitis; COPD, chronic obstructive pulmonary disease

TABLE 1 Comparison of demographic characteristics between the study groups (total population and participants with and without chronic bronchitis symptoms)

Parameter		Total population (n = 3558)	No CB symptoms (n = 3235)	CB symptoms (n = 323)	*P* value CB vs no CB
Age, y, mean (SD)		58.6 (10.8)	58.5 (10. 9)	59.7 (10.7)	0.06
Women, % (n)		52.1 (1852)	53.8 (1739)	35.0 (113)	<0.01
Education, % (n)	≤8 years (primary school)	48.5 (1726)	49.3 (1540)	58.49 (186)	0.01
	9–12 years (high school)	41.7 (1483)	43.79 (1368)	36.16 (115)	
	>12 years (university)	6.6 (233)	6.91 (216)	5.35 (17)	
Smoking, % (n)	Lifetime nonsmokers	44.7 (1591)	47.4 (1516)	23.4 (75)	<0.01
	Previous smokers	30.4 (1082)	31.2 (999)	25.9 (83)	
	Current smokers	23.7 (845)	21.4 (683)	50.6 (162)	
Current passive exposure to tobacco smoke, % (n)		21.3 (757)	20.8 (668)	27.7 (89)	0.04
Diagnosed asthma, % (n)		7.6 (270)	6.7 (218)	16.1 (52)	<0.01
Diagnosed chronic airway disease (asthma, COPD, emphysema), % (n)		9.5 (339)	8.2 (264)	23.2 (75)	<0.01

Abbreviations: see FIGURE 1

TABLE 2 Comparison of dyspnea rates, lung function, and medical history between the study groups (total population and participants with and without chronic bronchitis symptoms)

Parameter		Total population	No CB symptoms	CB symptoms	*P* value
Total population		n = 3558	n = 3235	n = 323	CB vs no CB
Dyspnea, % (n)		30.4 (1083)	27.5 (889)	60.1 (194)	<0.01
mMRC Dyspnea Scale score, points, median (IQR)		0.0 (1.0)	0.0 (0.0)	1.0 (4.0)	<0.01
Lung function[a], mean (SD)	FEV_1	103.2 (17.0)	103.5 (17.0)	100.1 (17.5)	0.01
	FVC	107.0 (17.2)	107.2 (17.1)	105.4 (18.0)	0.06
	FEV_1/FVC	79.0 (6.3)	79.2 (6.2)	76.8 (6.1)	<0.01
Medical therapy for lung disease, % (n)		7.3 (261)	6.0 (195)	20.4 (66)	<0.01
No. of hospitalizations for respiratory disorders in the previous year, median (IQR)		0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	<0.01
After exclusion of asthma-reporting particpants		n = 3288	n = 3017	n = 271	CB vs no CB
Dyspnea, % (n)		26.6 (873)	24.1 (727)	53.9 (146)	<0.01
mMRC Dyspnea Scale score, points, median (IQR)		0.0 (0.0)	0.0 (0.0)	0.0 (3.0)	<0.01
Lung function[a], mean (SD)	FEV_1	103.8 (16. 8)	104.0 (16.8)	101.7 (16.5)	0.03
	FVC	107.3 (17.0)	107.4 (17.0)	106.4 (17.3)	0.38
	FEV_1/FVC	72.2 (6.2)	79.4 (6.2)	77.3 (6.0)	<0.01
Medical treatment for lung disease, % (n)		1.7 (57)	1.2 (36)	7.7 (21)	<0.01
Number of hospitalizations for respiratory disorders in the previous year, median (IQR)		0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	<0.01

a postbronchodilator, expressed as % of predicted values

Abbreviations: FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; mMRC, modified Medical Research Council; others, see FIGURE 1

The characteristics of participants differed significantly between those with and without CB symptoms. Individuals with CB symptoms were more often male, smokers, less educated, and diagnosed with airway disorders (TABLE 1). Moreover, compared with participants without CB, those with CB more often had dyspnea, worse lung function, and more often received medical care for lung disease, including inpatient treatment (TABLE 2). These differences remained significant even after asthma-reporting participants were excluded from the analyses. Furthermore, associations of CB symptoms with a lower FEV_1/FVC ratio and a worse mMRC Dyspnea Scale score were still significant after adjustment for possible confounders including sex, age, asthma, and smoking (and lung function in the case of the mMRC Dyspnea Scale score) (TABLE 3).

A previous medical diagnosis of CB was reported in 155 participants (4.4% of the total

TABLE 3 Relationship of chronic bronchitis with lung function parameters and mMRC Dyspnea Scale score in a multivariate analysis

Dependent variable	Adjusted change in participants with CB vs those without CB (95% CI)[a]	*P* value
Total population (n = 3558)		
FEV_1, % pred.	–1.85 (–3.82–0.12)	0.06
FVC, % pred.	–0.89 (–2.9–1.12)	0.38
FEV_1/FVC, %	–0.75 (–1.41 to –0.09)	0.03
mMRC Dyspnea Scale score, points	0.81 (0.68–0.95)[b]	<0.01
After exclusion of asthma-reporting particpants (n = 3288)		
FEV_1, % pred.	–1.61 (–3.72–0.51)	0.14
FVC, % pred.	–0.61 (–2.77–1.55)	0.58
FEV_1/FVC ratio, %	–0.73 (–1.44 to –0.02)	0.04
mMRC Dyspnea Scale score, points	0.75 (0.61–0.88)[b]	<0.01

a Adjusted for sex, age, smoking status, and reported asthma diagnosis

b Adjusted for sex, age, smoking status, reported asthma diagnosis, and FEV_1

Abbreviations: see FIGURE 1 and TABLE 2

population), including 24 participants (7.4%) reporting CB symptoms and 131 asymptomatic ones (4.1%). When individuals with asthma were excluded from the analysis, the percentage of participants reporting CB symptoms who were previously diagnosed with CB was 5.95% (16 of 271).

In the multivariate analysis, male sex, age over 70 years, current smoking, passive exposure to tobacco smoke, household heating with gas or wood, occupational exposure to chemical agents, lower FEV_1, and asthma were associated with an increased probability of reporting CB symptoms (TABLE 4). When the analysis was repeated, taking also the number of cigarettes smoked daily into account, it did not reveal a significant effect of sex. When participants with asthma were excluded from the multivariate analysis, current smoking, passive exposure to tobacco smoke, occupational exposure to chemical agents, and household heating with gas remained significantly associated with the risk of CB symptoms. In an analysis limited to nonsmokers without asthma, only household heating with gas and occupational exposure to chemical agents were associated with an increased risk of CB symptoms.

DISCUSSION Our findings indicate that CB symptoms are common in individuals without COPD aged 40 years or older. The estimated prevalence of these symptoms in our study population was approximately 7%, and, importantly, most of the affected individuals did not have asthma. The estimated number of individuals affected with CB symptoms in Poland is approximately 2 million (more than 1.7 million after exclusion of those with asthma).[16] Moreover, in patients without COPD, CB symptoms were reported more often than asthma. Compared with other reports, the proportion of patients with CB symptoms in our sample was in the upper range. The prevalence of CB in the general population or individuals without COPD in most reports falls in the approximate range of 3% to 11%.[4,6,17-20] Even in younger adults (20–44 years old), the CB prevalence rates were reported to range from 0.7% to 9.7% in a multicenter study.[5] High prevalence of CB symptoms in people without COPD seems alarming, considering that: 1) they are at an increased risk of COPD[10-12]; 2) there is consistent research evidence to support a significant CB-related burden also in individuals with normal lung function[4,20,21]; and 3) most of them remain undiagnosed.

The results of studies on CB prevalence depend on the definitions used. Clinically, CB is defined "by cough and sputum expectoration occurring on most days for at least 3 months of the year and for at least 2 consecutive years when other respiratory or cardiac causes for the chronic productive cough are excluded."[22] In epidemiological studies, the latter part of the definition is usually omitted,[23] as clinical exclusion of underlying diseases is usually not feasible in the course of epidemiological studies, especially those dealing with large samples of subjects. Because asthma is the most common reason for reporting CB symptoms and is typically identified and self-reported by patients, some authors decided to perform their analyses after exclusion of such individuals. We also adopted this approach in the present study and reported data based on the analysis of the total sample as well as the population after exclusion of participants reporting asthma diagnosis.

We observed that CB symptoms were associated with significantly worse lung function and more dyspnea as compared with CB-free population and the size effect was large. This relationship was independent of the presence of asthma or other confounders. This finding is in line with other reports that linked CB, even in the absence of COPD, with a decreased quality of life.[20,24] No evidence-based medical interventions, except those aimed at smoking cessation, can be offered to these patients. However, it is important to identify these individuals because smoking cessation slows down lung function decline and may lead to resolution of CB (at least in some patients), and the proportion of smokers is still high in Poland despite the decrease observed in recent years.[25] Unfortunately, only a very small percentage of participants reporting CB symptoms were correctly diagnosed (<6% after exclusion of those reporting asthma diagnosis). This observation suggests that chronic cough with sputum production is overlooked or disregarded by patients and physicians.

The results of the risk factor analysis are mostly in keeping with previous evidence. Not surprisingly, current smoking was identified as a risk factor for CB symptoms. However, only about 50% of individuals with CB in our sample were current smokers. This indicates that CB should not be viewed exclusively as a "smoker's disease." In our sample, we

TABLE 4 Risk factors of chronic bronchitis in a multivariate analysis

Potential risk factor		Total		After excluding asthma-reporting participants		After excluding asthma-reporting participants and smokers	
		OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Male sex		1.64 (1.22–2.21)	0.001	1.48 (1.07–2.04)	0.017	1.35 (0.86–2.11)	0.188
Age, y	30–49	Ref.					
	50–59	1.31 (0.91–1.87)	0.147	1.25 (0.86–1.82)	0.243	1.14 (0.62–2.07)	0.68
	60–69	1.20 (0.83–1.74)	0.327	1.14 (0.77–1.68)	0.515	1.18 (0.66–2.12)	0.583
	≥70	1.57 (1.02–2.44)	0.043	1.40 (0.86–2.28)	0.176	1.73 (0.92–3.25)	0.09
Education	University	Ref.					
	Below primary	2.35 (0.3–18.5)	0.417	2.18 (0.28–17.21)	0.461	–	0.983
	Primary	1.80 (0.23–14.23)	0.578	1.66 (0.21–13.23)	0.63	–	0.983
	High	1.57 (0.19–13.32)	0.678	1.58 (0.18–13.55)	0.677	–	0.983
Smoking status	Lifetime nonsmokers	Ref.					
	Former smokers	1.23 (0.86–1.75)	0.252	1.23 (0.83–1.83)	0.309	1.31 (0.86–1.99)	0.206
	Current smokers	4.38 (3.13–6.12)	0.001	4.53 (3.15–6.49)	0.001	NA	NA
E-cigarette use		1.26 (0.8–1.98)	0.320	1.36 (0.86–2.16)	0.192	2.68 (0.74–9.71)	0.133
Exposure to tobacco smoke		1.47 (1.09–1.99)	0.013	1.48 (1.06–2.05)	0.021	1.55 (0.95–2.51)	0.078
Working for ≥3 months	Coal mine	1.41 (0.58–3.43)	0.447	1.47 (0.56–3.86)	0.436	0.56 (0.07–4.69)	0.595
	Steelworks	1.31 (0.83–2.08)	0.252	1.60 (0.99–2.57)	0.054	0.78 (0.30–2.01)	0.6
	Welding industry	0.83 (0.51–1.36)	0.464	0.91 (0.54–1.55)	0.731	0.63 (0.25–1.55)	0.312
	Farming	0.94 (0.63–1.4)	0.743	0.93 (0.61–1.43)	0.741	0.79 (0.43–1.44)	0.434
Occupational exposure	Pesticides or fertilizers	1.41 (1.00–2.01)	0.053	1.45 (0.98–2.14)	0.061	1.61 (0.94–2.75)	0.083
	Asbestos	2.00 (0.68–5.84)	0.207	2.22 (0.74–6.62)	0.153	1.12 (0.12–10.34)	0.918
	Chemical agents	1.56 (1.15–2.12)	0.004	1.67 (1.20–2.32)	0.002	1.99 (1.25–3.16)	0.004
Household heating	Coal	1.31 (0.67–2.54)	0.432	1.57 (0.73–3.37)	0.25	1.96 (0.68–5.59)	0.211
	Coke	1.00 (0.22–4.5)	0.998	1.50 (0.34–6.72)	0.595	1.22 (0.16–9.37)	0.846
	Gas	3.60 (1.83–7.08)	<0.001	4.56 (2.10–9.92)	0.001	3.95 (1.38–11.28)	0.01
	Wood	1.38 (1.04–1.84)	0.026	1.37 (1.00–1.87)	0.052	1.24 (0.80–1.91)	0.34
Cooking fuel	Electric	Ref.					
	Gas	1.09 (0.48–2.52)	0.832	0.91 (0.40–2.10)	0.832	1.40 (0.48–4.15)	0.54
	Wood	1.07 (0.39–2.98)	0.892	0.98 (0.53–1.81)	0.951	0.98 (0.44–2.19)	0.965
	Coal	1.30 (0.14–12.53)	0.821	1.19 (0.14–9.87)	0.874	3.34 (0.41–27.55)	0.262
Asthma		3.46 (2.39–5.01)	<0.001	NA	NA	NA	NA
Bronchiectasis		0.63 (0.08–5.27)	0.672	4.08 (0.42–39.78)	0.226	7.57 (0.73–79.01)	0.091
FEV_1, per 10% decrease		1.08 (1.00–1.17)	0.040	1.07 (0.98–1.17)	0.118	1.08 (0.96–1.21)	0.226

Abbreviations: NA, not applicable; OR, odds ratio; Ref., reference; others, see **TABLE 2**

identified occupational exposure to chemical agents as a potential risk factor. Various other environmental factors were reported to be related to an increased risk of CB,[26-29] with long-term exposure to multiple inhaled smokes, vapors, and particles likely to evoke CB symptoms. Surprisingly, we also observed a strong association between household heating with gas and an increased risk of CB. Such observations have been reported previously, yet the studies were carried out in other populations using different methods of gas heating.[30] There is no clear biological rationale for this finding, as households using gas for heating in the studied region are fitted with modern, low-emission, and hermetic gas boilers. Moreover, there was no association between using a gas oven for cooking (potentially linked to the exposure to gas combustion products) and the risk of CB symptoms. Locally, only relatively wealthy households can afford gas-powered heating installations, decreasing the odds that lower material status might play a role as a potential confounder. We hypothesize that household heating with gas may be related to building construction characteristics that alter the microclimate (increasing the temperature or decreasing the humidity) and slow down the air exchange rate inside the house. This appears to be supported by the fact that most local houses only have gravitational ventilation systems, and modern, typically gas-heated, buildings are more air-tight as compared with the old ones,

due to technological differences in construction. Regardless of the above speculations, this observation needs to be confirmed in further research.

Our study has one potentially significant limitation, namely, the eligibility assessment for spirometry was based on symptom/risk factor analysis score rather than random. However, the effect of these limitations is minimized by a large (relative and absolute) sample size and very broad selection criteria for spirometry (spirometry was offered to more than 50% of participants). To exclude possible overestimation of CB prevalence in a local population with normal lung function, a conservative approach was used, assuming that the proportion of COPD patients in the target population is similar to that in a sample with spirometry data available. Thus, we can state with a high degree of confidence that the prevalence of CB symptoms in individuals without COPD is at least as high as estimated in our study. The strengths of our study include a large sample size (including the majority of the target population) and high-quality spirometry data. It should also be stressed that these results apply to a population over 40 years old. Although the available data suggest that CB symptoms are also common in younger people,[5] the prevalence and correlations of CB in those under 40 years old may be significantly different from those reported here.

In conclusion, we demonstrated that in a population aged 40 years or older without COPD, CB is a common yet often undiagnosed condition associated with more dyspnea regardless of lung function and comorbidities.

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CONTRIBUTION STATEMENT WS, ZD, and FM designed the "Action Health" Program. WS and PN were responsible for quality control and data collection. FM planned the data analysis and drafted the manuscript. All authors edited and approved the final version of the manuscript.

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