

Prevalence of Undiagnosed Chronic Obstructive Pulmonary Disease among Smokers and Biomass-Fuel-Exposed Adults: A Multicenter Community-Based Study

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ABSTRACT

Objective: To determine the prevalence of previously undiagnosed chronic obstructive pulmonary disease and its associated factors among adults exposed to cigarette smoke or household biomass fuel in Pakistan.

Methods: This multicenter, community-based cross-sectional study included 220 adults aged ≥ 40 years recruited from community outreach sites affiliated with participating tertiary-care institutions across Pakistan between January and December 2025. Eligible participants had smoked at least 10 pack-years, used biomass fuel for at least 10 years, or experienced both exposures. Individuals with previously diagnosed chronic obstructive pulmonary disease were excluded. Symptoms and exposures were recorded through structured interviews. Pre-bronchodilator and post-bronchodilator spirometry was performed according to accepted standards. Undiagnosed chronic obstructive pulmonary disease was defined as a post-bronchodilator FEV₁/FVC ratio below 0.70.

Results: Spirometry confirmed previously undiagnosed chronic obstructive pulmonary disease in 41 participants, giving a prevalence of 18.6% (95% CI: 13.7-24.4%). Prevalence was 15.9% among smokers, 15.9% among biomass-exposed adults and 28.0% among participants with dual exposure. Most detected cases had mild or moderate airflow limitation. Older age, dual exposure, exposure lasting at least 20 years, chronic cough and exertional dyspnea remained independently associated with disease.

Conclusion: Nearly one in five high-risk adults had undiagnosed chronic obstructive pulmonary disease. Community-based symptom assessment followed by targeted spirometry could identify disease earlier within resource-constrained Pakistani healthcare settings.

Keywords: Biomass Fuel, Chronic Obstructive Pulmonary Disease, Community Screening.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a heterogeneous lung condition characterized by persistent respiratory symptoms and airflow obstruction resulting from abnormalities of the airways, alveoli, or both [1]. It develops through complex interactions between harmful environmental exposures, altered lung

development, ageing, infections and individual susceptibility [2]. Although COPD is preventable and treatable, it remains a major contributor to premature mortality, disability and healthcare expenditure worldwide [3]. An estimated 391.9 million adults aged 30–79 years were living with COPD in 2019, and more than four-fifths were residing in low- and middle-income countries

[4]. The global number of affected adults is projected to approach 600 million by 2050, with particularly marked growth among women and populations in resource-constrained regions [5].

Cigarette smoking remains the best-recognized preventable cause of COPD, but it does not explain the entire burden of disease [6]. Long-term exposure to smoke generated by burning wood, animal dung, crop residues and charcoal contributes substantially to chronic respiratory disease in communities where clean household energy is unavailable or unaffordable [7]. Biomass smoke contains respirable particulate matter, carbon monoxide, nitrogen oxides and numerous organic compounds capable of producing persistent airway inflammation, oxidative stress and structural lung injury [8]. Women in South Asian households may experience intense exposure because cooking is commonly undertaken in poorly ventilated indoor spaces [9]. Men may acquire overlapping exposure through cigarette smoking, agriculture, traffic pollution and dust-generating occupations, creating a varied risk profile within the same community [10].

A diagnosis of COPD requires compatible clinical circumstances and objective demonstration of persistent airflow obstruction on spirometry [11]. Current guidance requires a post-bronchodilator FEV₁/FVC ratio below 0.70 to confirm persistent airflow obstruction, while clinical history is needed to distinguish COPD from other respiratory disorders [12]. Reliance on symptoms alone is insufficient because chronic cough and breathlessness may be normalized as consequences of smoking, cooking smoke, ageing or physical work. Conversely, treatment without spirometric confirmation may lead to misclassification and inappropriate use of respiratory medicines [13]. Underdiagnosis is especially important in primary-care and community settings, where access to quality-assured spirometry and trained personnel remains limited. Many affected adults seek care only after airflow limitation has progressed or an exacerbation has occurred. Targeted case-finding among adults with meaningful exposures may therefore be more practical than unrestricted population screening, particularly in health systems with limited diagnostic resources [14]. Pakistan carries a combination of tobacco exposure, household solid-fuel use, ambient air pollution and restricted access to pulmonary-function testing. However, contemporary community-level evidence based on post-

bronchodilator spirometry remains limited. This study determined the prevalence of previously undiagnosed COPD among cigarette smokers and biomass-fuel-exposed adults in Pakistan and examined the demographic, exposure-related and clinical factors associated with undetected disease.

MATERIALS AND METHODS

A multicenter community-based cross-sectional study was conducted from January to December 2025 at community outreach sites affiliated with the departments of pulmonology and community medicine of participating tertiary-care institutions in Pakistan. The selected centers covered urban, peri-urban and rural populations. Ethical approval was obtained from the institutional review boards of all participating institutions before recruitment. Written informed consent was obtained from every participant. Individuals with abnormal spirometry findings were counseled and referred to the relevant respiratory clinic for further evaluation and management.

Adults aged 40 years or older who had lived in the selected community for at least one year were approached through community health camps, household mobilization and primary-care outreach activities. Participants were eligible when they reported cigarette smoking of at least 10 pack-years, household biomass-fuel exposure for at least 10 years, or both exposures. Biomass exposure was defined as regular participation in cooking or prolonged daily presence near a stove burning wood, crop residues, animal dung or charcoal.

Individuals with a previous physician diagnosis of COPD, current use of maintenance inhaled COPD medication, active pulmonary tuberculosis, previous lung resection, pregnancy, acute respiratory infection during the preceding four weeks, recent myocardial infarction, unstable angina or any condition preventing acceptable spirometry were excluded. Participants with a known diagnosis of asthma were also excluded to reduce clinical misclassification.

The required sample size was calculated using an anticipated prevalence of undiagnosed COPD of 18%, a 95% confidence level and 5% absolute precision. After allowing for incomplete interviews and unacceptable spirometry, 220 participants were enrolled. Each participating center recruited eligible adults through community health camps, household mobilization and primary-care outreach activities. Consecutive sampling was

continued until the required sample size was achieved. The operational definitions used for exposure assessment, respiratory symptoms,

undiagnosed COPD and severity of airflow limitation are presented in Table 1.

Table 1. Operational definitions used in the study

Study variable	Operational definition
Significant cigarette exposure	Current or previous cigarette smoking of at least 10 pack-years
Biomass-fuel exposure	Regular cooking or prolonged daily presence near burning wood, crop residues, animal dung or charcoal for at least 10 years
Dual exposure	Presence of both significant cigarette-smoking and biomass-fuel exposure
Chronic cough	Cough occurring on most days for at least three months during the preceding year
Chronic sputum production	Sputum production on most days for at least three months during the preceding year
Clinically relevant dyspnea	Modified Medical Research Council dyspnea grade ≥ 2
Undiagnosed COPD	No previous COPD diagnosis, compatible exposure history and post-bronchodilator $FEV_1/FVC < 0.70$
Mild airflow limitation	Post-bronchodilator $FEV_1 \geq 80\%$ predicted
Moderate airflow limitation	Post-bronchodilator FEV_1 50–79% predicted
Severe airflow limitation	Post-bronchodilator FEV_1 30–49% predicted
Very severe airflow limitation	Post-bronchodilator $FEV_1 < 30\%$ predicted

A trained research officer conducted a face-to-face interview using a standardized questionnaire. Information was recorded regarding age, sex, residence, education, occupation, cigarette consumption, smoking duration, biomass-fuel type, daily cooking exposure, exposure duration, kitchen location and ventilation. Pack-years were calculated by multiplying the number of cigarette packs smoked per day by the number of smoking years. Biomass exposure was recorded in years because reliable measurement of particulate concentration was not feasible in the community setting.

Respiratory symptoms included chronic cough, sputum production, wheeze and exertional dyspnea. Chronic cough and sputum were defined as symptoms occurring on most days for at least three months during the preceding year. Dyspnea was graded using the modified Medical Research Council scale. Height and weight were measured without shoes, and body mass index was calculated in kg/m^2 .

Spirometry was performed by trained technicians using portable, calibrated spirometers. Participants avoided smoking for at least one hour and short-acting bronchodilators for the clinically appropriate withholding period before testing. At least three

acceptable forced expiratory maneuvers were attempted while the participant was seated and wearing a nose clip. Testing was repeated after administration of 400 μg salbutamol through a metered-dose inhaler and spacer, allowing 15 minutes before post-bronchodilator measurements. Curves were reviewed for acceptability and repeatability by a pulmonologist who was unaware of the questionnaire-based risk classification.

Previously undiagnosed COPD was defined as compatible exposure history with a post-bronchodilator FEV_1/FVC ratio below 0.70 in a participant who had never received a COPD diagnosis. Airflow-limitation severity was categorized using post-bronchodilator FEV_1 percentage predicted as mild ($\geq 80\%$), moderate (50–79%), severe (30–49%) or very severe ($< 30\%$). Participants whose results suggested asthma, restrictive impairment or another respiratory condition were referred for further clinical assessment rather than being classified solely from screening spirometry.

Data were analyzed using SPSS version 26.0. Appropriate descriptive and comparative tests were applied. Factors associated with COPD were assessed using multivariable logistic regression and reported as adjusted odds ratios

with 95% confidence intervals. A p-value <0.05 was considered significant.

RESULTS

A total of 247 adults were assessed for eligibility. Twelve had previously diagnosed chronic respiratory disease, nine had a recent respiratory infection and six could not produce acceptable spirometry. The remaining 220 participants completed the interview and post-

bronchodilator testing. Their mean age was 53.8±9.1 years, and 120 (54.5%) were men. Ninety-nine participants lived in rural or peri-urban communities. Cigarette smoking alone was reported by 82 (37.3%), biomass exposure alone by 88 (40.0%), and both exposures by 50 (22.7%). The principal demographic and exposure characteristics are presented in Table 2.

Table 2. Demographic and exposure characteristics of participants (n=220)

Characteristic	Value
Age, years	53.8±9.1
Age ≥55 years	98 (44.5)
Male sex	120 (54.5)
Rural/peri-urban residence	99 (45.0)
No formal education	76 (34.5)
Current cigarette smoker	103 (46.8)
Former cigarette smoker	29 (13.2)
Smoking exposure, pack-years*	19 (13–28)
Biomass exposure	138 (62.7)
Biomass exposure duration, years*	21 (15–29)
Poorly ventilated kitchen†	89 (64.5)
Smoking exposure only	82 (37.3)
Biomass exposure only	88 (40.0)
Dual exposure	50 (22.7)
Body mass index, kg/m ²	24.6±4.2

Values are mean±standard deviation or n (%) unless otherwise stated.

*Median (interquartile range). †Among 138 biomass-exposed participants.

Post-bronchodilator spirometry identified persistent airflow obstruction in 41 participants, giving an undiagnosed COPD prevalence of 18.6% (95% CI: 13.7–24.4%). Prevalence was 15.9% in the smoking-only group, 15.9% in the biomass-only group and 28.0% among

participants with dual exposure. Although the difference across all three exposure groups did not reach conventional statistical significance, the dual-exposure group carried the highest observed burden (Table 3).

Table 3. Prevalence of undiagnosed COPD according to exposure

Exposure category	Participants	COPD, n (%)	95% CI
Smoking only	82	13 (15.9)	8.7–25.6
Biomass fuel only	88	14 (15.9)	9.0–25.2
Dual exposure	50	14 (28.0)	16.2–42.5
Overall	220	41 (18.6)	13.7–24.4

Overall comparison: p=0.140.

Participants with undiagnosed COPD were older than those without airflow obstruction and had longer exposure histories. Chronic cough, sputum production, wheeze and exertional dyspnea were more frequent among detected cases. Nevertheless, nine affected participants

did not report chronic cough, and six had neither chronic cough nor sputum production, indicating that reliance on a single symptom would have missed part of the disease burden (Table 4).

Table 4. Characteristics according to spirometry-confirmed undiagnosed COPD

Characteristic	COPD (n=41)	No COPD (n=179)	p-value
Age, years	59.2±8.1	52.5±8.8	<0.001

Age ≥55 years	28 (68.3)	70 (39.1)	0.001
Male sex	24 (58.5)	96 (53.6)	0.570
Rural/peri-urban residence	23 (56.1)	76 (42.5)	0.114
Exposure duration ≥20 years	31 (75.6)	82 (45.8)	0.001
Dual exposure	14 (34.1)	36 (20.1)	0.052
Chronic cough	32 (78.0)	62 (34.6)	<0.001
Sputum production	27 (65.9)	54 (30.2)	<0.001
Wheeze	24 (58.5)	49 (27.4)	<0.001
mMRC dyspnoea grade ≥2	22 (53.7)	38 (21.2)	<0.001
At least one respiratory symptom	38 (92.7)	119 (66.5)	0.001

Values are mean±standard deviation or n (%). mMRC: modified Medical Research Council.

Among the 41 newly detected cases, mean post-bronchodilator FEV₁ was 68.9±15.2% predicted and mean FEV₁/FVC was 0.62±0.06. Mild airflow limitation was present in 11 (26.8%), moderate limitation in 23 (56.1%) and severe limitation in seven (17.1%). No

participant had very severe airflow limitation. Biomass-only cases were predominantly women, whereas smoking-only cases were predominantly men. Dual-exposed participants included both sexes and showed the lowest mean FEV₁ percentage predicted (Table 5).

Table 5. Clinical and spirometric profile of newly detected cases

Finding	Smoking only (n=13)	Biomass only (n=14)	Dual exposure (n=14)	Total (n=41)
Male sex	12 (92.3)	2 (14.3)	10 (71.4)	24 (58.5)
Chronic cough	10 (76.9)	10 (71.4)	12 (85.7)	32 (78.0)
mMRC grade ≥2	6 (46.2)	7 (50.0)	9 (64.3)	22 (53.7)
Post-BD FEV ₁ , % predicted	71.8±14.1	72.1±14.7	63.0±15.5	68.9±15.2
Post-BD FEV ₁ /FVC	0.63±0.05	0.63±0.06	0.60±0.06	0.62±0.06
Mild airflow limitation	4 (30.8)	5 (35.7)	2 (14.3)	11 (26.8)
Moderate airflow limitation	8 (61.5)	7 (50.0)	8 (57.1)	23 (56.1)
Severe airflow limitation	1 (7.7)	2 (14.3)	4 (28.6)	7 (17.1)

BD: bronchodilator; FEV₁: forced expiratory volume in one second; FVC: forced vital capacity.

In multivariable analysis, age of at least 55 years, dual exposure, exposure duration of at least 20 years, chronic cough and mMRC dyspnoea grade ≥2 remained independently associated with undiagnosed COPD. Sex,

residence, education and body mass index did not retain significant associations after adjustment. The model showed acceptable calibration (Hosmer–Lemeshow p=0.61) and no important multicollinearity (Table 6).

Table 6. Multivariable logistic regression for undiagnosed COPD

Predictor	AOR	95% CI	p-value
Age ≥55 years	2.48	1.16–5.31	0.019
Male sex	1.12	0.49–2.56	0.788
Rural/peri-urban residence	1.37	0.65–2.90	0.407
Dual exposure*	2.31	1.02–5.24	0.045
Exposure duration ≥20 years	2.67	1.18–6.04	0.018
Chronic cough	3.54	1.53–8.20	0.003
mMRC dyspnoea grade ≥2	2.42	1.12–5.23	0.025

AOR: adjusted odds ratio; CI: confidence interval.

*Compared with a single exposure category.

DISCUSSION

This multicenter community-based study identified previously undiagnosed COPD in

18.6% of high-risk Pakistani adults. The finding meant that almost one in five participants with substantial cigarette or biomass exposure had persistent airflow obstruction despite never having received a COPD diagnosis. Under-recognition remains common because early respiratory symptoms develop gradually, are frequently normalized by patients and may not prompt spirometric assessment in primary care [15].

The observed prevalence exceeded the estimated global population prevalence of approximately 10%, which was expected because recruitment was restricted to adults aged at least 40 years with meaningful harmful exposure [16]. Case-finding studies similarly show that selecting patients according to age, exposure and respiratory symptoms produces a higher diagnostic yield than unselected screening [17]. This distinction is important in Pakistan, where population-wide spirometry would require substantial equipment, trained staff and quality-control arrangements.

Smoking-only and biomass-only participants had identical COPD prevalence, while adults with both exposures had the highest prevalence and poorer mean lung function. COPD is now understood as the outcome of cumulative and interacting lifetime influences rather than cigarette smoking alone [18]. Biomass combustion releases fine particles and irritant gases that reach the small airways and produce chronic inflammation, mucus hyper secretion and airway remodeling [19]. A systematic review also found that indoor biomass-fuel exposure increased the likelihood of COPD, supporting household smoke as a clinically important exposure [20].

The biomass-only cases were predominantly women, reflecting patterns of household cooking exposure in South Asian communities. Evidence from Pakistan has demonstrated substantial indoor particulate exposure and associations between household air pollution, breathlessness and impaired respiratory health [21]. Women who have never smoked may therefore remain undiagnosed when clinicians use smoking history as the main reason for requesting spirometry. Asking about fuel type, kitchen ventilation, cooking duration and proximity to the stove should form part of routine respiratory assessment.

More than half of newly detected cases had moderate airflow limitation, whereas a smaller but important proportion already had severe disease. This pattern suggested that many participants had passed the earliest stage

before objective testing was offered. Earlier identification creates an opportunity for smoking cessation, reduction of household smoke exposure, vaccination, physical activity advice and appropriate treatment before repeated exacerbations and disability occur [22].

Chronic cough and clinically relevant dyspnea independently predicted undiagnosed COPD, but some affected adults lacked prominent cough or sputum. Symptom questionnaires can support case selection

but cannot replace spirometry because symptoms have limited specificity and early airflow obstruction may be clinically quiet [23]. A practical approach for Pakistan would combine a brief exposure-and-symptom assessment with quality-assured portable spirometry for individuals at increased risk.

Age and longer exposure duration remained associated with disease after adjustment. These findings were biologically credible because cumulative inhalational injury and age-related decline in lung function may jointly reduce respiratory reserve [24]. However, use of the fixed FEV₁/FVC threshold may overestimate obstruction in some older adults. Borderline findings should therefore be interpreted alongside symptoms, exposure history, test quality and repeat spirometry when clinically indicated [25].

The study was strengthened by its multicenter community design, inclusion of smoking and biomass exposure, standardized post-bronchodilator spirometry, and pulmonologist-led quality assessment. Its practical approach could be readily integrated into community and primary-care services in Pakistan.

CONCLUSION

Previously undiagnosed COPD was present in nearly one-fifth of adults with substantial cigarette-smoking or biomass-fuel exposure. Dual exposure, older age, longer exposure duration, chronic cough and exertional dyspnea identified participants with the greatest likelihood of disease. Biomass-exposed women represented an important group who could be missed when diagnostic attention remained focused on cigarette smoking. A targeted community case-finding pathway based on exposure assessment, selected respiratory symptoms and quality-assured post-bronchodilator spirometry could support earlier diagnosis in Pakistan. Such services should be linked with smoking cessation, cleaner

household energy, improved kitchen ventilation and appropriate pulmonary follow-up.

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