

PREVALENCE OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND DETERMINANTS OF UNDERDIAGNOSIS IN WOMEN EXPOSED TO BIOMASS FUEL: A HOSPITAL- AND RURAL HEALTH CENTRE-BASED CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is a leading cause of morbidity and mortality worldwide. While tobacco smoking remains its principal risk factor, a substantial proportion of cases occur among non-smokers, particularly women exposed to biomass fuel smoke in poorly ventilated kitchens. In resource-limited settings, COPD in this population frequently remains underdiagnosed due to limited access to spirometry and low awareness. The aim and objective is to determine the prevalence of COPD among women exposed to biomass fuel attending a tertiary hospital and its affiliated rural health centre, and to identify the determinants contributing to its underdiagnosis in this population. **Materials and Methods:** This hospital-based cross-sectional observational study was conducted over 18 months at the Department of Respiratory Medicine, Kanachur Institute of Medical Sciences Hospital and Research Centre, Mangalore, and its affiliated rural health centre, after Institutional Ethics Committee approval. The calculated sample size was 209 participants. A total of 210 eligible women were finally recruited and included in the analysis. Demographic, occupational, and exposure data were recorded using a structured proforma. Pre- and post-bronchodilator spirometry was performed as per GOLD/ATS-ERS criteria, and COPD was defined as a post-bronchodilator FEV1/FVC ratio <0.70. Data were analysed using SPSS software; chi-square test and independent t-test/Mann-Whitney U test were applied, with $p < 0.05$ considered significant. **Result:** Of 210 women evaluated, 52 (24.8%) were diagnosed with COPD. COPD was significantly associated with lower educational status, lower socioeconomic class, and homemaker occupation ($p < 0.001$ for all). Among biomass fuels, firewood use showed a significant association with COPD ($p = 0.012$). Longer duration of exposure (≥ 25 years), indoor cooking, delayed onset of exposure, and poor kitchen ventilation were significantly linked to COPD ($p < 0.05$). The mean Biomass Exposure Index was significantly higher in the COPD group (112.52 ± 28.19 vs 105.85 ± 25.10 ; $p = 0.035$). Dyspnoea, cough, sputum production, and wheeze were significantly more frequent among COPD patients, with higher MMRC grades predominating ($p < 0.001$). Of the 52 COPD cases, 38 (73.1%) were newly diagnosed during the study. Significant determinants of underdiagnosis included lack of awareness of biomass-related risk ($p < 0.0001$), absence of social support ($p < 0.0001$), poverty ($p = 0.037$), and never having been advised spirometry ($p < 0.001$). **Conclusion:** COPD is a substantial and largely underrecognised health burden among women exposed to biomass fuel. Prolonged biomass exposure, socioeconomic disadvantage, poor awareness, and limited access to spirometry together drive underdiagnosis. Early screening with spirometry, community awareness programmes, and improved healthcare access are essential to reduce this burden.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a major contributor to global morbidity and mortality and currently ranks as the fourth leading cause of death worldwide.^[1] The World Health Organization estimates that approximately 65 million people have moderate to severe COPD, and the disease is projected to become the third leading cause of death by 2030 based on disability-adjusted life years.^[2]

While tobacco smoking is the leading cause of COPD, an estimated 25–45% of affected individuals have never smoked, indicating that non-smoking-related COPD is more widespread than previously recognised.^[3] Among non-smokers, exposure to household and occupational air pollution, recurrent childhood respiratory infections, prior pulmonary tuberculosis, and low socioeconomic status are important contributors. Notably, while roughly 1.01 billion people worldwide use tobacco, nearly 3 billion people—about half the global population—are exposed to biomass smoke, making it potentially the single largest risk factor for COPD globally.^[4,5] Indoor air pollution reaches particularly high levels when wood, coal, animal dung, or crop residues are burned in open fires or poorly ventilated kitchens. Women, who bear the primary responsibility for cooking in many households across developing countries, are disproportionately exposed to these pollutants over decades, placing them at heightened risk of chronic airway inflammation and progressive airflow limitation.^[4,5]

Spirometry remains the objective standard for confirming airflow limitation and diagnosing COPD, defined as a post-bronchodilator FEV1/FVC ratio of less than 0.70.1 However, in resource-limited settings, spirometry is frequently unavailable, underutilised, or inaccessible, and non-smoking women with COPD are often misclassified as having bronchial asthma, cardiac disease, or age-related decline in lung function, leading to substantial underdiagnosis. Understanding both the burden of COPD attributable to biomass exposure and the specific determinants of its underdiagnosis is essential to inform targeted screening and public health strategies in such populations.

Aims and objectives

1. To study the prevalence of COPD in women exposed to biomass fuel attending a tertiary hospital and rural health centre.
2. To identify the factors associated with underdiagnosis of COPD among these participants.

MATERIALS AND METHODS

Study Design and Setting: This was a hospital-based, cross-sectional, observational study conducted in the Department of Respiratory Medicine, Kanachur Institute of Medical Sciences Hospital and Research Centre, Mangalore, and its affiliated rural

health centre, over a period of 18 months, following approval from the Institutional Ethics Committee.

Study Population: Female patients attending the tertiary hospital or rural health centre, aged between 35 and 70 years, with a history of biomass fuel exposure exceeding 10 years, who provided written informed consent, were included consecutively.

Inclusion Criteria:

Female patients aged 35–70 years with a documented history of biomass fuel exposure for more than 10 years, willing to provide written informed consent, were included.

Exclusion Criteria

Participants were excluded if they were male, aged outside the 35–70 year range, had biomass exposure of less than 10 years, had active upper or lower respiratory tract infections, known chest wall abnormalities, cardiac illness, pulmonary tuberculosis, HIV infection, a current or past history of active or passive smoking, or any contraindication to spirometry.

Sample Size: Sample size was calculated using the formula $n = Z^2pq/d^2$, with $Z=1.96$ (95% confidence interval), an expected prevalence (p) of COPD among biomass-exposed women of 14.2%, and an allowable error (d) of 5%. After accounting for a 10% non-response rate, a final sample size of 209 was derived; 210 women were ultimately enrolled and analysed.

Study Methodology: A detailed clinical history covering demographic profile, occupational history, duration and type of biomass exposure, and respiratory symptoms was obtained using a predesigned structured proforma. General physical and systemic examinations were performed, and anthropometric parameters including height, weight, and body mass index (BMI) were recorded using standard methods.

Biomass exposure was quantified using the Biomass Exposure Index (BEI), calculated as the number of hours of cooking per day multiplied by the number of years of biomass exposure. Spirometry was performed using a standardised spirometer in accordance with GOLD and ATS/ERS guidelines and interpreted using standard reference strategies, with pre- and post-bronchodilator FEV1, FVC, and FEV1/FVC ratio recorded.^{1,14} COPD was diagnosed when the post-bronchodilator FEV1/FVC ratio was less than 0.70.1 Information on determinants of underdiagnosis—including access to spirometry, awareness of biomass-related risk, educational level, healthcare access, and treatment adherence—was also recorded.

Statistical Analysis: Data were entered in Microsoft Excel and analysed using SPSS software (version 27.0). Categorical variables were expressed as frequencies and percentages, and continuous variables as mean $\pm$ standard deviation. The chi-square test was used to assess associations between categorical variables, and the independent samples t-test or Mann-Whitney U test was used to compare continuous variables between COPD and non-COPD

groups, depending on distribution. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants, and confidentiality was maintained throughout the study.

RESULTS

A total of 210 women exposed to biomass fuel were evaluated. Of these, 52 (24.8%) were diagnosed with COPD, while 158 (75.2%) were not — indicating that approximately one in four biomass-exposed women in the study population had COPD.

Table 1: Prevalence of COPD among Study Participants

COPD Status	Frequency	Percent
Diagnosed without COPD	158	75.2
Diagnosed with COPD	52	24.8
Total	210	100.0

Sociodemographic Characteristics: The mean age was comparable between women without COPD (51.39 ± 10.02 years) and those with COPD (53.92 ± 10.03 years; $p=0.114$). Education status showed a significant association with COPD ($\chi^2=22.5$, $p<0.001$), with the highest proportion of COPD seen among illiterate participants (30.8%) and the lowest among those with higher secondary education (7.7%). Socioeconomic status was also significantly

associated with COPD ($\chi^2=16.3$, $p=0.001$), with the highest COPD prevalence in the lower socioeconomic group (40.4%). Occupation showed a significant association ($\chi^2=21.6$, $p<0.001$), with homemakers constituting the largest proportion among COPD cases (53.8%), compared to agricultural workers, who predominated in the non-COPD group (39.9%).

Table 2: Association of Sociodemographic Characteristics with COPD Status

Characteristic	Without COPD (n=158)	With COPD (n=52)	χ^2/t value	p value
Age (Mean $\pm$ SD, years)	51.39 ± 10.02	53.92 ± 10.03	1.584*	0.114
Illiterate	16 (10.1%)	16 (30.8%)	22.5	<0.001
Primary school	21 (13.3%)	12 (23.1%)		
Lower socioeconomic class	30 (19.0%)	21 (40.4%)	16.3	0.001
Homemaker (occupation)	33 (20.9%)	28 (53.8%)	21.6	<0.001

*t value

Biomass Fuel Type and Exposure Characteristics:

Among household fuels, firewood use showed a significant association with COPD (94.2% vs 79.1%; $\chi^2=6.294$, $p=0.012$), while charcoal, crop residue, and cow dung cake use showed no significant association ($p>0.05$ for all, with crop residue borderline at $p=0.052$). Duration of biomass exposure of 25 years or more was significantly more common among COPD patients (46.2% vs 20.3%; $\chi^2=13.728$, $p=0.003$). Daily exposure of less than 5 hours was

paradoxically more frequent among COPD patients (71.2% vs 53.2%; $p=0.023$). Indoor-only cooking (61.5% vs 41.8%; $p=0.013$), onset of exposure after 18 years of age (53.8% vs 34.8%; $p=0.015$), and poor kitchen ventilation (44.2% vs 25.3%; $p=0.014$) were all significantly associated with COPD. The mean Biomass Exposure Index was significantly higher among COPD patients (112.519 ± 28.191) than non-COPD participants (105.848 ± 25.103 ; $p=0.035$).

Table 3: Biomass Fuel Exposure Characteristics and COPD Status

Characteristic	Without COPD (n=158)	With COPD (n=52)	χ^2 value	p value
Firewood use	125 (79.1%)	49 (94.2%)	6.294	0.012
Duration ≥ 25 years	32 (20.3%)	24 (46.2%)	13.728	0.003
Indoor cooking	66 (41.8%)	32 (61.5%)	6.142	0.013
Onset >18 years of age	55 (34.8%)	28 (53.8%)	5.931	0.015
Poor kitchen ventilation	40 (25.3%)	23 (44.2%)	8.5	0.014
Biomass Exposure Index (Mean $\pm$ SD)	105.848 ± 25.103	112.519 ± 28.191	1.531*	0.035

*t value

Clinical Features and Spirometry: BMI category showed no significant association with COPD ($\chi^2=2.304$, $p=0.512$). Respiratory symptoms—sputum production, mucoid expectoration, cough, dyspnoea, and wheeze—were all significantly more common among COPD patients ($p<0.001$ for all), with dyspnoea showing the strongest association (96.2% vs 24.1%; $\chi^2=80.61$, $p<0.001$). MMRC dyspnoea grade showed a highly significant association with COPD ($\chi^2=52.88$, $p<0.001$), with

Grade 3 (48.1%) and Grade 4 (25%) predominating among COPD patients, compared to Grade 1 (53.7%) predominating among non-COPD participants. Vital parameters—pulse rate, respiratory rate, blood pressure, and oxygen saturation—showed no significant differences between groups ($p>0.05$ for all).

Spirometry confirmed persistent airflow limitation in all 52 COPD cases, with markedly reduced pre- and post-bronchodilator FEV₁, FVC, and FEV₁/FVC

ratio compared to the non-COPD group, and minimal bronchodilator reversibility. Among COPD patients, the majority were classified as GOLD stage 2

(59.6%), followed by GOLD stage 3 (34.6%), with only 1.9% in GOLD stage 1 and 3.8% in GOLD stage 4.

Table 4: Spirometric Parameters by COPD Status (Mean $\pm$ SD)

Parameter	Without COPD	With COPD
Pre-FEV1 (L)	2.1017 $\pm$ 0.4765	1.4688 $\pm$ 0.3589
Post-FEV1 (L)	2.3250 $\pm$ 0.2732	1.4696 $\pm$ 0.2350
Pre-FVC (L)	2.5431 $\pm$ 0.4462	2.3770 $\pm$ 0.4082
Post-FVC (L)	2.8642 $\pm$ 0.4159	2.4344 $\pm$ 0.3548
Pre-FEV1/FVC	0.7823 $\pm$ 0.0638	0.6197 $\pm$ 0.0890
Post-FEV1/FVC	0.8252 $\pm$ 0.0168	0.6598 $\pm$ 0.0789

Determinants of Underdiagnosis: Of the 52 women diagnosed with COPD, only 14 (26.9%) were previously known cases, while the majority, 38 (73.1%), were newly diagnosed during the study. Significant determinants of underdiagnosis included lack of awareness of biomass-related respiratory risk (88.5% among COPD patients unaware vs 13.3% among non-COPD; $\chi^2=98.3$, $p<0.0001$), absence of social support (76.9% vs 30.4%; $\chi^2=34.8$, $p<0.0001$), poverty (78.8% vs 63.3%; $\chi^2=4.33$, $p=0.037$), and low educational status (84.6% vs 68.4%; $\chi^2=5.175$, $p=0.023$). Non-availability of transport was more frequent among COPD patients but did not reach statistical significance ($p=0.23$).

Healthcare interaction analysis revealed that although a majority of COPD patients (82.7%) had previously visited a physician, 32.6% had never been informed of their diagnosis despite the visit ($p<0.001$), and 53.5% had never been advised to undergo spirometry ($p<0.001$). Non-compliance with medical guidance was seen in 80.0% of COPD patients advised such guidance, and only 46.7% used inhalers regularly. Among those in whom spirometry was advised but not performed, non-availability of the device was the most common reason (71.4%), followed by patient negligence (28.6%).

Table 5: Determinants of Underdiagnosis of COPD

Determinant	Without COPD (n=158)	With COPD (n=52)	χ^2 value	p value
Low level of education	108 (68.4%)	44 (84.6%)	5.175	0.023
Lack of social support	48 (30.4%)	40 (76.9%)	34.8	<0.0001
Unaware of biomass-related risk	21 (13.3%)	46 (88.5%)	98.3	<0.0001
Poverty	100 (63.3%)	41 (78.8%)	4.33	0.037
Visited physician, not informed of diagnosis	0 (0.0%)	14 (32.6%)	40.4	<0.001
Never advised spirometry	0 (0.0%)	20 (46.5%)	60.3	<0.001

DISCUSSION

COPD is increasingly recognised as a major cause of chronic respiratory illness among individuals who have never smoked but are chronically exposed to environmental pollutants, particularly women who spend prolonged periods cooking with biomass fuel in poorly ventilated indoor spaces. This study aimed to determine the prevalence of COPD and the determinants of its underdiagnosis in this specific, high-risk population.

The observed prevalence of 24.8% in the present study — nearly one in four biomass-exposed women — is consistent with the substantial burden reported in earlier work among rural Indian women exposed to biomass smoke³ and with the INSEARCH study, which similarly documented a high burden of chronic respiratory symptoms and airflow limitation across Indian populations.⁷ Comparable findings have also been reported among women using biomass fuel in rural settings elsewhere, reinforcing that indoor air pollution from traditional cooking fuels is a globally significant, though under-recognised, contributor to chronic respiratory disease in women.^[4,9] Sociodemographic analysis showed that while age did not differ significantly between groups, lower

educational status, poorer socioeconomic class, and homemaker occupation were each significantly associated with COPD. These associations likely reflect a combination of prolonged exposure to indoor air pollution among women whose primary occupational role is cooking, and of reduced health literacy that delays symptom recognition and healthcare-seeking, consistent with previously described links between socioeconomic status and COPD¹⁰ and with recognised sex-based differences in COPD risk and presentation.^[12]

Among biomass fuel types, only firewood use showed a statistically significant association with COPD, while charcoal, crop residue, and cow dung cake use did not reach significance. This may reflect differences in the combustion characteristics and particulate emission profiles of different biomass sources, with firewood combustion generating higher concentrations of respirable particulate matter, in keeping with measured household PM_{2.5} concentrations from solid cookfuel use reported in Indian populations.⁶ Several exposure characteristics — prolonged duration of exposure (≥ 25 years), indoor-only cooking, delayed onset of exposure, and poor kitchen ventilation — were each independently associated with COPD, and the composite Biomass

Exposure Index (combining hours of daily cooking and years of exposure) was significantly higher among COPD patients. This supports the concept that cumulative, rather than single-point, exposure to biomass smoke drives disease risk, consistent with a dose–response relationship described in prior literature.^[4,5]

No significant association was found between BMI category and COPD status, although a modestly higher proportion of underweight participants among COPD cases and a lower proportion of overweight participants is consistent with the previously described 'obesity paradox' in COPD, wherein higher BMI may confer a degree of protective metabolic reserve despite not being a primary determinant of disease risk in this population.^[3]

Respiratory symptoms, particularly dyspnoea, cough, sputum production, and wheeze, were markedly more frequent among COPD patients, and higher MMRC dyspnoea grades predominated in this group, in keeping with global literature linking MMRC grade to disease severity and reduced quality of life. Vital parameters, however, did not differ significantly between groups, underscoring that normal vital signs do not exclude COPD and that reliance on routine clinical examination alone is insufficient for detection — reaffirming the central diagnostic role of spirometry and standardised interpretation of lung function tests.^[1,14]

The most striking finding of this study relates to underdiagnosis: nearly three-quarters of COPD cases identified were newly diagnosed during the study itself. Similar underdiagnosis of COPD among women, along with its quantification and associated determinants, has previously been described by Ancochea and colleagues, who likewise highlighted a substantial gap between disease burden and clinical recognition.^[8] In the present study, this underdiagnosis was strongly linked to lack of awareness of biomass-related respiratory risk, absence of social support, poverty, and low educational attainment — determinants consistent with the well-described role of social disadvantage in shaping health outcomes,^[13] and with recognised novel risk factors and structural barriers contributing to the global burden of COPD.^[11] Importantly, healthcare contact alone did not guarantee diagnosis — a substantial proportion of COPD patients had previously visited a physician without being informed of their condition, and over half had never been advised to undergo spirometry, highlighting critical gaps in both diagnostic practice and physician–patient communication rather than merely patient-level barriers to care.

Limitations: This study has certain limitations. It was conducted at a single tertiary care hospital and its affiliated rural health centre, which may limit the generalisability of findings to other populations. Although detailed information regarding duration and intensity of biomass fuel exposure was collected, the cross-sectional design precludes definitive establishment of the temporal sequence and causal

relationship between biomass exposure and the development of COPD. Biomass exposure history was self-reported, introducing the possibility of recall bias. Potential confounders such as passive smoking, occupational dust exposure, and outdoor air pollution were not fully accounted for. Limited prior access to spirometry may have contributed to underestimation of previously diagnosed cases, and treatment adherence and healthcare-seeking behaviour, being self-reported, may be subject to reporting bias. Finally, the sample size, while adequate for the calculated prevalence estimate, was modest, and the study was restricted to women, limiting comparisons across sexes.

CONCLUSION

COPD represents a significant and largely underrecognised health burden among women exposed to biomass fuel, with a prevalence of 24.8% in this study population. Prolonged duration of exposure, early age at initiation, indoor cooking, poor kitchen ventilation, and firewood use in particular were significantly associated with disease occurrence, alongside sociodemographic disadvantage — including lower education, poorer socioeconomic status, and homemaker occupation. Nearly three-quarters of COPD cases were newly diagnosed during the study, driven by limited awareness, poor social support, and critical gaps in spirometry access and physician–patient communication rather than by lack of healthcare contact per se. These findings underscore the urgent need for targeted community awareness programmes, wider availability of spirometry at the primary care level, and structured screening of biomass-exposed women to enable earlier diagnosis, timely intervention, and improved respiratory health outcomes in this vulnerable population.

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