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Original Research Paper

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COMPARISON OF CLINICAL AND PULMONARY FUNCTION TEST CHARACTERISTICS BETWEEN BIOMASS FUEL SMOKE AND TOBACCO SMOKE EXPOSED COPD PATIENTS

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ABSTRACT **Background:** Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of morbidity and mortality worldwide. While tobacco smoking is the primary risk factor, biomass fuel smoke exposure is an important contributor to COPD in developing countries such as India. This study aimed to compare the clinical characteristics and pulmonary function test parameters between biomass fuel smoke-exposed and tobacco smoke-exposed COPD patients. **Methods:** This cross-sectional observational study was conducted at a tertiary care hospital over 18 months. A total of 105 COPD patients aged ≥40 years with confirmed spirometric diagnosis were included. Participants were divided into biomass exposure (n=51) and tobacco exposure (n=54) groups. Clinical evaluation included symptom assessment, mMRC dyspnea grading, and COPD Assessment Test (CAT) scoring. Spirometry was performed according to ATS/ERS guidelines. **Results:** The mean age was 61.01 ± 8.86 years. Biomass exposure was predominant in females (84.3%), while tobacco exposure was common in males (96.3%) ($p < 0.001$). Dyspnea severity and GOLD spirometric grading showed no significant difference between groups ($p > 0.05$). However, CAT scores were significantly higher in biomass-exposed patients ($p = 0.047$). Spirometric parameters (FEV1, FVC, FEV1/FVC) were comparable between groups. **Conclusion:** Biomass-related COPD produces airflow limitation similar to tobacco-related COPD but with greater symptom burden. Early recognition and preventive strategies for biomass exposure are essential.

KEYWORDS : COPD, Biomass Fuel, Tobacco Smoke, Spirometry, CAT Score, mMRC

1. INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a heterogeneous lung disorder characterized by persistent respiratory symptoms and progressive airflow limitation. It is currently the third leading cause of death worldwide, accounting for nearly 3 million deaths annually [1]. While tobacco smoking is the most widely recognized risk factor, exposure to biomass fuel smoke has emerged as a major contributor to COPD in developing countries, particularly India [2].

Biomass fuels include firewood, animal dung cakes, crop residues, and coal, which are used by nearly 65-70% of rural households in India for cooking and heating [3]. The combustion of these fuels releases fine particulate matter (PM2.5), carbon monoxide, nitrogen oxides, and other toxic compounds, leading to chronic airway inflammation and oxidative stress. Women in rural households are disproportionately affected due to their primary responsibility for cooking in poorly ventilated kitchens [4].

Studies have suggested that biomass-related COPD may represent a distinct phenotype from tobacco-related COPD, with differences in clinical presentation, inflammatory profile, and disease progression [5]. However, comparative data from India remain limited. This study was undertaken to compare the clinical characteristics and pulmonary function test parameters between biomass fuel smoke-exposed and tobacco smoke-exposed COPD patients.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This was a cross-sectional observational study conducted at the Department of Respiratory Medicine, G S Medical College and Hospital, Pilkhuwa, Hapur, Uttar Pradesh, India. The study was carried out over 18 months following approval from the Institutional Research and Ethics Committee.

2.2 Study Population

Adult patients aged ≥40 years with a confirmed diagnosis of COPD according to GOLD guidelines were included. All participants had a documented history of either biomass fuel smoke exposure or tobacco smoke exposure.

Inclusion Criteria: Age ≥40 years, confirmed diagnosis of COPD (post-bronchodilator FEV1/FVC < 0.70), history of either biomass fuel smoke exposure (≥15 years) or tobacco smoke exposure (≥10 pack-years).
Exclusion Criteria: Patients with other chronic respiratory diseases (asthma, bronchiectasis, interstitial lung disease), active pulmonary tuberculosis, history of both biomass and tobacco exposure (dual exposure), and those unable to perform spirometry.

2.3 Sample Size Calculation

Sample size was calculated based on the comparison of mean FEV1 between exposure groups. Assuming a mean FEV1 of 58% in biomass-exposed and 62% in tobacco-exposed patients, with a common standard deviation of 14.6%, 80% power, and $\alpha = 0.05$, the estimated sample size was 105 patients.

2.4 Clinical Assessment

All patients underwent detailed clinical evaluation including:

- Demographic data: Age, gender, residence, socio-economic status, occupation
- Exposure history: Duration of biomass exposure (years), pack-year history for tobacco smokers
- Symptom assessment: Dyspnea severity using mMRC scale (0-4), cough, sputum production
- COPD Assessment Test (CAT): Eight-item questionnaire (score 0-40) to quantify symptom burden

2.5 Spirometry

Spirometry was performed according to American Thoracic Society (ATS) and European Respiratory Society (ERS) guidelines using a calibrated spirometer. Parameters recorded included FEV1 (liters and % predicted), FVC (liters and % predicted), and FEV1/FVC ratio, both before and 15 minutes after administration of inhaled bronchodilator. COPD severity was classified according to GOLD spirometric grading (GOLD 1-4).

2.6 Statistical Analysis

Data were analyzed using IBM SPSS software. Categorical variables were compared using Chi-square test. Continuous variables were expressed as mean ± standard deviation and compared using independent samples t-test. A p-value < 0.05 was considered statistically significant.

2.7 Ethical Approval

The study was approved by the Institutional Ethics Committee of G S Medical College and Hospital. Written informed consent was obtained from all participants. The study followed the principles of the Declaration of Helsinki.

3. RESULTS

3.1 Demographic Characteristics

A total of 105 patients were enrolled. The mean age was 61.01 ± 8.86 years, with the majority (36.2%) in the 61-70 year age group. Males comprised 57.1% and females 42.9% of the study population. Urban residents constituted 67.6% of participants, and 62.9% belonged to the lower socioeconomic class. Housewives were the largest occupational group (41.0%).

Table 1. Baseline Demographic Characteristics (N = 105)

Mean age (years)	61.01 ± 8.86
Male gender	60 (57.1%)
Female gender	45 (42.9%)
Urban residence	71 (67.6%)
Rural residence	34 (32.4%)
Lower socioeconomic status	66 (62.9%)
Occupation - Housewife	43 (41.0%)

3.2 Exposure Characteristics

Biomass fuel smoke exposure was present in 51 patients (48.6%) and tobacco smoke exposure in 54 patients (51.4%). The mean duration of exposure was 27.57 ± 7.29 years overall. In the tobacco group, mean pack-year exposure was 41.61 ± 11.47 pack-years. In the biomass group, mean exposure duration was 27.25 ± 8.05 years.

Table 2. Exposure Characteristics

Biomass exposure	51 (48.6%)
Tobacco exposure	54 (51.4%)
Mean exposure duration (years)	27.57 ± 7.29
Mean pack-years (tobacco group)	41.61 ± 11.47
Mean biomass exposure duration (years)	27.25 ± 8.05

3.3 Association Between Sex and Exposure Type

A highly significant association was observed between sex and exposure type ($p < 0.001$). Females were predominantly exposed to biomass smoke (84.3%), while males were predominantly exposed to tobacco smoke (96.3%). The odds of biomass exposure among females were approximately 140 times that of males (OR 139.75, 95% CI: 28.18-693.08).

Table 3. Gender × Exposure Type Crosstabulation

Gender	Biomass (n=51)	Tobacco (n=54)	Total
Female	43 (84.3%)	2 (3.7%)	45
Male	8 (15.7%)	52 (96.3%)	60

Pearson Chi-square = 69.593, df = 1, $p < 0.001$

3.4 Symptom Profile and Dyspnea Severity

Dyspnea, chronic cough, and sputum production were present in all 105 patients (100%). The majority of patients (83.8%) were classified as mMRC Grade 2 or 3. No statistically significant difference was observed in mMRC grade distribution between biomass and tobacco exposure groups ($p = 0.418$).

Table 4. mMRC Grade Distribution by Exposure Type

mMRC Grade	Biomass (n=51)	Tobacco (n=54)	Total
Grade 1	0 (0.0%)	2 (3.7%)	2
Grade 2	16 (31.4%)	21 (38.9%)	37
Grade 3	27 (52.9%)	24 (44.4%)	51
Grade 4	8 (15.7%)	7 (13.0%)	15

Pearson Chi-square = 2.835, df = 3, $p = 0.418$

3.5 COPD Assessment Test (CAT) Score

The majority of patients (52.4%) were in the medium-impact category (CAT 11-20), while 44.8% were in the high-impact category (CAT 21-30). A statistically significant association was observed between CAT category and exposure type ($p = 0.047$). Biomass-exposed patients were more likely to be classified in the high-impact category (54.9%) compared to tobacco-exposed patients (35.2%).

Table 5. CAT Score Category by Exposure Type

CAT Category	Biomass (n=51)	Tobacco (n=54)	Total
Low impact (0-10)	0 (0.0%)	3 (5.6%)	3
Medium impact (11-20)	23 (45.1%)	32 (59.3%)	55
High impact (21-30)	28 (54.9%)	19 (35.2%)	47

Pearson Chi-square = 6.115, df = 2, $p = 0.047$

3.6 Spirometric Parameters and GOLD Staging

The mean post-bronchodilator FEV1/FVC ratio was 0.579 ± 0.074. Mean FEV1 (% predicted) was 51.86 ± 10.55%, and mean FVC (% predicted) was 70.05 ± 8.94%. Most patients were classified as GOLD Stage II (54.3%) or Stage III (45.7%). No patients were in GOLD Stage I or IV.

No statistically significant differences were observed between biomass and tobacco exposure groups in any spirometric parameter or GOLD stage distribution.

Table 6. Comparison of Spirometric Parameters Between Exposure Groups

Parameter	Biomass (n=51) Mean ± SD	Tobacco (n=54) Mean ± SD	p-value
FEV1/FVC ratio	0.568 ± 0.076	0.590 ± 0.070	0.122
FEV1 (% predicted)	51.72 ± 9.50	51.99 ± 11.54	0.900
FVC (% predicted)	69.43 ± 9.35	70.64 ± 8.59	0.488

Table 7. GOLD Stage Distribution by Exposure Type

GOLD Stage	Biomass (n=51)	Tobacco (n=54)	Total
GOLD 2 (Moderate)	28 (54.9%)	29 (53.7%)	57
GOLD 3 (Severe)	23 (45.1%)	25 (46.3%)	48

Pearson Chi-square = 0.015, df = 1, $p = 0.902$

3.7 Summary of Key Findings

1. Gender-exposure association: Females were predominantly exposed to biomass smoke (84.3%), males to tobacco smoke (96.3%) ($p < 0.001$).

2. Symptom burden: Biomass-exposed patients had significantly higher CAT scores (more symptoms) compared to tobacco-exposed patients ($p = 0.047$).
3. Dyspnea severity (mMRC): No significant difference between groups ($p = 0.418$).
4. Spirometric severity: No significant differences in FEV1, FVC, or FEV1/FVC ratio between groups ($p > 0.05$ for all).
5. GOLD stage distribution: Comparable between biomass and tobacco groups ($p = 0.902$).

4. DISCUSSION

4.1 Summary of Key Findings

In this cross-sectional study of 105 COPD patients, we found that biomass fuel smoke exposure and tobacco smoke exposure produce comparable degrees of airflow limitation as measured by spirometry and GOLD staging. However, biomass-exposed patients reported significantly higher symptom burden as measured by the CAT score ($p = 0.047$), despite similar dyspnea severity on the mMRC scale. A striking gender-exposure association was observed, with females almost exclusively exposed to biomass smoke and males to tobacco smoke.

4.2 Comparison with Existing Literature

The demographic profile of our study population—mean age in the early sixties, predominance of lower socioeconomic status—aligns with previous studies on biomass-related COPD [6,7]. The finding that biomass exposure is almost exclusive to females and tobacco exposure to males is consistent with the landmark studies by Camp et al. (2014) and Ramirez-Venegas et al. (2012), who reported similar patterns in Mexican women [8,9]. The odds ratio of 139.75 for biomass exposure in females highlights the profound gender disparity in exposure patterns in India.

The comparable spirometric parameters between biomass and tobacco groups in our study corroborate the findings of multiple previous investigations. Camp et al. (2014) reported no significant differences in FEV1 or FVC between biomass-exposed and tobacco-exposed women with COPD [8]. Similarly, Balcan et al. (2019) found comparable FEV1 values in biomass-related and tobacco-related COPD after adjusting for age and gender [10]. These findings challenge the earlier assumption that biomass-related COPD is a milder form of the disease.

The significantly higher CAT scores in biomass-exposed patients despite similar spirometry is a novel and important finding. This suggests that biomass-related COPD may cause greater symptom burden for the same degree of airflow obstruction. Possible explanations include:

- Greater small airway involvement with minimal emphysema, leading to disproportionate dyspnea
- Higher prevalence of chronic bronchitis phenotype in biomass exposure
- Associated comorbidities such as anemia and malnutrition in biomass-exposed women [11]
- Delayed healthcare seeking leading to more advanced symptomatic disease at presentation

Golpe et al. (2015) and Golpe et al. (2022) have reported similar patterns, noting that biomass-related COPD patients often have higher symptom scores despite comparable spirometry [12,13].

The absence of a significant difference in mMRC grades between groups, despite higher CAT scores in biomass patients, is noteworthy. This may reflect that the mMRC scale primarily captures dyspnea, while the CAT encompasses a broader range of symptoms including fatigue, sleep disturbance, and activity limitation. Biomass-exposed women may experience greater systemic symptom burden beyond breathlessness alone.

4.3 Biological Mechanisms

The comparable spirometric severity but higher symptom burden in biomass-related COPD may be explained by distinct pathophysiological mechanisms. Biomass smoke contains high concentrations of particulate matter that penetrate deep into small airways, inducing chronic inflammation, fibrosis, and airway remodeling with relatively preserved alveolar structures [14]. This "airway-predominant" phenotype produces significant airflow obstruction but may cause disproportionate dyspnea due to small airway dysfunction.

In contrast, tobacco-related COPD is more often "emphysema-predominant," with alveolar destruction and reduced diffusion capacity. While emphysema also causes dyspnea, patients may adapt gradually, and the symptom burden may be perceived differently.

The higher CAT scores in biomass patients may also reflect the cumulative effect of comorbidities. Biomass-exposed women in rural India often have anemia, malnutrition, and musculoskeletal deconditioning, all of which contribute to fatigue and reduced activity levels captured by the CAT [15].

4.4 Clinical Implications

Our findings have several important clinical implications:

1. Biomass COPD is not mild: Despite similar spirometry, biomass-exposed patients have higher symptom burden and require equally aggressive management.
2. Use CAT for assessment: The CAT score is more sensitive than mMRC in capturing the full symptom burden of biomass-related COPD.
3. Gender-specific prevention: Public health interventions must target women in rural households with clean cooking fuel programs and improved ventilation.
4. Integrated management: Biomass COPD patients may benefit from nutritional support, anemia correction, and pulmonary rehabilitation alongside bronchodilator therapy.

4.5 Strengths and Limitations

Strengths: Adequate sample size, standardized diagnostic criteria, use of validated assessment tools (mMRC, CAT, spirometry), and direct comparison between exposure groups with comparable exposure durations.

Limitations: Cross-sectional design (cannot assess causality or disease progression), single-center study (limits generalizability), lack of imaging (CT) to quantify emphysema vs. airway disease, and absence of detailed comorbidity assessment.

5. CONCLUSION

This study demonstrates that biomass fuel smoke exposure and tobacco smoke exposure produce comparable degrees of airflow limitation in COPD patients, as measured by spirometry and GOLD staging. However, biomass-exposed patients experience a significantly higher symptom burden as measured by the COPD Assessment Test (CAT) score ($p = 0.047$), despite similar dyspnea severity on the mMRC scale. A striking gender disparity exists: females are almost exclusively exposed to biomass smoke (84.3%) and males to tobacco smoke (96.3%) ($p < 0.001$). Biomass-related COPD is not a milder form of the disease and warrants equal clinical attention, systematic evaluation, and aggressive management comparable to tobacco-related COPD. Public health interventions aimed at reducing biomass smoke exposure—through promotion of clean cooking fuels, improved kitchen ventilation, and community awareness programs—are urgently needed, particularly in socio-economically disadvantaged rural populations where women bear the greatest burden of exposure.

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