



## OBSERVATIONAL STUDY OF LUNG FUNCTIONS BY COMPUTERIZED SPIROMETRY IN BIOMASS EXPOSED & NON-BIOMASS GAS EXPOSED WOMEN IN FIROZABAD REGION

### Respiratory Medicine

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### ABSTRACT

**Background:** Biomass fuel combustion is a leading indoor air pollutant, significantly impacting women's respiratory health in rural India. Chronic exposure to pollutants like particulate matter and carbon monoxide contributes to airway inflammation and reduced lung function, often mimicking the effects of smoking. **Objectives:** To compare lung function using computerized spirometry between biomass-exposed and clean fuel-using women in Firozabad and assess associated respiratory symptoms. **Methods:** A hospital-based, cross-sectional observational study was conducted on 100 adult women attending the Respiratory Medicine Department at FH Medical College, Agra. Fifty women with prolonged biomass exposure (Group A) and 50 age-matched controls using clean fuels (Group B) were enrolled over 18 months. Participants underwent a structured clinical history, environmental exposure assessment, and computerized spirometry using EasyOne Pro per ATS/ERS 2022 guidelines. Spirometric indices—FVC, FEV<sub>1</sub>, FEV<sub>1</sub>/FVC, and PEFr—were compared using unpaired t-tests. Socioeconomic and environmental variables were recorded, and exposure indices were calculated. **Results:** Group A had significantly lower mean values of FVC (2.63±0.58 L vs 2.07±0.39 L), FEV<sub>1</sub> (2.47±0.40 L vs 1.92±0.34 L), and PEFr (4.43±0.61 vs 3.97±0.98 L; p<0.01). Respiratory symptoms including chronic cough, phlegm, wheeze, and breathlessness were more prevalent among biomass users (p<0.05). Exposure index and cooking hours were significantly higher in Group A. **Conclusion:** Biomass exposure is associated with significant pulmonary function decline and elevated respiratory symptoms. Urgent public health strategies are needed to reduce exposure and prevent long-term morbidity.

### KEYWORDS

Biomass fuel; Spirometry; Indoor air pollution; COPD; Rural women

### INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) remains one of the top three causes of death.<sup>1</sup> Globally, affecting over 212 million people and responsible for 3.65 million deaths in 2021 alone.<sup>2</sup> While smoking has historically been the dominant risk factor, exposure to household air pollution from biomass fuels has emerged as a major contributor, particularly among women in developing countries.<sup>2,3</sup> Biomass fuels—such as wood, animal dung, and crop residues—are still used by nearly 2.4 billion people worldwide, primarily for cooking.<sup>4</sup> In India, more than 60% of rural households rely on biomass fuels, with women being disproportionately affected due to prolonged cooking hours and inadequate ventilation.<sup>5</sup> Recent estimates suggest that nearly 16.3% of Indian women over the age of 40 suffer from COPD, with biomass smoke accounting for a significant proportion of this burden.<sup>6,7</sup> In fact, the prevalence of non-smoking COPD (NS-COPD) is alarmingly high among Indian women, with biomass smoke increasing the risk by 2.4 to 3 times compared to LPG users.<sup>8,9</sup> Particulate matter (PM<sub>2.5</sub>), carbon monoxide, and other noxious gases released during biomass combustion induce oxidative stress, chronic airway inflammation, and epithelial damage.<sup>10</sup> This leads to spirometric abnormalities, including obstructive, restrictive, and mixed ventilatory patterns.<sup>11</sup> Studies have shown that cumulative biomass exposure is equivalent to a 10–15 pack-year smoking history in terms of lung damage.<sup>12</sup> Spirometry, particularly computerized spirometry, is a non-invasive and accurate method for assessing pulmonary function by measuring key indicators such as Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV<sub>1</sub>), and the FEV<sub>1</sub>/FVC ratio.<sup>13</sup> These parameters are integral to diagnosing and classifying COPD severity, as per the GOLD 2024 guidelines.<sup>14</sup>

Despite increasing awareness, region-specific studies using computerized spirometry to compare lung function in biomass- vs. non-exposed women remain limited.<sup>15</sup> The Firozabad region, with high biomass use and poor ventilation, provides a suitable setting. This study aimed to quantify and compare spirometric parameters between biomass and clean fuel users, highlighting the hidden respiratory burden among rural women.

### MATERIALS AND METHODS

“This hospital-based cross-sectional observational study was carried out in the Department of Respiratory Medicine at FH Medical College, Agra, over a duration of 18 months, following approval from the Institutional Ethical Committee. Written informed consent was

obtained from all participants before inclusion in the study.”

“A total of 100 women were enrolled after meeting the eligibility criteria. The sample size was determined using the formula

$$N = Z^2 \times p(1-p) / d^2$$

where  $Z = 1.96$  for 95% confidence,  $p = 0.07$  (estimated prevalence), and  $d = 0.05$  (margin of error). The calculated sample size was 86, which was rounded to 100 to improve statistical power and reliability”.

#### Inclusion Criteria:

- “Women presenting with chronic breathlessness, with or without cough”
- “History of exposure to biomass or clean cooking fuels”
- “Willingness to participate and ability to perform spirometry”

#### Exclusion Criteria:

- “Inability to perform spirometry or contraindications such as heart failure, advanced systemic illness, recent surgeries, active hemoptysis, tuberculosis, or pregnancy”
- “Refusal to provide informed consent”

“Participants were categorized into two groups: Group A (biomass fuel users) and Group B (non-biomass or clean fuel users). Each subject underwent thorough clinical assessment, chest X-ray, complete blood count (CBC), and pulmonary function testing (PFT).

Spirometry was conducted using the EasyOne Pro portable spirometer, calibrated daily, and following ATS/ERS 2022 guidelines. Participants were instructed to perform tidal breathing followed by a full inhalation and forced exhalation while standing and wearing a nose clip. The main parameters recorded were Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV<sub>1</sub>), and the FEV<sub>1</sub>/FVC ratio. Based on spirometric values, patterns were classified as normal, obstructive, restrictive (possible), or mixed.

Data were analyzed using SPSS version 23.0. Descriptive statistics such as mean, standard deviation, and frequency distributions were used. Group comparisons were performed using ANOVA, and

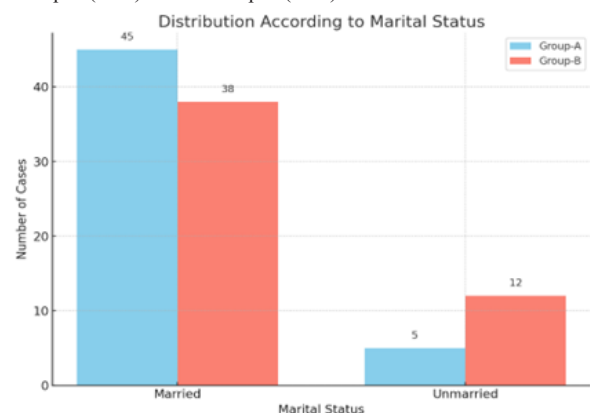
correlations were assessed using Pearson's coefficient. A p-value of less than 0.05 was considered statistically significant."

**RESULTS**

**"Table 1: Comparison Of The Demographic Characteristics In The Study Groups"**

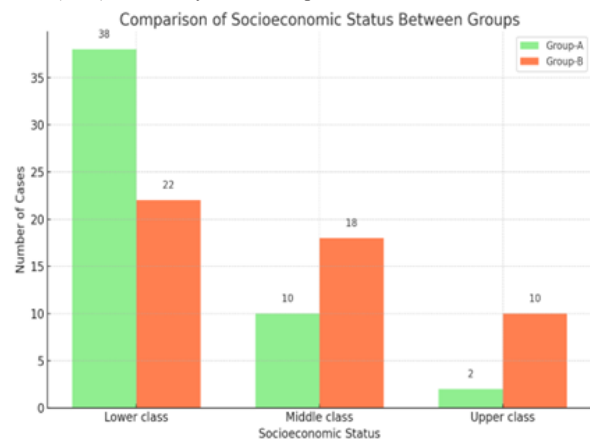
Parameters	Group-A	Group-B	P-value
Age (Years)	41.62 ± 12.58	39.47 ± 10.74	0.36
Height (cm)	153.47 ± 7.37	150.67 ± 9.76	0.11
Weight (Kg)	48.69 ± 10.27	46.44 ± 11.41	0.30
BMI (Kg/m <sup>2</sup> )	19.88 ± 4.20	22.39 ± 7.52	0.04

The majority of women in both groups were married, with Group-A having a higher percentage (90%) compared to Group-B (76%). A relatively greater proportion of unmarried women was observed in Group-B (24%) than in Group-A (10%).



**"Figure 1: Distribution According To Marital Status"**

A significantly higher proportion of women in Group-A belonged to the lower socioeconomic class (76%) compared to Group-B (44%) (p = 0.008). In contrast, Group-B had a greater representation in the upper class (20%) versus only 4% in Group-A.



**"Figure 2: Comparison of Socioeconomic Status Between Groups"**

**"Table 2: Comparison According to Type of House Between Group-A and Group-B"**

Variable	Category	Group-A		Group-B		P-value
		No of cases	Percent age	No of cases	Percent age	
Type of House	Kachha	20	40.00%	2	4.00%	<0.0001
	Pakka	16	32.00%	45	90.00%	
	Mixed	14	28.00%	3	6.00%	
Food Habits	Veg	32	64.00%	15	30.00%	0.007
	Non-veg	18	36.00%	35	70.00%	
Kitchen Type	Inside house	46	92.00%	38	76.00%	0.029
	Separate	4	8.00%	12	24.00%	
Ventilation Facility	Available	42	84.00%	49	98.00%	0.01
	Not available	8	16.00%	1	2.00%	

**"Table 3: Lung Function Parameters"**

Parameters	Group-A	Group-B	P-value
FVC	2.63 ± 0.58	2.07 ± 0.39	<0.0001
FEV <sub>1</sub>	2.47 ± 0.40	1.92 ± 0.34	<0.0001
PEFR (L)	4.43 ± 0.61	3.97 ± 0.98	0.005
FEV <sub>1</sub> /FVC	0.97 ± 0.07	0.93 ± 0.09	0.014

**"Table 4: Prevalence of Different Respiratory Symptoms According to Fuel Type"**

Respiratory Symptoms / Disease	Presence	Group-A		Group-B		P-value
		No of cases	Percent age	No of cases	Percent age	
Cough during winter season	Yes	36	72.00%	20	40.00%	0.0013
	No	14	28.00%	30	60.00%	
Cough during last 3 months	Yes	6	12.00%	1	2.00%	0.05
	No	44	88.00%	49	98.00%	
Phlegm during winter season	Yes	35	70.00%	13	26.00%	<0.0001
	No	15	30.00%	37	74.00%	
Phlegm during last 3 months	Yes	7	14.00%	1	2.00%	0.027
	No	43	86.00%	49	98.00%	
Wheeze during last 12 months	Yes	10	20.00%	3	6.00%	0.037
	No	40	80.00%	47	94.00%	
Shortness of breath during last 12 months	Yes	8	16.00%	2	4.00%	0.045
	No	42	84.00%	48	96.00%	
Awake at night from breathlessness during last 12 months	Yes	4	8.00%	2	4.00%	0.40
	No	46	92.00%	48	96.00%	
Any history of bronchitis	No	50	100.00%	50	100.00%	-
Any history of pneumonia	No	50	100.00%	50	100.00%	-
Any history of pulmonary tuberculosis	No	50	100.00%	50	100.00%	-
Any history of asthma	Yes	1	2.00%	7	10.00%	0.027
	No	49	98.00%	43	86.00%	
Any history of hay fever	No	50	100.00%	50	100.00%	-

**"Table 5: Exposure Index Between Group-A and Group-B"**

Parameters	Group-A (Mean ± SD)	Group-B (Mean ± SD)	P-value
BF %	30.81 ± 7.14	29.12 ± 14.18	0.45
Exposure hours/day	3.28 ± 0.67	2.43 ± 0.50	<0.0001
Exposure years	25.39 ± 11.28	16.77 ± 9.32	0.0001
Exposure index (hr-yrs)	48.69 ± 24.30	19.37 ± 10.17	<0.0001

**DISCUSSION**

Prolonged exposure to biomass fuel smoke, especially among Indian women who spend significant time indoors, poses serious health risks including chronic respiratory diseases and undernutrition. A study in Tamil Nadu reported 90% household reliance on biomass fuel,<sup>16</sup> with the Global Burden of Disease 2017 attributing 19,625 deaths and 709 DALYs per 100,000 people in the state to household air pollution (HAP).<sup>17</sup> In this study, the mean age was slightly higher in biomass users (Group A) than non-users (Group B), with significantly lower BMI in Group A. These results align with findings by Kizhakke Puliyakote AS et al.,<sup>18</sup> who reported lower BMI among biomass users, and Kurmi OP et al.,<sup>19</sup> who observed underweight prevalence and anthropometric differences favoring non-users. However, Berlin J and Raj T<sup>20</sup> found no significant difference in BMI across groups.

Marital status differences were non-significant, consistent with Deng et al.<sup>21</sup>, who also noted no marital status impact on fuel usage. Socioeconomic status was notably lower in biomass users, with 76% in the lower class. Jaiswal VB et al.<sup>22</sup> similarly noted biomass use among low-income and poorly ventilated households, linking financial limitations and resistance to change as reasons for continued usage despite income improvements.

Dietary habits differed, with more vegetarians in Group A (64%). This aligns with Bihari V et al.<sup>23</sup>, who found vegetarianism more common in

biomass users, likely due to socioeconomic and cultural factors. Housing type also varied; 40% of biomass users lived in kachha houses versus only 4% in Group B. Prial RH et al.<sup>15</sup> and Jaiswal VB et al.<sup>22</sup> also observed similar housing trends among biomass users, emphasizing inadequate ventilation and structural deficiencies as contributing to HAP. The study confirmed that biomass users had poorer ventilation and cooked indoors more frequently, consistent with Prial RH et al.<sup>15</sup> and Bihari V et al.<sup>23</sup>.

Pulmonary function tests revealed significantly lower FVC, FEV<sub>1</sub>, and PEFR in Group A. Stapleton EM et al.<sup>24</sup> reported similar restrictive and obstructive patterns in biomass users, while Berlin J and Raj T<sup>20</sup>, and Regalado et al.<sup>25</sup> also documented reduced lung functions associated with biomass exposure.

Respiratory symptoms such as seasonal cough, wheezing, and phlegm were more prevalent in Group A. Prial RH et al.<sup>15</sup> also reported increased symptoms among biomass users. Asthma was more frequent in non-biomass users, a finding consistent with both Prial RH et al.<sup>15</sup> and the current study. Broader support comes from the study by Mazumder et al.<sup>26</sup>, all of whom noted increased respiratory morbidity linked to biomass fuel. Lastly, Group A had significantly higher exposure indices due to longer daily and cumulative exposure. Though body fat % was similar, exposure duration was substantially higher in biomass users. These results are supported by Bihari V et al.<sup>23</sup>, who also noted longer fuel use duration and cumulative exposure in biomass groups, aligning with IARC (2010)<sup>27</sup> findings that biomass fuels require longer burning times than LPG due to lower energy content.

## CONCLUSION

Chronic exposure to biomass fuel significantly compromises lung function and elevates the prevalence of respiratory symptoms among women, especially those from socioeconomically disadvantaged backgrounds. The study highlights a critical public health concern in rural settings, emphasizing the need for urgent implementation of clean cooking alternatives, awareness programs, and policy-driven initiatives to reduce indoor air pollution and protect respiratory health in vulnerable populations.

**Conflict Of Interest:** None.

**Funding:** None.

**Ethical Approval:** Obtained.

**Consent:** Written consent secured.

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