Original Article

The adverse effects of solid biomass fuel exposure on lung functions in non-smoking female population

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Abstract

Background: Though, smoking is the leading cause of chronic obstructive pulmonary disease worldwide, the household air pollution due to use of solid biomass fuel is considered as a major risk factor for the development of obstructive lung disease. The aim of the study was to assess the effect of solid biomass fuel exposure on lung functions in non-smoking female population. **Methods:** A hospital based, descriptive cross sectional study was carried out among 140 non-smoking female patients aged 40 or more and who had been exposed to solid biomass fuel. These patients underwent spirometry to assess their lung function and were classified as obstructive, restrictive or mixed. Modified medical research council (mMRC) dyspnoea scale for symptom assessment, 6-minute walk test (6 MWT) to determine the exercise capacity and Cumulative exposure index to assess the duration of exposure were also done. **Results:** All 140 (100%) patients having abnormal lung function, 4 (2.86%) had restrictive pattern, 5 (3.57%) had mixed pattern and 131 (93.57%) had obstructive pattern. Of 131 patients having obstructive pattern, 11 had mild obstruction, 49 had moderate obstruction, 39 had severe obstruction and 32 had very severe obstruction. Most commonly used biomass fuel was wood (43.57%). All the patients had shortness of breath, whereas cough was present in only 35.71% cases. 77 (55%) patients presented with a dyspnoea of mMRC grade 3 and above. **Conclusion:** Cumulative exposure index for solid biomass fuel is directly proportional to the severity of lung impairment as well as the symptom severity.

Keywords: COPD, cumulative exposure index, lung function, non-smoking females, solid biomass fuel

Introduction

Solid biomass fuel refers to the use of materials such as wood, agricultural residues or dung cakes, which have low combustion efficiency, for cooking or heating purposes. This is a cheap and easily available source of energy and is widely used in rural India where majority of the households utilize them as the primary cooking fuel.[1] Incomplete combustion leads to discharge of smoke formed by fine particulate matter. Household air pollution (HAP) from the use of solid biomass fuel is considered as the fourth leading risk factor for burden of the diseases globally and the third leading risk factor in India.[1] Household air pollution emanating from traditional fuels and cooking stoves is considered to be a major risk factor for lung cancer and other non-communicable respiratory diseases such as chronic obstructive pulmonary disease (COPD), asthma, acute respiratory infections (ARI) and chronic bronchitis as well as for cardiovascular disease.[2]

Very few studies had conducted an objective assessment of chronic biomass exposure on women in India. This is partly because of limited access and awareness among researchers and partly due to the fact that this evidence has not been packaged into the language of policy makers.[1] India has recently identified

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HAP as one of the key indicators in its National Monitoring Framework for Prevention and Control of Non-Communicable Diseases (NCD). This provides an excellent opportunity to advocate the reduction of adverse effects due to household biomass fuel use.[1] So this study was performed to evaluate the effect of biomass fuel combustion on pulmonary function in solid biomass fuel exposed non-smoker females. Cumulative exposure index (CEI) which can be used as an important tool to understand duration of exposure, and its relationship with the severity of disease was also calculated.

Methods

Descriptive cross sectional study was conducted at a tertiary care centre in North India, from January 2019 to June 2020. 140 non-smoking women aged 40 or more years, who had a history of exposure to solid biomass fuel (in the form of wood, crop residue, dung cakes) and who presented with complains of breathlessness and/or cough (with or without expectoration) were enrolled in the study.

Patients who had active or healed tuberculosis, SpO2 < 90%, diabetes, hypertension and a history of cardiac or psychiatric illness were excluded from the study.

Study participants were evaluated with a detailed clinical history and complete clinical examination. A chest X-ray and Sputum for AFB examination were carried out in all recruited participants to rule out active or healed tuberculosis. Spirometry was conducted to record changes in FEV1, FVC and FEV1/FVC. mMRC dyspnoea scale to assess the symptom severity and six minute walk test to assess the exercising capacity were also done in all the study participants.

Cases with FEV_1/FVC ratio < 0.7 on spirometry were labelled as those with obstructive pattern, and were further categorized as mild (FEV_1 > 80%), moderate ($FEV_{1:}$ 50-79%), severe ($FEV_{1:}$ 30-49%) and very severe (FEV_1 < 30%); while those with FVC values < 80% with normal FEV_1 and FEV_1/FVC ratio were considered to have restrictive pattern. Patients with FVC < 80% along with FEV_1/FVC ratio <70% were considered to have Mixed pattern.

Cumulative Exposure Index was calculated by multiplying the duration of biomass exposure (in years) with frequency of exposure (hours per day, and weeks per month) and dividing the product by 3. CEI was categorised as Mild (CEI of 40 to 80), Moderate (CEI of 80 to 120), Severe (CEI of more than 120).

Sample size was calculated considering the study by Panigrahi *et al.*[3] the prevalence of airflow obstruction was observed to be 22.4% amongst the non-smoking women who were exposed to solid biomass fuel. Assuming value of α to be 0.05 and allowable error in the estimate of 8%, Sample size was calculated using formula 4 pq/d,[3] where 'p' (22.4%) is prevalence, 'q' (1-0.224) is 100-prevalence and 'd' (8%) is permissible error. The sample size came out to be 108.64, thus 140 subjects were recruited.

Data was analysed using SPSS Version 16.0. Categorical data was presented in the form of percentages and continuous data was presented in the form of means and standard deviation. Students' t-test and Chi-square test were used to test for significance between the groups. A *P* value of ≤ 0.05 was considered significant.

Ethical clearance for conducting the study was obtained from the Institutional Ethics Committee. A written informed consent was obtained from all study participants before recruitment and confidentiality of data was strictly maintained.

Results

The mean age of the study group was 59.2 ± 9.7 years and majority of study participants were aged between 51 and 70 years [Table 1].

107 (76.43%), patients in the study group had normal BMI while twenty-two (15.71%) participants had a BMI > 25 kg/m^2 and hence were categorised as overweight, of whom only two participants were categorised as obese.

Of all the 140 patients, only 5 (3.6%) patients were anganwadi worker and rest 135 (96.4%) patients were home-maker by occupation. The most commonly used biomass fuel was wood [Table 2].

More than a half of the cases in this study presented to the OPD with less than ten years of duration of symptoms while a very few cases had presented to the OPD with more than twenty years of duration of symptoms [Graph 1].

All the participants experienced exertional and/or non-exertional shortness of breath. 36% (51) patients had grade 2 dyspnoea while 30% (42) had grade 4 dyspnoea. Fifty (35.7%) patients had cough, of which more than half patients had non-productive cough.

Table 1: Age distribution of the patients

Age (in years)	Number of Patients
>/=40	7 (5%)
41-50	26 (18.57%)
51-60	40 (28.57%)
61-70	61 (43.57%)
71-80	5 (3.57%)
81-90	1 (0.71%)
Total	140

Table 2: Exposure to different kinds of solid biomass fuel

Type of exposure	Number of Patients
Cow dung	45 (32.14%)
Wood	61 (43.57%)
Crop Residue	34 (24.28%)
Total	140

On chest radiograph, 131 cases (93.6%) had hyperinflation alone, only four (2.9%) had fibrosis alone, while five cases (3.7%) had fibrosis along with hyperinflation.

The average hours of biomass exposure were 2.36 hours/day and average weeks of exposure were 3.98 weeks/month. More than two-thirds of the study participants (70.7%) had a biomass fuel exposure of 16-35 years. Four participants had a biomass exposure of more than 46 years. The average years of exposure to biomass fuel was 29.2 years. Most of the cases had Moderate Cumulative Exposure Index. [Table 3].

Three forth of the study participants (77, 55%) presented to us with a dyspnoea of mMRC Grade 3 and above. A significant fall in SpO_2 of almost 10% was noticed in cases with dyspnoea of mMRC grade 4 [Table 4].

Most of the study participants 131 (93.6%) had an obstructive findings on spirometry [Table 5].

The mean FEV1 of entire study group was 50.9%, in which patients with restrictive pattern had mean FEV1 of 79.2% while patients with obstructive pattern had mean FEV1 of 49.7%. The mean FVC of the entire study group was 85.9%. Patients with restrictive pattern had a mean FVC of 64.7% while patients with obstructive pattern had a mean FVC of 87.5%.

Mean FEV1/FVC of all 140 cases was 57.7%. Patients with restrictive disease had a mean FEV1/FVC of 75.7%, compared with patients who had an obstructive disease in whom the mean FEV1/FVC was 57.4%.

Table 3: Distribution of patients as per Cumulative Exposure Index

Cumulative exposure index	Category	Number of patients
40-80	Mild	57 (40.71%)
80-120	Moderate	63 (45%)
>120	Severe	20 (14.29%)

Table 4: Results of 6-minute walk test

	Pulse Rate		Respiratory rate		SPO_2	
	Pre	Post	Pre	Post	Pre	Post
mMRC grade						
Grade 1	76.83	80.5	15.41	17.33	98	96.9
Grade2	76.53	94.27	15.29	26.47	96.98	89.26
Grade 3	82.17	123.23	20.14	34.97	92.4	82.74
Grade 4	109.02	140.59	28.43	47.36	91.78	82.40

Table 5: Distribution on the basis of Pulmonary Function Tests

Type of disease	Number of Patients
Restrictive	4 (2.86%)
Mixed	5 (3.57%)
Obstructive	Mild -11 cases
	Moderate-49 Cases
	Severe-39 Cases
	Very Severe-32 Cases

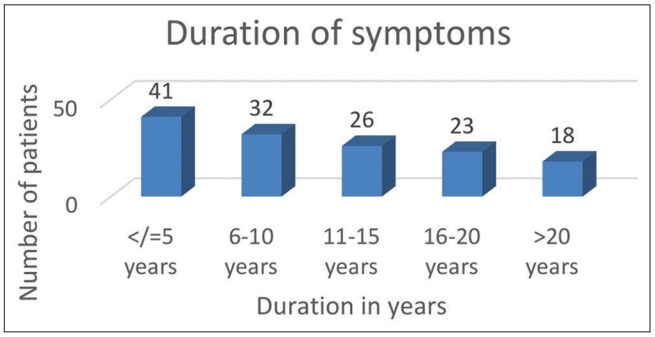
Discussion

In this study, only non-smoking women were recruited who had a history of exposure to solid biomass fuel. The mean age of the study group was 59.2 years. This is consistent with the fact that the use of biomass as cooking fuel has been gradually phased out and is being replaced with LPG gas. Younger women do not present with such a history of biomass fuel exposure, while in a study conducted by Arora P, Gupta R, *et al.*[3] most of the patients were in the age group of 30-45 years (maximum were in 40-45 years age group) which is much less than this study.

Most common biomass fuel used was wood followed by cow dung and crop residue, which was similar to a study conducted by Arora P, Gupta R *et al.*[3]

All the patients had complaint of shortness of breath either on rest, walking a few steps, waking fast or walking a flight of stairs. Cough was present in 35.71% of the total cases in which 27 (54% of patients with cough) patients had dry cough and 23 (46% of patients with cough) patients had cough with expectoration, whereas Kaur-Sidhu M, Ravindra K *et al.*[4] found cough with or without phlegm as most common symptom, followed by wheezing breath, chest pain, shortness of breath, nasal obstruction and nausea. Asmi Panigrahi and Bijaya K. Padhi[5] found the chest tightness as most common symptom followed by Phlegm and cough in morning.

Average Hours of exposure to biomass fuel was 2.36 Hours. Average weeks of exposure per month were 3.98 weeks and average years of exposure were 30. Baran Balcan *et al.*[6] noticed median starting age for cooking was 18.3 years, hours of exposure per day was 2.9 hours (25 minutes less than the present study), 2.5 weeks/month exposure (1.4 week less), mean exposure duration of 14.5 years (almost half as compared to the present study). Arora P, Gupta R *et al.*[3] noticed mean duration of cooking was 21 years and mean hours of exposure was 4.5 hours/day. In a study by Asmi Panigrahi and Bijaya K. Padhi,[5] mean Cooking hours per day in solid biomass fuel users was 4.45 hours, mean years of cooking was 10 years (1/3rd of the present study).



Graph 1: Distribution of the subjects according to Duration of Symptoms

An extremely limited data is available regarding the non-smoker COPD female patients. This is because most of the studies that had been conducted in past does not excluded the patients with co-morbidities. The authors, in this study had included exclusively the non-smoker female patients with no co-morbidities.

The Cumulative Exposure Index (CEI) calculated in the study has never been reported in the Indian population. CEI suggests that the duration of exposure to solid biomass fuel smoke is directly proportional to the severity of Lung function impairment. Solid Biomass fuels have detrimental effect on health of humans, more so because they are used inside houses without proper ventilation. Never-smoking women who cook on biomass fuel have lower lung functions and frequent breathlessness with cough and phlegm production. Considering the challenges in diagnosing lung diseases early in a developing country, these findings have significant public health implications.

Conclusion

In this study, it has been noticed that the duration of exposure to solid biomass smoke is directly proportional to severity of obstructive lung disease. Thus, CEI can be used as a primary tool to quantify the exposure. This may help the primary care physicians to know the magnitude of exposure and to correlate the patient symptoms with exposure in order to reach the diagnosis at initial stage, which can be treated with the help of a bronchodilator. An increased attention must be paid towards the improvement of cooking fuel in view of the health hazards developing due to use of solid biomass fuel, particularly in rural areas. Cleaner fuels like LPG must be made available at a subsidised prize to people with lower socio-economic status.

According to GOLD 2021, wood, animal dung, crop residues, typically burned in poorly functioning stoves, may lead to very high level of indoor air pollution. There is growing evidence that indoor biomass exposure used during cooking may predispose women to develop COPD in many developing countries. There is a lack of research about biomass related COPD.[7]

There is a need to create effective intervention programs such as advertisements, newspaper articles, posters and skits with an objective to provide a better quality of life to individuals exposed to biomass smoke pollutants. Precautions must be taken for populations living in these kinds of rural areas, and people must be educated about the adverse effects of biomass smoke.

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Conflicts of interest

There are no conflicts of interest.

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