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A study of effect of domestic cooking fuel on lung functions in healthy women

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Abstract
Majority of women living in rural area use bio mass fuel for production of domestic energy. Bio mass fuel combustion causes indoor air pollution when used inside the dwellings. Combustion products may induce various effects on lung functions. According to world health report indoor air pollution is ranked on the 10th of preventable risk factors contributing to the global burden of a disease. Around 1.5- 2 million deaths/ year are attributing to indoor air pollution, mainly affecting the children under 5 year due to acute respiratory infections; chronic obstructive pulmonary disease and lung cancer among women. Biomass contributes to one-fourth of the total energy consumed in India. About 78% homes rely on biomass fuels and another 3% on coal.

Keywords: bio mass fuel, chronic obstructive pulmonary disease (COPD), carbon monoxide (CO)

Introduction

Cooking indoors with solid fuels in poorly ventilated rooms produces a great deal of smoke that those living in the home breathe In many low–income countries cooking is done indoors in poorly ventilated rooms, leading to high levels of indoor air pollution due to bio mass and coal smoke [1]. Half of the entire world, most living in low income countries, relies on solid fuel for cooking, lighting and heating [2-4]. Burning solid fuels produces levels of air pollution that far exceed the health based standards for safety in the households, especially with repeated episodes of intense emissions [5]. Cooking and / or heating with biomass fuels or coal, even in stoves or fireplaces vented to the outdoors (airtight stoves), can also produce high levels of indoor air pollution, greatly exceeding levels of outdoor pollution with regards to several important pollutants.

Smoke from biomass combustion produces a large number of health-damaging air pollutants such as respirable particulate matter, carbon monoxide (CO), nitrogen oxides, formaldehyde, benzene, poly-cyclic aromatic hydrocarbons and many other toxic organic compounds [2]. In developing countries where large proportions of households rely on biomass fuels for cooking and space heating, concentrations of these air pollutants tend to be highest indoors [2]. The fuels are typically burned in simple, inefficient, and mostly unvented household cook stoves, which, combined with poor ventilation, generate large volumes of smoke indoors. Moreover, cook stoves are typically used for several hours each day at times when people are present indoors, resulting in much higher exposure to air pollutants than from outdoor sources [6].

Solid fuel smoke causes damage to patients with asthma through the particles, gases and fumes that it contains. The most dangerous particles from solid fuel smoke are the smallest ones. Another important element is the sulphur dioxide produced by coal burning. These are the components of the smoke that have most important immediate affects, causing irritation and inflammation of the lining of the airways. Exposure to irritant gases produced during cooking on *Chulha* (indigenous-cooking stove where biomass is used as fuel) is considered a primary cause of bronchitis and chronic corpulmonale [7]. Recent rural development has been accompanied by a transition away from traditional biomass fuels to modern fuels (usually kerosene, diesel, liquefied petroleum gas, and electricity). Biomass fuel's contribution to total energy consumption in India in 1989 was 50%, having declined from 74% in 1972-73 and 66% in 1982-83 [8].

The inflammatory reactions caused by recurrent exposure to irritant and mucus coagulating emissions make the trachea, bronchi and bronchioles susceptible to infections, which may manifest itself infective bronchitis, bronchiolitis or pneumonia [9]. As a result of this, the people living in the regions of biomass use have higher incidence of respiratory diseases [10]. Pulmonary function tests have an importance in investigating the effects of biomass on respiratory system and in diagnose of the respiratory diseases. FEV_1, FVC, FEV_1/FVC, FEF 25-75 are the major spirometric parameters that are used for determining the airflow limitations [11]. Biomass fuels are used mostly by poor people; predominantly in rural areas of developing countries due to its easy availability and mostly free of cost when compared to other fuels (LPG, electricity, kerosene stoves). Globally 50% of the deaths from COPD in developing countries are contributed by biomass exposure and 75% of the women are sufferers [2].

Domestic cooking is one of the major activities of the rural Indian housewives. Cooking is carried out in an enclosed space with poor ventilation and in inefficient stoves. Women, young girls and children are the most affected group due to long duration exposure of biomass exposure. In developing countries, at the age of 15 years, girls start cooking and spend an average of 4-6 hours daily in kitchen for cooking food. Therefore, during her lifetime, she is exposed to the biomass

fuel smoke for 30-40 years, equivalent to 60,000 hours of exposure and inhaling 25 million liters of polluted indoor air [12]. Different studies have reported biomass smoke as a cause of acute upper and lower respiratory infection [13], otitis media [14], chronic bronchitis/obstructive airway diseases [15], lung cancer [16], asthma, pulmonary tuberculosis [17], low-birth-weight babies, cataracts, and mouth/nasopharyngeal carcinoma [18], These effects are attributed to respiratory irritants like oxides of carbon, nitrogen, and sulfur, and to unburned hydrocarbon particles and polycyclic organic compounds, including carcinogens such as benzo-pyrene [19].

Experimental Section/Material and Methods

The present study was designed to compare the pulmonary functions in healthy women who had used either bio mass or LPG as their sole cooking fuel. The 120 subjects (60 each from biomass group or LPG group) were included from the female attendants of patients who were seeking medical care at the chest and TB hospital Amritsar, Punjab, India.

Inclusion Criteria

1. Age: 20-50 years
2. Non smokers
3. Using either bio mass or LPG as their sole cooking fuel
4. Minimum period cooking of 10 years.

Exclusion Criteria

1. Smokers or who had ever smoked in life.
2. Women who suffer from any chest disease in present or past.
3. Women with spine deformity or rib cage deformity.
4. Decline consent.

120 subjects for the study were divided into two groups. Group 1: 60 biomass users, Group 2: 60 LPG users.

Each subject was explained the purpose of study and need for complete co-operation emphasized. Those who satisfied the inclusion criteria and gave informed consent was taken for study. The age, weight, height was taken for standardizing the readings. The questionnaire used for this study was based on the modified American Thoracic Society Questionnaire and Division of Lung Disease (ATS-DLD) which was developed by the Epidemiology Standardization Project Committee [148]. The pulmonary function test was performed using an electronic rolling seal spirometer. Peak expiratory flow rates (PEFR) was determined with a calibrated Wright's peak flow meter. The subject was made to sit comfortably in a well lit room and procedure explained in vernacular as understood by subject. Nose clips were used to take the mouth pressure only for this procedure. At least three satisfactory readings were recorded and the highest was taken as the representative value for a given individual. The values obtained after performing tests were compared in both groups (i.e. biomass using group and LPG using group), put to statistical analysis using epi info 7 (7.1.1.0 version) software and unpaired T test used, to reach a valid conclusion.

Results and Discussion

In this study 120 females were considered from the attendants of the patients seeking treatment as indoor cases. These subjects were grouped as per the use of cooking fuel type like biomass (dung cake, wood etc.) and LPG. In both groups equal number (60) of women included considering inclusion and exclusion criteria.

Table 1: Distribution of Subjects According To Lung Function Tests

Parameters	Normal	Decrease	Total
FEV1	102(85%)	18(15%)	120(100%0
FVC	120(100%)	0(0.0%)	120(100%)
FEV1/FVC	102(85%)	18(15%)	120(100%)

This table shows the decrease in FEV1 in 15% (N 18) of subjects with an equal percent decrease in FEV1/FVC i.e in 15% of subjects, while FVC remains unchanged in all the subjects which equal 120. These changes are consistent with obstructive disease in these subjects which is finding of effect of effect of smoke of domestic cooking fuel over lung functions.

Table 2: Ventilation of Cooking Area and Fev1

Ventilation	FEV1		
	Decrease	**Normal**	**Total**
Poorly ventilated	14	4	18
Row %	77.78%	22.22%	100.00%
Well ventilated	4	98	102
Row %	3.92%	96.08%	100.00%
Total	18	102	120
Row %	15.00%	85.00%	100.00%

x^2=65.4569; p=0; highly significant

It had been observed that 77.78% (N 14) of subjects cooking in poorly ventilated areas have decreased FEV1 while 3.92% (N 4) of those cooking in well ventilated areas were also having decreased FEV1. This shows effect of ventilation of cooking area. (p = 0; highly significant)

Table 3: Ventilation of Cooking Area and Fev1/Fvc

Ventilation	FEV1/FVC		
	Decrease	**Normal**	**Total**
Poorly ventilated	14	4	18
Row %	77.78%	22.22%	100.00%
Well ventilated	4	98	102
Row %	3.92%	96.08%	100.00%
Total	18	102	120
Row %	15.00%	85.00%	100.00%

X^2=65.4569; p=0; highly significant

This had been observed from above table that 77.78% (N 14) subjects with poor ventilator conditions have decrease in FEV1/FVC whereas 3.92% (N 4) of well ventilation have also decreased FEV1/FVC (p = 0; highly significant).

In our study decrease of FEV1, FEV1/ FVC was observed in 23.33% of chullah users while only 6.67% of LPG users have decrease in these parameters (p=0.0105; significant). Whereas PEFR was decreased in only 3.33% of chullah users (p=0.153; not significant). These findings are consistent with airflow obstruction which might have occurred due to inflammation of airways, upon exposure to fuel fumes while cooking.

In present study the distance of cooking device from window i.e. cross ventilation of cooking area was also studied. Observations were also made their effect over the lung functions. Out of 120 females 16 have less cross ventilation which possibly leads to decrease in FEV1 and FEV1/FVC in 81.25% of these subjects (p=0; highly significant). Decrease in PEFR was also observed in 12.50% (p=0.0002; highly significant) of females with cooking device away from window. It was also observed that imprsoved ventilation and

outdoor cooking cause less exposure to biomass fumes leading to better health conditions and absence of significance differences in lung functions

Summary and Conclusion

- Among these females 60 were using biomass as their cooking fuel while other 60 used to cook with LPG. Biomass combustion causes more deleterious effect on ventilatory functions.
- Computerized spirometry and peak flow expiratory rate is considered to diagnose the airflow limitation caused by toxic fumes generated by burning of different cooking fuels. Use of these tests in routine helps distinguishing healthy pulmonary functions from that of impaired ones.
- In our study FEV1 and FEV1/FVC ratio was significantly decreased in 23.33% ($p<0.05$) females who used to cook on chullah with biomass whereas only 6.67% subjects having decreased values in LPG users.
- LPG is comparatively better fuel with less toxic effect on lung functions but affordabilitys remains the issue with females having low socioeconomic status.
- In the present study poor ventilation of cooking area, distance of chullah or LPG stove from the ventilators or windows or whether cooking is done outdoor or indoor, had significant effect on lung function.
- In 16 females (20%) who used to cook indoor, decrease of FEV1, FEV1/FVC ($p<0.03$; significant) was observed while PEFR was decreased in 2.50% cases ($p>0.05$; not significant). Females cooking outdoor having less exposure to cooking fuel smoke than indoor cooking.
- Overcrowding in rural area and low socioeconomic strata were observed in our study. It causes increased indoor air pollution, have to breathe in polluted air due to less area of ventilation.

This study shows the early lung function impairment in females using biomass as cooking fuel in poorly ventilated kitchens. Pulmonary function tests evaluation using computerized spirometery are simple and sensitive measures to detect such changes in respiratory system as compared to history and physical examination. Exposure of high concentration of pollutants generated by biomass fuels could be the possible cause for lung function impairment. Such adverse effects on lungs could be prevented by educating women, improving ventilation, outdoor cooking and by using clean fuels (e.g. LPG etc.).

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