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Lung function impairment in women exposed to biomass fuels during cooking compared to cleaner fuels in Uttar Pradesh, India

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Abstract

A national survey has shown that approximately 75-80% use of fire wood and chips, 10% of dung cake rural women in Uttar Pradesh, India. Considering the respiratory health risk of biomass fuel exposure to women, a cross sectional study was conducted to elucidate the relationship between cooking smoke and lung function impairments. The present study showed significant decline in air flow limitation based on reduced PEFR (3.69 l sec^{-1}) and FEV_1 (1.34 l sec^{-1}) in women cooking with biomass fuels compared to PEFR (4.26 l sec^{-1}) and FEV_1 (1.73 l sec^{-1}) in women cooking with cleaner fuels. The noxious gases and particles generated from biomass fuels during cooking reported in earlier studies may be the reason for the slight decline in airway status PEFR (3.69 l sec^{-1}) and lung volumes FEV_1 (1.34 l sec^{-1}) . The higher mean bio-fuels exposure index (52.15 hr-yrs) can attribute to reduced lung function in rural women.

Key words

Biomass fuels, Lung function, Rural women

Introduction

India derives the bulk of its cooking energy needs from solid fuels, such as firewood, crop residues or cattle dung (Sehgal *et al.,* 2010). According to the National Family Health Survey, about 80% of Indian rural households rely primarily on biomass fuels for cooking (Mishra *et al.,* 1999; Smith and Liu, 1994). Cooking in rural India is often done under poorly ventilated conditions using inefficient stoves that produce a great deal of smoke (Mishra *et al.,* 1999). Such stoves are often no more than a pit, a *chulha* (u shaped construction made of mud, or three pieces of brick). To a considerable extent, life revolves around the cooking area, and women, in particular, spend much of their time exposed to cooking smoke in rural areas (Mishra *et al.,* 1999). The use of wood, live stock dung cake and other forms of biomass as a cooking fuel is also common in developing countries (Bruce *et al.,* 2000).

Fuels such as wood, animal dung, crop residues, and grasses produce large quantities of smoke that contains many noxious components. These include respirable suspended particulates, carbon monoxide, nitrogen oxides, formaldehyde, and polyaromatic hydrocarbons such as benzo[a]pyrene (ICMR Bulletin, 2001; Mishra *et al.,* 1999).

Periodic and long time exposure to biomass fuel smoke may lead to various types of health impairments. Chronic exposure to wood smoke and other forms of biomass in adults can lead to chronic bronchitis (Albalak *et al.,* 1999), increases the risk of tuberculosis (Mishra *et al.,* 1999), respiratory failure, and cor pulmonale (Sandoval *et al.,* 1993). Women cooking with biomass fuels have increased respiratory symptoms and a slight average reduction in lung function compared to those cooking with liquefied petroleum gas (Regalado *et al.,* 2006).

A survey conducted by National Sample Survey Organization during 2006 to 2007 on the percentage of rural households across states in India using different fuel types for cooking source showed the use of the biomass the fuels i.e., use of approximately 75-80% (fire wood and chips), 10% (dung cake) among rural population in Uttar Pradesh, India (Fuel wood report, 2012). Only 3.1% liquified petroleum gas (LPG) and 0.1% kerosene was used by rural households of Uttar Pradesh (IIPS, 2010). Considering the respiratory health risk, lack of available study on the cause-effect relationship on biomass fuel exposure and risk of lung function impairment in rural women, a cross sectional study was conducted to elucidate the relationship between exposure to biomass fuel smoke and lung function status, more precisely. A comparative assessment of lung function among women using biomass fuel and cleaner fuels was also undertaken.

Materials and Methods

Subjects: Ninety four women cooking with biomass fuels and 76 cooking with cleaner fuels (LPG) were selected from rural areas and urban slum of Lucknow. The inclusion criteria were women cooking with biomass fuels and cleaner fuels regularly in kitchen (average hours/day 2.16 ± 0.55; and average years 23.61±9.12) with no communicable or non-communicable disease and not taking any medication for the last one month. The study subjects without habits of not consuming or smoking any forms of tobacco products were included in the study**.** The clinical examination of all system organs including general examination, systemic examination, skin examination, examination of eyes, examination of respiratory system, measurement of blood pressure, pulse rate etc. was done by a doctor. The approval from Institutional Human Ethics Committee was taken before the study. The socio economic status was assessed by Kuppuswamy's socio-economic status (Kumar *et al.,* 2007) and found out to be matching in both the groups (cleaner and biomass fuel users).

Calculation of life time cumulative exposure by cumulative exposure index (CEI) : An estimate of the lifetime cumulative exposure from cooking fuels was assessed by calculating CEI in hour$_*$years**.** It was computed by multiplying duration of cooking per day and the number of years of cooking. (Regalado *et al.,* 2006).

Body composition factors : Body composition monitoring was measured using a bio-impedance analysis based body fat monitor (Omron, Singapore). The parameters measured were weight and body fat percent (BF %). The body mass index (BMI) was calculated by dividing weight (kg) by square of height (m).

Lung function studies : Lung function parameters like peak expiratory flow rate (PEER) and forced expiratory volume in 1 sec (FEV_1) were recorded using calibrated Spirometer (PIKO-1, Ferraris Respiratory Europe Ltd, UK) in standing position and manoeuvre recommended by American Thoracic Society Recommendations (Pellegrino *et al.,*2005).

Statistical analysis : Significance among two groups was compared using the chi-square test. Significance of mean values among both groups were compared using Student's *t*-test where the variance between the groups was homogeneous. For heterogeneous variances, the Behrens and Fisher modified *t*-test was used.

Results and Discussion

There was no significant difference in mean age (39.98 yr), height (150.16 cm) and weight (45.01 kg) among biomass fuel exposed women compared to women using cleaner fuels. This denotes similar age group and physical characteristics among study subjects (Table 1). Illiteracy was considered as a significant factor (p<0.05) among women using biomass fuels. Most of the women using biomass fuels take vegetarian food compared to women using cleaner fuels. The study subjects belonged to class 4 category of socio-economic status *i.e.*, upper lower class. The types of houses of study subjects of exposed group

Table 1 : Demographic profile of women exposed to biomass fuel (n=94) and cleaner fuel (n=76)

Parameter	Biomass fuels		Cleaner fuels	
Age (yrs)	39.98±11.31		35.41±9.98	
Height (cm)	150.16±5.39		150.67±6.40	
Weight (kg)	45.01±10.31		46.42±10.35	
Type of family				
Joint	33	(35.11)	27	(35.53)
Nuclear	61	(64.89)	49	(64.47)
Marital status				
Married	94	(100)	76	(100)
Educational status				
Graduate	1	(1.06)	0	
High school	0		8	(10.53)
Primary school	11	(11.70)	13	(17.10)
Illiterate	82	(87.24)	55	(72.37)*
Food habits				
Vegetarian	61	(64.89)	13	(17.11)**
Socio-economic status				
Class- IV	94	(100)	76	(100)
Type of house				
Kachcha	36	(38.30)	2	(2.63)**
Pukka	31	(32.98)	73	(96.05)**
Mixed	27	(28.72)	1	(1.32)**
Kitchen				
Inside house	86	(91.49)	71	(93.42)
Separate/outside house	8	(8.51)	5	(6.58)

Values in parentheses indicates per cent; Values are mean of replicates ± SD; Significant at *p<0.05, **p<0.0001

Table 2 : Exposure index and BMI of women exposed to biomass fuel (n=94) and cleaner fuel (n=76)

Parameters	Biomass fuels	Cleaner fuels
BMI (kg m^{-2})	19.94± 4.31	21.79±11.81
BF %	29.62±6.48	29.73±16.28
Exposure hours/day	2.16 ± 0.55	1.25 ± 0.43
Exposure years	23.61 ± 9.12	14.18 ± 8.91
Exposure index(hr-yrs)	52.15 ± 25.20	17.57 ± 12.36

Values are mean ± SD; Normal range of BMI = 18.5 - 24.9 kg m^{-2} (Global database on Body Mass Index (2006)

were kachcha (made of mud), pukka (made of bricks) and mixed (partially of brick and mud). Maximum women using cleaner fuels live in pukka house. Both the study groups mostly cook food inside their house (Table 1).

Both the groups were within the normal range of BMI. Mean BMI for women using biomass fuels were 19.94 kg m^{-2} and cleaner fuels were 21.79 kg m^{-2}. The normal range of BMI was 18.5 - 24.9 kg m^{-2} as per World Health Organization classification (Global database on Body Mass Index, 2006). Body fat percent was also within the normal range. There was no significant difference between their BMI and BF% which again denote the same physical characteristics among both groups (Table 2). The study showed that exposure index (hour$_*$year) among women using biomass fuels as compared to cleaner fuels was non significant (Table 2). This difference may be due to long duration required for cooking food with biomass fuels compared quick cooking with cleaner fuels because biomass fuel have less energy content per kg of fuel as compared to LPG (IARC, 2010).

A significant decline was observed in PEFR ($p<0.003$) and reduced FEV_1 among women using biomass fuels for cooking compared to women using cleaner fuels due to air flow limitation. Decline in mean PEFR (3.69 l sec^{-1}) and FEV_1 (1.34 l sec^{-1}) was observed in biomass fuels exposed women compared to women using cleaner fuel (Fig. 1).

The present study showed slight deteriorations in lung function and air flow limitation in women cooking with bio-fuels. Our observation supports the earlier study on women exposed to biomass fuels in rural Mexican women (Regalado *et al.,* 2006). This denotes the lesser capacities of lungs among women, may be due to deposition of particles in the lungs from biomass fuels. The gases evolved from the biomass fuels which contain toxic materials including PAH (Zelikoft *et al.,* 2002) can be another reason for deteriorated lung capacities. Toxic particles like PAH and particulate matter evolved from burring of biomass fuels can penetrate into pharynx, trachea, bronchi, and bronchioles and ultimately reach alveoli (Torres-Duque *et al.,* 2008). The penetration and deposition of particles may have lead to decline in airway

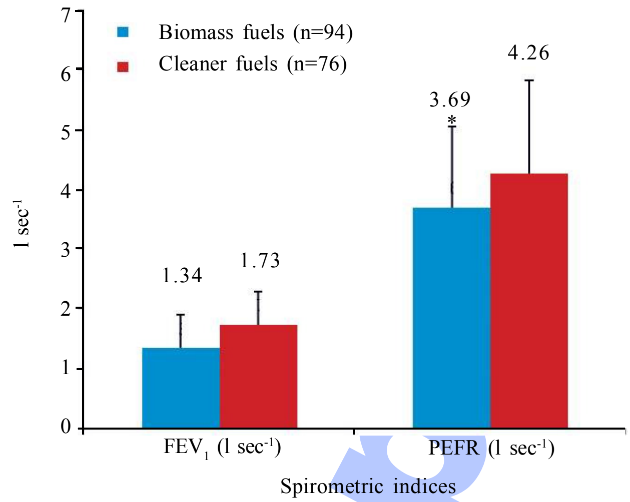

Fig. 1 : FEV_1 and PEFR among women exposed to biomass fuel (n=94) and cleaner fuel (n=76); Significant at $*p<0.003$

status like PEFR among women exposed to biomass fuels in the present study (Torres-Duque *et al.,* 2008). PEFR was considered as a sensitive indicator for bronchial airway obstructions (Mridha *et al.,* 2011).

Women who cooked with biomass fuel expectorated more sputum, had lower FEV_1/FVC ratios than women cooking with cleaner fuels and their deterioration was considered as mild type of lung function impairment (Regalado *et al.,* 2006). Earlier study showed that higher indoor PM_{10} concentrations during cooking of biomass fuels can lead to reduction in FEV_1 and FVC, and increased prevalence of cough (Regalado *et al.,* 2006). Dennis *et at.* (1996) and Dossing *et al.* (1994) reported high risk as per odds ratio with respect to chronic bronchitis and airflow obstruction in women exposed to wood smoke.

The strength of the study was the higher exposure (exposure index (hr-yrs) 52.15 ± 25.20) of study subjects and statistically large sample size in both groups. Therefore, the study shows that the women exposed to biomass fuels for a longer duration (hr-yrs) can lead to deteriorated lung functions. The confounding effect of lungs functions like smoking and chewing using tobacco-related products, major respiratory ailments, medication was ruled out in the inclusion criteria of the subjects. Thus, study can claim the true biomass fuel exposure among rural women. Longitudinal study including lung function test is required to demonstrate whether or not any observed changes are variable, reversible, or progress to lung diseases (Diette *et al.,* 2012).

The availability of cleaner fuels in villages should be improved. Technologies that harness the use of affordable fuels like biomass in a high efficiency, low-emission mode, must be promoted (Sehgal *et al*., 2010).

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