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Household Air Pollution Risk on Respiratory Health among Women: A Case Study of Indian District after Clean Fuel Programme

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Abstract

Objectives: Some of the highest exposures to air pollutants in developing countries occur inside homes where biomass fuels are used for daily cooking. Inhalation of these pollutants may cause deleterious effects on health. Study Design: A total of 450 non-smoking, non-pregnant women aged 15 years and above exposed to domestic smoke from cooking fuels from an early age, working in poorly ventilated kitchen were selected and on investigation presented various health problems.

Method: Symptoms were enquired by means of using standard questionnaire adopted from that of the American Thoracic Society (ATS, 1995). Lung function was assessed by the measurement of Forced Vital Capacity (FVC), (FEV1), i.e. volume of air (in liter) that is forcefully exhaled in one second. Using ratio of FEV1 to FVC (FEVI/FVC), expressed as percentage.

Results: FVC less than 80% of the predicted was considered as abnormal pulmonary function. Symptoms like chest pain, breathlessness, eye irritation, and blackout were found to be significantly higher in biomass users ($P < 0.05$). Moreover, an increasing trend in the prevalence of symptoms/morbid conditions was observed with increase in exposure. Conclusion Thus women exposed to biomass fuels smoke suffer more from health problems and are at greater risk of respiratory illnesses when compared with other fuel users.

Keywords: Biomass fuel; Household air pollution; Health effects; Chronic bronchitis; Lung function; Environmental risk

Introduction

HAP is recognized as a significant source of potential health risk to exposed populations throughout the world. The major sources of HAP worldwide include combustion of fuels, tobacco smoke, ventilation systems, furnishings and construction materials. These sources vary considerably among developing, and developed nations. Environmental Tobacco Smoke, volatile organic compounds from furnishings and radon from soil are major sources of importance in developed countries [1]. Household Air Pollution (HAP) is caused mainly by the residential burning of solid fuels for cooking and to some extent heating, the major types of which are wood, dung, agricultural residues, coal, and charcoal [2-4]. According to the Global Burden of Disease Report, IAP is the leading cause of Disability Adjusted Life Years (DALYs) in Southeast Asia and the third leading cause of DALYs worldwide [5]. It is considered a silent killer that has resulted in 4.3 million deaths worldwide accounting for 7.7% of the global mortality. The adoption of clean stoves by the 3 billion people using traditional fuels is necessary to achieve health, climate, and gender equality goals [6]. The South-East Asian region contributes to the maximum mortality due to household air pollution followed by the Western Pacific region [7]. A developing country like India faces the dual challenge of exposures from both ambient and household air pollution [5]. The most important issue that concerns indoor air quality in household environments of developing countries like India is the exposure to pollutants released during the combustion of solid fuels. Existing evidence suggests that India, with a population of 1.38 billion people living across states at different levels of economic, social, and health development, has one of the highest air pollution levels in the world [8].

In India, approximately 86.7% of rural households and 26.3% of urban households rely on solid biomass fuels for their cooking needs [9]. These practices can adversely affect the respiratory health of individuals and local forests and other environmental resources, as well as contribute to climate change. When used in simple cooking stoves (mostly traditional Indian Chulah), these fuels emit substantial amount of toxic pollutants that include respirable particles, carbon monoxide, oxides of nitrogen , sulfur, benzene, formaldehyde, 1,3-butadiene, and polyaromatic compounds, such as benzo (α) pyrene [10-16]. In households with limited ventilation as is common in rural household of developing countries, exposures experienced by household members, particularly women and young children who spend a large proportion of their time indoors, have been measured to be many times higher than World Health Organization (WHO) guidelines [17]. Millions of people die every year from exposure to fine particles in polluted air that penetrate deep into the lungs and cardiovascular system, causing diseases including stroke, heart disease, lung cancer, Chronic Obstructive Pulmonary Diseases (COPD) and respiratory infections, including pneumonia. Fine

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particles less than 2.5 micrometers in diameter (PM2.5) pose the greatest health risks because of their small size, as they can lodge deeply into the lungs. Also, the evidence is now emerging of links with a number of other conditions, including low birth weight, asthma, tuberculosis, cataracts and cancer of the upper airways 18. Household Air Pollution (HAP) arising from the combustion of solid fuels for cooking is a major contributor to four of the top five causes of mortality and morbidity in India, and HAP is a significant contributor to outdoor air pollution [19-21]. Clean cooking fuels are a highly cost-effective health intervention and household's energy-behavior indicates the economic development of a country [21].

In "Pradhan Mantri Ujjwala Yojana" (PMUY), the government provided gas connections to a total of 50 million poor households (from 2016 to 2018) [22]. Piped Natural Gas (PNG) connections have reached more than 11% of households annually with a goal of 20 million by early next decade helping to move LPG to rural areas.

Despite being an industrialized state, over 78% of rural households in Maharashtra state in India use firewood as principle cooking fuel [23]. Yet there is limited data available on health effects involved in the biomass and clean fuels in view of availability of clean fuel the rural areas.

Methods

The study was carried out in the rural area of Nagpur district in the state of Maharashtra, India during the span of the year 2017-18. The study was cross sectional and used multistage random sampling technique. The randomization was done at three levels that are district, tehsil (block) and village to identify the study area (Figure 1). District Nagpur has fourteen blocks, out of which Katol was selected randomly for the study, which has 82.38% biomass fuel use according to Census 2011. Katol block has over 165 villages out of which twenty villages were then selected from the block based on their distance from the block headquarter and their proximity from national highway to reduce the confounding factor of vehicular pollution. Seven villages were with-in 10km, 8 were in 10-20 km radius and 5 were more than 20km. All procedures were in accordance with the ethical standards of the Institutional Review Board and with the Helsinki declaration of 1975 that was revised in 2000. Ethical clearance was taken from the Institutional Ethics Committee of Rashtrasant Tukdoji Maharaj Nagpur University India. Informed consent was obtained from all subjects of the study. Respiratory symptoms in detail were enquired by means of a standard questionnaire adopted from the American thoracic society [24], and chronic bronchitis was diagnosed from the presence of cough with expectoration for 3 months in a year for at least two consecutive years on the recommended criteria of ATS. The survey was conducted at two levels, viz., individual and household. The study population was rural women who cook using the different types of fuel. Women aged 15 years and above involved in cooking who were non-smokers, non-pregnant were included in the study. For sample calculation, prevalence of three major diseases like Chronic Obstructive Pulmonary Disease (COPD), lower respiratory infection and low back pain was taken into consideration. Four hundred and fifty (450) households having at least one women cook were selected

Figure 1:

for collecting primary data on several household parameters like socio-economic, demographic, and housing characteristics. Information about the prevalence of respiratory symptoms experienced in the past 1 year lasting for 3 months or more, frequency of the signs and symptoms, were collected. Respiratory symptoms broadly included dry cough, cough with phlegm, wheezing and chest discomfort, chest pain and nasal obstruction [25]. In addition, prevalence of headache, eye irritation, nausea, dizziness, shortness of breath etc. were also evaluated. Lung function was measured on completion of interviews. Lung function tests by spirometry were performed with informed consent of the participant. The tests were performed according to the methods suggested by the American Thoracic Society using a portable, electronic spirometer (Schillar Ltd, UK). Calibration checks were undertaken weekly. Before performing the pulmonary function test, each woman was subjected to a detailed history including the history of smoking, location of the kitchen, adequacy of ventilation, type of cooking fuel used, and clinical examination. Exposure was calculated in each woman by the number of hours spent in a day for cooking. Height was measured in standing position and without shoes, and weight was recorded with minimal clothing. Body Mass Index (BMI) was calculated. For spirometry, participants were seated without nose clips and measurements were classified as acceptable if the woman had at least three good blows, and if best and second best values of Forced Expiratory Vital Capacity (FVC) and Forced Expiratory Volume in 1 second (FEV 1), respectively, did not differ by more than 0.20 liters. The data were compared with predictive values based on age, sex and height. The parameters like Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV1), FEV1% and Forced Expiratory Flow 25-75 (FEF25-75). Peak Expiratory Flow Rate (PEFR) was measured using Wright's Peak Flow Meter (Clement and Clarke, UK). FVC and FEV1 were expressed in litres, PEFR in litres/min, FEF25-75 in litres/sec, FEV1% was presented as the ratio of FEV1, and FVC expressed in percentage.

Statistical analysis was done using IBM 21 version of SPSS. Percentage, mean and standard deviation was calculated. The Chi-square test trend and analysis of variance was used for statistical analysis a confidence level of 95%.

Results

Physical access to LPG was reported by (44.9%) of respondents, although 50.9 % of them used mixed fuels as main source of fuel (that is gas and wood, crop residue, dung cakes). Only 10 % of the respondents were using LPG alone for their energy requirement. Out of the 202 households, which had a gas connection, only 40 households (8.89%) obtained their gas connection under Pradhan Mantri Ujjwala Yojna (PMUY) a Government of India scheme to provide clean fuel to low income population. Most frequently used fuel for cooking was LPG (52.4%) in combination with wood (47.6%). The overall mean household consumption of wood fuel was 5kg per day. Dung (21.6%) and Kerosene (12.0%) were used less frequently.

Table 1 shows the distribution of age, height, weight, BMI, and exposure index of cooking according to different types of symptoms (eye irritation, dizziness, dry cough, phlegm, wheezing, headache, nasal irritation, and body ache) encountered by study subjects. The symptomatic women had higher age ($P <0.05$) and low BMI. Similarly, the symptomatic women had a higher duration of exposure ($P <0.05$). The height was similar in all the groups irrespective of presence or absence of symptoms/morbid conditions. Women with morbid conditions (abnormal pulmonary function, chronic bronchitis, bronchial asthma, cataract, and anemia) had significantly higher age and greater duration of exposure ($P <0.05$) except for bronchial asthma where it did not reach statistical significance though the mean age and EI was higher

Table 2 shows the comparisons of symptoms/morbidities in different fuel users for all the 450 study participants who were able to perform spirometry. All the participants were divided into two fuel categories that is LPG/biogas users, and biomass fuel users based on the primary fuel type used by the households. The comparison was made for lung function parameters among women cooking with fuel in these two categories. Significance test at 5% level of significance was used to estimate the difference between the means of the three groups. The results showed that the mean values of FEV1 and the ratio of FEV1/FVC of LPG users were more than the corresponding values for biomass fuel users. The analysis of variance shows that the difference was found statistically significant for and FVC/FEV% ratio for biomass fuel users while for gas users it was not significant.

Table 3 describes the comparison of symptoms/morbidities in different fuel users. Participants experienced various symptoms like eye irritation, headache, giddiness, dry cough, and nasal irritation during cooking. The prevalence of symptoms like eye irritation, headache, and dry cough was higher among biomass users as compared with, LPG. Chi-square test across all cooking fuel categories revealed statistically significant difference for eye irritation, chest pain, blackout ($P<0.01$) and breathlessness ($P <0.05$). Furthermore, the prevalence of morbid conditions was found to be significantly higher among biomass users for Dysnosea (64.5%), chestpain (66.8%), eye irritation (65.4%) and blackout (62.1%) compared with other fuels.

Table 4 shows the lung function parameter FVC (observed and percent predicted) among participants with respiratory symptoms/ morbidities. The presence of symptoms/morbid conditions (dry cough, phelgm, abnormal pulmonary function, chronic bronchitis, bronchial asthma) was associated with lower values of FVC, FEV and FVC/FEV ratio ($P <0.05$ to 0.001). The asymptomatic women had significantly higher values as compared to symptomatic women ($P <0.05$ to 0.001).

Discussion

The study determined the role of domestic smoke on the health of 450 non-smoking rural women exposed to different types of cooking fuels. The study also included the clinical diagnosis of the symptoms reported by the women through spirometry during field visits and the duration of health conditions was assessed, information regarding use of fuels in years was enquired with The time spent near the biomass fuel was subjected to recall bias. Women presenting with various symptoms/morbid conditions were older and had a greater duration of cooking. Symptoms like eye irritation, headache, and diminution of vision were found to be significantly higher in biomass users ($P <0.05$). Pokheral AK et al. observed a significant association between current biomass usage and the development of nuclear cataracts (OR=2.58; 95% CI: 1.22-5.46), which also increased with the duration of exposure in years [26]. Similar findings were also reported by Ravilla TD et al. (AOR = 1.28; 95% CI: 1.10-1.48) [27].

Table 1: Distribution of age, height, body mass index and Exposure Index of cooking among biomass fuel users and non-users according to presence or absence of symptoms (mean ± SD).

Symptoms	Age	Weight	Height	BMI	Duration	Exposure Index
Cough						
Presence	41.89 ± 13.75	51.24 ± 7.95	153 ± 14.81	22.21 ± 4.13	1.763 ± 0.63	313 ± 3.444
Absence	40.30 ± 13.62	52.04 ± 9.50	155.99 ± 12.91	21.43 ± 3.19	1.73 ± 0.66	137 ± 3.39
P value	P >0.05	P >0.05	**P <0.05**	P >0.05	P >0.5	0.386
Phelgm						
Presence	42.9 ± 13.45	51.34 ± 7.80	152.22 ± 15.05	22.51 ± 4.12	1.77 ± 0.63	279 ± 3.48
Absence	39.35 ± 14.12	52.37 ± 9.27	156.88 ± 12.84	21.35 ± 3.20	1.71 ± 0.66	162 ± 3.36
P value	P >0.05	P >0.05	**P <0.001**	**P <0.01**	P >0.5	0.104
Cough Phelgm						
Presence	42.96	50.82 ± 7.77	151.38 ± 15.51	22.5814	1.77 ± 0.63	247 ± 3.488
Absence	39.53	52.28 ± 9.172	157.09 ± 11.98	21.245	1.72 ± 0.66	203 ± 3.33
P value	P >0.05	P >0.05	**P <0.001**	**P <0.001**		**0.06**
Wheezing						
Presence	43.68 ± 13.71	51.00 ± 8.071	151.02 ± 15.42	22.77 ± 4.42	1.78 ± 0.63	2143 ± 233.56
Absence	39.35 ± 13.43	51.91 ± 8.78	156.61 ± 12.62	21.25 ± 3.17	1.72 ± 0.66	2363 ± 233.23
P value	**P <0.05**	P >0.05	**P <0.001**	**P <0.001**	P <0.5	**0.002**
Headache						
Presence	41.73 ± 13.74	51.49	153.97 ± 14.46	22.00 ± 3.97	1.76 ± 0.63	424 ± 3.42
Absence	36.27 ± 12.50	51.27 ± 9.22	153.69 ± 11.47	21.60 ± 1.95	1.57 ± 0.75	26 ± 3.23
P value	**P <0.001**	**P <0.001**	**P <0.001**	P >0.05	P <0.5	**0.052**
Chest pain						
Presence	51.48 ± 8.45	51.86 ± 8.80	153.53 ± 13.43	22.18 ± 3.76	1.78 ± 0.63	275 ± 3.674
Absence	41.99 ± 13.76	5090 ± 7.85	154.61 ± 13.43	21.64 ± 4.06	1.70 ± 0.66	175 ± 2.99
P value	P >0.05	P >0.05	P >0.05	P >0.05	<0.5	0.32
Breathlessness						
Presence	42.36 ± 13.77	52.37 ± 8.61	153.63 ± 13.47	22.38 ± 3.68	1.78 ± 0.63	270 ± 3.68
Absence	39.99 ± 13.56	50.15 ± 8.042	154.45 ± 15.48	21.37 ± 4.11	1.71 ± 0.66	180 ± 2.98
P value	P >0.05	**P <0.01**	P >0.05	**P <0.01**	P <0.5	0.098
Eye Irritation						
Presence	41.57 ± 14.03	52.38 ± 8.61	154.33 ± 13.05	22.18 ± 3.74	1.78 ± 0.64	269 ± 3.59
Absence	41.41 ± 13.16	50.24 ± 8.20	153.53 ± 16.30	21.68 ± 4.15	1.71 ± 0.65	174 ± 3.125
P value	P >0.05	**P <0.05**	P >0.05	P >0.05	P <0.5	0.564
Blackout						
Presence	41.30 ± 13.94	52.61 ± 8.65	154.51 ± 13.54	22.23 ± 3.74	1.77 ± 0.64	256 ± 3.58
Absence	41.56 ± 13.45	50.01 ± 7.96	153.23 ± 15.36	21.64 ± 4.04	1.73 ± 0.64	194 ± 3.21
P value	P >0.05	**P <0.001**	P >0.05	P >0.05	P <0.5	0.72
Sneezing						
Presence	40.88 ± 15.15	53.38 ± 8.18	153.93 ± 15.46	22.88 ± 4.21	1.8163	98 ± 3.66
Absence	41.56 ± 13.31	50.96 ± 8.46	153.97 ± 13.98	21.72 ± 3.76	1.7386	352 ± 3.36
P value	P >0.05	**P <0.01**	P >0.05	**P <0.01**	P <0.5	0.83
Chest tightness						
Presence	40.44 ± 15.05	52.92 ± 8.14	153.71 ± 15.53	22.741 ± 4.10	1.75 ± 0.69	105 ± 3.61
Absence	41.71 ± 13.30	51.05 ± 8.50	154.03 ± 13.92	21.74 ± 3.79	1.75 ± 0.63	241 ± 3.37

P value	P >0.05	**P <0.05**	P >0.05	**P <0.05**		0.9
Joint pain						
Presence	40.63 ± 14.96	51.48 ± 8.06	156.42 ± 13.97	21.13 ± 2.59	1.75 ± 0.69	90 ± 3.67
Absence	41.61 ± 13.41	51.49 ± 8.55	153.34 ± 14.33	22.18 ± 4.12	1.75 ± 0.63	360 ± 3.36
P value	P >0.05	P >0.05	P >0.05	**P <0.05**	>0.5	0.784
Dizziness						
Presence	42.15±14.49	51.98±8.91	155.46±13.08	21.62±3.37	1.79±.64	209 ±3.69
Absence	40.77±13.01	51.06±8.02	152.65±15.18	22.28±4.26	1.72±.64	345± 3.37
P value	P>0.05	P>0.05	**P<0.05**	P>0.05	**P<0.05**	**0.05**
Nausea						
Presence	43.09 ± 14.90	50.06 ± 8.10	156.24 ± 13.59	20.61 ± 2.996	1.74 ± 0.70	54 ± 4.22
Absence	41.18 ± 13.55	51.68 ± 8.49	153.65 ± 14.30	22.16 ± 3.88	1.75 ± 0.63	396 ± 3.3
P value	P >0.05	P >0.05	P >0.05	**P <0.01**	P >0.05	0.36
Nasal Discharge						
Presence	40.86 ± 13.66	52.60 ± 7.31	155.11 ± 13.20	24.99 ± 3.67	1.678 ± 0.66	56 ± 3.21
Absence	41.49 ± 13.47	51.32 ± 8.59	153.95 ± 14.09	21.55 ± 3.72	1.76 ± 0.64	39 ± 43.45
P value	P >0.05	P >0.05	**P <0.001**	**P <0.001**	**P <0.5**	0.34

Table 2: Comparison of symptoms/morbidities in different fuel users.

		N	Mean	Std. Deviation	Sig.
FVC Predicted	wood	249	2.84	0.927	0.656
	LPG/Bioga	201	2.88	1.136	
FVC Measured	wood	249	1.2935	1.37433	0.274
	LPG/Bioga	201	1.4411	1.48157	
FVC Percentage	wood	249	44.26	44.745	0.201
	LPG/Bioga	201	49.91	48.624	
FEV1 Predicted	wood	249	2.362	0.79359	0.77
	LPG/Bioga	201	2.3863	0.97336	
FVC1 Measured	wood	249	1.1255	1.24093	0.715
	LPG/Bioga	201	1.1698	1.32366	
FEV1%	wood	249	47.4297	48.7313	0.228
	LPG/Bioga	201	53.2786	53.832	
FVC/FEV1%	wood	249	89.0861	18.6204	0.031
	LPG/Bioga	201	84.75	23.9426	

Table 3: Comparison of symptoms/morbidities in different fuel users.

Respiratory Index	wood	LPG	Total	P value
Cough	151(70.6)	162(68.6)	313(69.6)	>0.05
Phelgm	135(65.2)	144(61.5)	279(63.3)	>0.05
Nasal discharge	31(14.5)	25(10.6)	56(12.4)	>0.05
Nasal Obstruction				
Sneezing	49(22.9)	49(20.8)	98(21.8)	>0.05
Chest pain	143(66.8)	132(55.9)	275(61.1)	<0.05
Shortness of breath	138(64.5)	132(53.8)	270(60.0)	<0.05
Non Respirotory Index				
Eye irritation	136(65.4)	133(56.6)	269(60.7)	<0.05
Wheezy chest	105(49.1)	109(46.2)	214(47.6)	>0.05
CO symptoms				
Dizziness	103(48.1)	106(44.6)	209(46.4)	>0.05
Headache	205(95.8)	219(92.8)	424(94.2)	>0.05
Nausea	25(11.7)	29(12.3)	54(12.0)	>0.05
Other	11.70%	12.30%	12.00%	
Joint pain	36(16.8)	54(22.9)	90(20)	>0.05
Blackout	133(62.1)	127(53.8)	260(57.8)	<0.001

It was observed that women with respiratory symptoms had higher risk of being exposed to biomass fuel as compared to those without symptoms, which is similar to the findings reported in Mexico and in India [28,29]. A systematic review by Sana A. et al. also concluded that COPD was more likely to be diagnosed among women who had a history of exposure to biomass fuel (OR = 1.38; 95% CI: 1.28-1.57) [30]. However, a study in Pakistan found no such associations [31].

The present study showed that women with self-reported cardiovascular symptoms/conditions were at higher risk of being ever exposed to biomass fuel and similar findings were reported by a study in Odisha, India ($p < 0.05$), in Nigeria (OR = 1.67; 95% CI: 1.56-4.99) and in China (OR = 2.58; 95% CI: 1.53-4.32) [32-34].

To summarize, more than two-thirds of the families were using biomass in our study and it was found that being ever exposed to biomass fuel was significantly associated with their socio-demographic characteristics, self-reported ophthalmic, respiratory, dermatological, cardiovascular symptoms/conditions.

Our study findings also suggest that households using both LPG and biomass fuel for cooking may have serious health implications from exposure to mixed fuel use. Although the best health benefits result from exclusive use of LPG, even partial LPG adoption has shown to improve health outcomes [35]. Access to the clean fuels like LPG though increased by a program like PMUY, but the stacking (multiple fuel use) of fuels needs to be addressed. India's Council for

Table 4: FVC, FEV and FVC/FEV ratio among study subjects with respiratory symptom/morbidities.

Symptoms	FEV/FVC ratio	FEV 1	FVC
Cough			
Presence	86.59 ± 20.76	2.91 ± 1.35	2.96 ± 1.29
Absence	88.40 ± 22.34	2.75 ± 1.42	2.77 ± 1.35
P value	>0.05	>0.05	>0.05
Phelgm			
Presence	89.25 ± 13.94	2.94 ± 1.33	3.12 ± 1.28
Absence	84.59 ± 27.48	2.78 ± 1.41	2.60 ± 1.33
P value	**<0.001**	>0.05	**<0.001**
Cough Phelgm			
Presence	89.25 ± 13.93	2.93 ± 1.35	3.06 ± 1.30
Absence	84.59 ± 27.48	2.78 ± 1.35	2.70 ± 1.31
P value	**<0.05**	>0.05	**<0.05**
Wheezing			
Presence	88.48 ± 14.67	3.03 ± 1.33	3.17 ± 1.25
Absence	85.94 ± 25.77	2.71 ± 1.35	2.66 ± 1.32
P value	>0.05	**<0.05**	**<0.001**
Headache			
Presence	86.91 ± 21.79	2.95 ± 1.32	2.99 ± 1.27
Absence	90.93 ± 7.52	1.46 ± 1.10	1.46 ± 1.10
P value	>0.05	**<0.001**	**>0.001**
Chest pain			
Presence	92.61 ± 14.29	3 ± 1.31	3.00 ± 1.32
Absence	78.55 ± 26.86	2.64 ± 1.38	2.74 ± 1.28
P value	**<0.001**	**<0.05**	**<0.05**
Breathlessness			
Presence	91.13 ± 17.57	3.05 ± 1.32	3.05 ± 1.33
Absence	81.16 ± 24.66	2.58 ± 1.36	2.68 ± 1.26
P value	**<0.001**	**<0.001**	**<0.05**
Eye Irritation			
Presence	92.02 ± 14.35	3.04 ± 1.31	3.05 ± 1.33
Absence	79.09 ± 27.27	2.55 ± 1.37	2.63 ± 1.26
P value	**<0.001**	**<0.001**	**<0.001**
Blackout			
Presence	91.80 ± 14.55	3.07 ± 1.28	3.10 ± 1.30
Absence	80.78 ± 26.68	2.59 ± 1.40	2.63 ± 1.28
P value	**<0.001**	**<0.001**	**<0.001**
Sneezing			
Presence	90.02 ± 14.04	3.01 ± 1.19	3.11 ± 1.28
Absence	86.34 ± 22.80	2.82 ± 1.39	2.84 ± 1.32
P value	>0.05	>0.05	>0.05
Dizziness			
Presence	90.76 ± 15.93	3.23 ± 1.17	3.28 ± 1.20
Absence	84.01 ± 24.56	2.54 ± 1.41	2.580 ± 1.32
P value	**<0.05**	**<0.001**	**<0.001**

Energy, Environment, and Water (CEEW) noted in their Access to Clean Cooking Energy and Electricity Survey of States (ACCESS) that households' use of LPG increases with the age of connection [36]. Therefore, if the PMUY policy provides an impetus for families to even partially adopt LPG when they would otherwise be wholly reliant on unclean fuels, it can be considered an effective policy. The penetration of clean fuel was low in the study area and as such, the number of connections given in the whole Nagpur district until 2018 were only 12,000 [37]. So considering that Nagpur has 14 blocks, these are less as compare to other parts of India. The reason for this could be the district was not a high priority district in the programme [38].

The study observes a higher prevalence of respiratory symptoms and lung function capacity impairment in Biomass Fuel users as compared with clean fuel (LPG), users. This urges to have a greater emphasis on clean fuel programmes to improve the health of women cooks [39]. In a study conducted in Turkey a highly significant (p <0.00001) reduction of FEV1, FVC, FEV1/FVC and FEF25-75 was observed in case of biomass fuel users. A study conducted in an urban Indian slum showed significantly lower FVC, FEV1, FEV1% and PEFR values in bio-fuel using women in comparison to modern fuel users (kerosene and LPG) his study eventually concludes showing the adverse effects of biomass fuels (especially wood) use on the deterioration of pulmonary function.

The other objective of the PMUY scheme that of health benefits of clean fuel are not achieved in the study area as seen from the results of spirometry.

Conclusion

The present study investigated the association of symptoms (HAP related) such as difficulty in breathing, and dry cough with the presence of HAP sources and contributory factors. HAP and its detrimental effects are preventable. The rural poor living in ill-ventilated house should be provided with better housing conditions. The policy makers should promote the use of clean fuel (LPG) in cost effective manner. Incomplete switchover to cleaner alternatives has hampered the health benefits of cleaner fuels and behavioral changes may decrease the health effects of HAP. Therefore, these households may require continued public health interventions such as subsidies and regular health education. Grass root workers in the health system need to be involved in PMUY programme to educate women and make them aware of the deleterious effects of HAP on their own health and of their children.

Thus, in conclusion the present study showed that the women using biomass fuel for cooking suffered more from respiratory and other morbidities than the women using other types of cooking fuels. Also, the morbidities found to be increased with increase in duration of cooking.

Ethical Approval

Ethical clearance was taken from the Institutional Ethics Committee of Rashtrasant Tukdoji Maharaj Nagpur University India. Informed consent was obtained from all subjects of the study.

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