INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY
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www.ijrbat.in

INDOOR AIR POLLUTION AND REDUCED LUNG FUNCTION IN WOMEN EXPOSED TO BIOMASS FUEL SMOKE IN RURAL AREA OF SANGLI DISTRICT (MAHARASHTRA)

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ABSTRACT:
In developing countries majority of households uses biomass fuel for cooking and heating purposes which in presence of poor ventilation produces a very high level of indoor air pollution. The smoke released due to incomplete combustion of unprocessed solid biomass fuel contains high volume of health damaging air born pollutants. Such as respirable Particulate Matter (PM), Carbon Mono-oxide (CO), Nitrogen Oxide (NO_2), Sulfur dioxide (SO_2) formaldehyde, polycyclic organic hydrocarbons and other some toxic compounds. Inhalation of such air born pollutants causes adverse effect on respiratory system, which reduces lung function and causes Chronic Obstructive Pulmonary Disease (COPD). COPD is the inflammation of bronchi and bronchioles. In COPD if $FEV_1\% < 80$ then there is obstructive type of disorder. In this study, we selected 100 women using biomass fuel and 100 women using LPG from rural area Kakadwadi, which is 6 to 7 km away from Sangli City. Biomass fuel users were considered as Subject and LPG users were considered as control. Survey of women using chulla and LPG was done. Information regarding type of house, type of kitchen, number of years and number of hours exposed to biomass fuel and LPG was collected. Spirometry was done in total 200 women. Spirometric parameters Forced Expiratory Volume per one second ($FEV_1\%$), Forced Vital Capacity (FVC%) and ratio of Forced Expiratory Volume per one second / Forced Vital Capacity (FEV_1/ FVC%) were recorded. We found, out of 100 subject women using chulla 64 women had reduced lung function. In 64 women Forced expiratory volume in one second ($FEV_1\%$) is less than 80% ($FEV_1\% < 80\%$) and ratio of $FEV_1\%/FVC\% < 80\%$. In 64 women obstructive type of Chronic Obstructive Pulmonary Disease (COPD) was found.

Keywords: *Biomass Fuel, $FEV_1\%$ (Forced Expiratory Volume per one second), indoor air pollution, forced vital capacity, COPD.*

INTRODUCTION:

In developing countries majority of households uses biomass fuel for cooking and heating purpose. Desai *et al.* (2004) Cooking is the most important activity contributing to Indoor air pollution. Jin *et al.* (2005). Wood and other form of biomass, animal dung and crop residues are commonly used as source of energy in developing countries. Albalak *et al.* (1997) In rural India nearly 90% of the primary energy is derived from biomass (wood 56%, crop residues 16%, dung 21%) Balkrishna *et al.* (2002). Three quarters of all households in India use processed biomass as their primary fuel for cooking and among these primary fuel for cooking and among these more than 90% use either wood or animal dung IIPS (1995).

Due to easy availability of biomass fuel women from rural are uses biomass fuel such as crop residue and wood for cooking heating purpose. Kitchens are not properly ventilated. Incomplete combustion of biomass fuel release smoke which contains high volume and number of air pollutantants such as PM, CO, NO_2, SO_2. Inhalation of smoke causes adverse effect on respiratory system, it reduces the lung function that is Forced expiratory volume in one second causes COPD and ratio FEV1%/FVC% < 80%.

Objectives:

- Survey of women using chulla and LPG from rural area Kakadwadi of Sangli district.
- To estimate forced expiratory volume per one second in percentage, ($FEV_1\%$), Forced Vital Capacity in percentage (FVC%) and Ratio of forced expiratory volume per one second and Forced Vital Capacity in Percentage (FEV_1/FVC%).

MATERIAL METHODS:

For this study we selected Kakadwadi rural area of Sangli district, which is 6 to 8 km away from Sangli City. Survey of women using chulla and LPG was done from this rural area. We selected 100 women using chulla and LPG. All women participated in this study are above 35 yrs of age and are from low socio economic status. Information regarding type of house, type of kitchen, number of hours and number of years exposed to biomass fuel and LPG was collected. Spirometery was done in total 200 women. Spirometric parameters Forced Expiratory Volume in One Second ($FEV_1\%$), Forced Vital Capacity (FVC%) and ratio of $FEV_1/FEV\%$ were recorded.

STATISTICAL ANALYSIS: (Gupta and Kappor, 1983)

i) Calculated Z test based on null hypothesis:

The formula and interpretation of Z test is :

$$Cal\ |z| = \left[\frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{\sigma 1^2}{n_1} + \frac{\sigma 2^2}{n_2}}}\right]$$

$\bar{x}_1$ Mean of Control $\overline{x_2}$ Mean of Subject

$\overline{\sigma_1}$ Standard deviation of Control

$\overline{\sigma_2}$ Standard deviation of subject

n_1= Number of observations of control

n_2 = Number of observations of subject

H_0: There is no significant difference between control and subject women FEV_1.

Vs

H_1: There is significant difference between control and subject women FEV_1.

Cal |Z| = > table Z = 1.96 at 5% level of significance. If Z value is greater than table value 1.96 then

∴ Reject H_0

∴ There is significance difference between control and subject.

OBSERVATION:

From Table No.1 it is observed that 100 women using LPG, live in concrete house and use indoor kitchen. From this 90 women using LPG for greater than 4 years and 10 women using LPG less than 4 years. 86 women using LPG for more than 15 years and 14 women using LPG less than 15 years. From control group 99 women are literate and 1 woman is illiterate.

From Table No. 2 in subject group it is observed that 83 women using Biomass fuel, wood and 17 women using wood and dung. 97 women living in kutcha type of houses and 3 women in semikutcha type of house. Total 100 subject women using indoor kitchen. 86 women exposed to biomass fuel for more than 15 years and 14 women exposed to biomass fuel for less than 15 years. 87 women exposed to biomass fuel for greater than 6 hours and 13 women exposed to biomass fuel for less than 6 hours. In subject group 96 women were illiterate and 4 women were literate.

Observations on spirometry (in percentage) of women exposed to biomass fuel from Kakadwadi village

Table No.3 represents observations on Age, years of exposure and spirometry (in percentage) of control and Subject women in the village Kakadwadi. 100 women using LPG (Control) and 100 women using chulla (Subject) from village Kakadwadi were selected for the study of spirometry. The values of Age, years of exposure and the values of $FEV_1\%$, FVC%, $FEV_1/FVC\%$ in percentage of each control and Subject women were recorded in Table No. 3. The mean values and Z values of Age, years of exposure and $FEV_1\%$, FVC%, $FEV_1/FVC\%$ from this table are as below.

The mean values of Age and years of exposure of control women are 41.50 and 21.77. While mean values of Age and year of exposure of subject women are 42.62 and 22.44. The mean values of $FEV_1\%$, FVC%, $FEV_1/FVC\%$, of control women are 97.83,

90.94 and 86.10 respectively, the mean values of FEV_1%, FVC%, FEV_1/FVC% of Subject women are 68.05, 76.21 and 77.04 respectively. These values are shown at the base of each column in the Table No. 1.

The calculated Z value of Age and years of exposure and calculated Z value of FEV_1%, FVC%, FEV_1/FVC% based on null hypothesis are at the last of each column in the Table No.3. The calculated Z value of Age and years of exposure are 1.88 and 0.93. The calculated Z values of Age and years of exposure are less than table value 1.96 hence there is no significant difference in age and year of exposure of control and subject women. While calculated Z values of FEV_1%, FVC% and FEV_1/FVC% are 9.97, 4.81 and 8.77 respectively. The calculated Z values of FEV_1%, FVC%, FEV_1/FVC% are greater than table value 1.96 hence there is significant difference in FEV_1%, FVC%, FEV_1/FVC% of control and Subject women. The result is significant at 5% level of significance.

RESULT & DISCUSSION :

In present study out of 100 subject women 64 women had FEV_1% < 80% and ration of FEV_1% / FVC% < 80%. In the rural area of Kakadwadi, women from low socio economic status uses biomass fuel wood and dung. Majority of women exposed to biomass fuel smoke more than 15 yrs and more than 6 hrs per day. These women suffered from COPD which is obstructive type of disorder.

In obstructive type of spirometry pattern there is narrowing of small airway due to chronic inflammation. According to Dennis *et al.* (1996), Orozco *et al.* (2006), Caballero *et al.* (2006) the reduction in FEV_1% and FEV_1%/ FVC% may be due to chronic inhalation of toxic substance emitted during biomass combustion leading to inflammatory changes in (bronchi and bronchioles) FEV_1% < 80% and ration of Dutt *et al.* (1996) reported that the parameters FEV_1% and FEV_1%/ FVC% was significantly lower in biofuel users compared with both kerosene and LPG users.

Mangat *et al.* (2013) studied pulmonary function tests in rural women exposed to biomass fuel and reported that the lung function parameters FEV_1% and FEV_1/FVC% were significantly lower in the study group exposed to biomass fuel than control.

Similar types of results are observed in present investigation. In this study, 64 women out of 100 women had FEV_1% < 80% and FEV_1/FVC% < 80%. The results of spirometry of subject and control group shows that there was significant difference in the 'Z' values of parameters of spirometry (FEV_1% and FEV_1/FVC%). Statistical analysis showed that 'Z' values of FEV_1% and FEV_1/FVC% were significantly reduced in subject group as compared to control group.

CONCLUSION.

Prolonged exposure to biomass fuel smoke in poorly ventilated kitchen causes reduced lung functions and women suffered from Chronic Obstructive Pulmonary Piseases (COPD). In subject group the type of COPD observed was obstructive. As age and years of exposure increases COPD increases.

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Survey of LPG using women (n=100) as per House Type, Kitchen Type, Exposure Time, Exposure Year, Literacy.

Survey	House type	Kitchen type	Hours Exposure		Years of Exposure		Literacy	
	Concrete	Indoor	>4	<4	>15	<15	Literate	Illiterate
LPG	100	100	90	10	86	14	99	1
Total	100	100	100		100		100	

Survey of Biomass fuel using women (n=100) as per Use of fuel, Type of House, Exposure time, Exposure years, Literacy.

Survey	Women using Type of Fuel		Women using House type		Women using indoor Kitchen	No. of women Exposed for years		No. of women Exposed for hours per day		Data of women Literacy	
	Wood	Wood + Dung	Kutcha	Semikutcha		> 15 yrs	< 15 yrs	>6 hrs	<6 hrs	Literate	Illiterate
Biomass fuel	83	17	97	3	100	86	14	87	13	4	96
Total	100		100		100	100		100		100	

Table No. – 3
Data of Spirometry (FEV_1%, FVC%, FEV_1/FVC%) of Rural Women from Kakadwadi Exposed to Biomass smoke

Sr. No.	CONTROL					SUBJECT				
	Age	Years	FEV_1%	FVC%	FEV_1/ FVC%	Age	Years	FEV_1%	FVC%	FEV_1/ FVC%
1	38	12	82.56	61.07	83.04	38	20	57.27	60.82	79.75
2	40	20	98.03	91.30	88.69	45	21	98.03	125.37	88.69
3	38	21	95.54	91.43	86.16	58	38	77.82	99.00	78.61
4	39	20	82.56	61.07	83.04	38	20	73.94	98.00	75.45
5	46	27	121.33	114.67	86.26	45	27	21.56	25.74	69.23
6	43	13	98.03	91.30	88.69	42	14	67.02	99.00	67.70
7	37	18	79.00	61.07	79.53	52	32	21.56	25.74	69.23
8	45	26	98.03	91.30	88.69	49	30	54.46	67.47	69.05
9	40	20	98.03	91.30	88.69	50	31	61.43	77.69	66.15
10	48	14	121.33	114.67	86.26	45	26	61.43	77.69	66.15
11	47	28	101.27	96.37	86.02	45	27	76.23	99.25	76.81
12	42	23	68.00	114.67	48.34	50	30	58.28	63.45	76.00
13	36	20	101.27	96.37	86.02	47	26	50.00	58.15	70.09
14	38	21	92.79	91.43	86.16	49	30	21.56	25.74	69.23
15	42	11	121.33	114.67	86.26	40	17	54.46	67.47	69.05
16	38	20	101.27	96.37	86.02	45	26	61.43	77.69	66.15
17	41	22	98.03	91.30	88.69	41	24	53.37	102.01	52.32
18	43	23	87.58	86.26	88.47	55	37	51.54	53.22	73.63
19	41	24	87.33	58.93	79.39	45	25	54.46	67.47	69.05
20	39	12	121.33	114.67	86.26	45	14	71.19	96.36	73.88
21	42	22	98.03	91.30	88.69	43	26	30.43	40.36	75.40
22	45	26	101.27	96.37	86.02	45	22	98.03	135.48	88.69
23	40	20	92.79	91.43	86.16	40	19	52.21	78.36	66.63
24	43	23	82.56	61.07	83.04	45	13	101.27	96.37	86.02
25	42	23	87.58	86.26	88.47	50	30	95.54	91.43	86.16
26	40	21	121.33	114.67	86.26	39	21	68.80	88.36	77.86
27	38	12	87.58	86.26	88.47	38	18	121.33	114.67	86.26
28	39	20	98.03	91.30	88.69	40	19	63.11	82.06	76.91
29	43	26	87.58	86.26	88.47	38	17	92.79	91.43	86.16
30	45	27	121.33	114.67	86.26	46	25	121.33	114.67	86.26
31	48	29	101.27	96.37	86.02	38	22	76.23	96.63	78.89
32	41	23	82.56	61.07	83.04	36	19	49.22	63.45	76.00
33	49	12	98.03	91.30	88.69	45	25	21.56	25.74	69.23
34	40	20	82.56	39.29	129.09	41	20	87.58	86.26	88.47
35	49	30	98.03	91.30	88.69	48	30	87.33	58.72	79.39
36	46	29	87.58	86.26	88.47	40	20	87.58	86.26	88.47
37	43	27	98.03	91.30	88.69	45	23	98.03	91.30	88.69

Sr. No.	CONTROL					SUBJECT				
	Age	Years	FEV_1%	FVC%	FEV_1/ FVC%	Age	Years	FEV_1%	FVC%	FEV_1/ FVC%
38	49	14	121.33	114.67	86.26	40	20	98.03	91.30	88.69
39	47	29	101.27	96.37	86.02	48	27	52.59	71.63	73.42
40	40	21	101.27	96.37	86.02	40	20	101.27	96.37	86.02
41	48	30	121.33	114.67	86.26	50	30	95.54	91.43	86.16
42	42	24	121.33	114.67	86.26	55	14	50.00	58.15	70.09
43	40	23	98.03	91.30	88.69	43	21	94.67	114.67	67.30
44	44	27	87.58	86.26	88.47	45	27	53.37	73.36	72.75
45	42	24	87.33	90.66	79.39	41	23	54.46	67.47	69.05
46	54	36	73.79	80.49	76.77	42	23	48.55	53.22	73.63
47	44	24	101.27	96.37	86.02	48	30	21.56	25.74	69.23
48	38	20	92.79	91.43	86.16	45	14	82.00	71.85	83.04
49	49	30	87.58	86.26	88.47	38	20	30.43	41.12	74.00
50	42	24	92.79	91.43	86.16	41	21	92.79	91.43	86.16
51	41	20	92.79	91.43	86.16	43	22	21.56	25.74	69.23
52	38	18	82.56	61.07	83.04	40	20	92.79	91.43	86.16
53	38	13	78.00	61.07	78.36	38	18	121.33	114.67	86.26
54	39	17	87.33	58.51	79.39	42	25	54.46	67.47	69.05
55	43	24	92.79	91.43	86.16	45	20	51.64	72.62	71.11
56	41	21	82.56	61.07	83.04	39	14	95.07	88.54	86.16
57	36	18	95.54	91.43	86.16	40	20	21.56	25.74	69.23
58	38	19	83.04	61.07	83.04	37	18	121.33	114.67	86.26
59	37	14	87.33	90.66	79.39	40	17	87.33	89.67	79.39
60	36	17	92.79	91.43	86.16	45	24	87.58	86.26	88.47
61	38	20	83.04	61.07	83.04	38	20	54.46	67.47	69.05
62	41	21	83.04	61.07	83.04	45	28	21.56	25.74	69.23
63	39	23	98.03	91.30	88.69	38	19	61.43	77.69	66.15
64	42	26	121.33	114.67	86.26	40	14	53.37	69.36	76.95
65	37	20	121.33	114.67	86.26	48	30	55.36	71.61	77.31
66	44	28	71.00	36.36	103.89	37	19	98.03	91.30	88.69
67	40	24	92.79	91.43	86.16	39	20	56.74	72.41	78.36
68	39	21	101.27	96.37	86.02	47	30	21.56	25.74	69.23
69	40	14	87.58	86.26	88.47	38	20	98.03	91.30	88.69
70	39	23	121.33	114.67	86.26	38	17	51.82	65.78	78.78
71	44	27	101.27	96.37	86.02	38	18	54.38	73.36	74.13
72	48	30	101.27	96.37	86.02	42	13	55.36	77.56	71.38
73	37	20	92.79	91.43	86.16	50	25	101.27	121.57	86.02
74	39	21	121.33	114.67	86.26	42	25	51.63	66.63	77.49
75	36	20	98.03	91.30	88.69	42	24	53.40	67.39	79.24
76	41	12	101.27	96.37	86.02	36	18	61.43	77.69	66.15

Sr. No.	CONTROL					SUBJECT				
	Age	Years	FEV_1%	FVC%	FEV_1/ FVC%	Age	Years	FEV_1%	FVC%	FEV_1/ FVC%
77	38	20	98.03	91.30	88.69	38	20	95.54	92.18	86.16
78	40	25	87.58	86.26	88.47	40	14	121.33	114.67	86.26
79	39	20	98.03	91.30	88.69	43	22	83.53	77.73	83.04
80	43	25	87.33	90.66	79.39	45	23	54.63	71.79	76.10
81	41	24	87.33	90.66	79.39	48	30	61.43	77.69	66.15
82	40	22	121.33	114.67	86.26	40	21	92.79	91.43	86.16
83	39	21	87.33	90.66	79.39	38	14	111.66	114.67	86.26
84	38	20	98.03	91.30	88.69	37	21	55.31	73.36	75.40
85	41	21	121.33	114.67	86.26	50	30	58.36	76.63	76.16
86	44	13	101.27	96.37	86.02	42	22	87.33	58.10	79.39
87	41	23	101.27	96.37	86.02	40	23	57.27	60.82	79.75
88	38	20	92.79	91.43	86.16	43	26	54.46	67.47	69.05
89	48	31	121.33	114.67	86.26	41	18	21.56	25.74	69.23
90	39	21	98.03	91.30	88.69	42	25	54.46	67.47	69.05
91	43	27	92.79	91.43	86.16	40	23	52.36	69.36	75.49
92	37	20	121.33	114.67	86.26	41	20	70.94	91.36	77.65
93	48	30	82.56	61.07	83.04	45	26	78.40	99.36	78.90
94	37	20	98.03	91.30	88.69	38	18	87.58	86.26	88.47
95	39	14	121.33	114.67	86.26	35	26	70.94	92.45	76.73
96	45	25	98.03	91.30	88.69	38	23	21.56	25.74	69.23
97	38	20	121.33	114.67	86.26	40	24	98.03	91.30	88.69
98	40	21	87.58	86.26	88.47	38	23	98.03	91.30	88.69
99	41	22	98.03	91.30	88.69	36	18	83.53	61.07	83.04
100	49	30	121.33	114.67	86.26	40	22	54.46	67.47	69.05
Mean	41.50	21.77	97.83	90.94	86.10	42.62	22.44	68.05	76.21	77.04
Var.	14.11	25.44	187.81	310.02	43.80	21.52	26.95	704.79	627.69	63.04
Sqrt	0.60	0.72	2.99	3.06	1.03					
Z	-1.88	-0.93	9.97	4.81	8.77					

Figure No. 1: Data of Spirometry (FEV_1%, FVC%, FEV_1/FVC%) of Rural Women from Kakadwadi Exposed to Biomass smoke