

Original article:

Pulmonary function tests in rural women exposed to biomass fumes

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ABSTRACT:

Introduction: Exposure to the fumes produced as a result of burning of biomass used for cooking is considered a cause of chronic bronchitis, chronic airway obstruction and chronic obstructive pulmonary disease. The severity depends on duration of exposure. Present study was aimed to assess the lung function of rural women exposed to biomass fumes during cooking.

Methodology: Women from Agashivnagar (104), a village free from any type of industrial air pollution were participants. A control group of age matched women (50) from the same area but not exposed to biomass fumes was taken. Both the groups were brought in department of Physiology where the pulmonary function tests were done which included FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume in one second), FEV1/FVC ratio, PEF (Peak Expiratory Flow Rate), MVV (Maximum Voluntary Ventilation) were carried. Before doing pulmonary function tests both types of participants were clinically examined to rule out pre-existing respiratory or cardiac problem not caused by biomass fume exposure. The values of tests were compared among groups and analyzed.

Results: Compared to control group values of all tests (except FEV1/FVC ratio) were significantly reduced in study group women ($p < 0.05$). As per earlier studies done in India and abroad, we also found that there is impairment of the lung function in women exposed to biomass fumes compared to those not exposed to such fumes. The severity of exposure was directly related to the duration of exposure.

Conclusion: Exposure to biomass fumes during cooking causes lung dysfunction in women. Some measures should be taken to prevent such exposure to the biomass fumes by proper ventilation, such as using a chimney to vent out the fumes, or by using fuels those do not produce such fumes.

Key Words: Rural women , Cooking , Biomass fumes exposure , Pulmonary function tests

INTRODUCTION:

Nearly 50% of the world's population uses biomass fuels such as firewood, plant residues and cow/buffalo dung for cooking (1). Rural India still relies on unprocessed biomass such as wooden sticks or cow dung for their cooking purpose. These fuels

are burnt indoors in traditional *Chulha*, such as a pit, three pieces of brick, or a U-shaped construction made up from mud. These chulhas burn these fuels inefficiently and do not vent the fumes outside. This produces indoor air pollution of varying degree depending on the cooking or heating devices used

and type of dwelling. These fumes contain respirable sized particulate matter (PM10 and PM2.5), carbon monoxide (CO), Nitrogen oxides (NOx), sulfur oxides (SOx), formaldehyde, benzene, 1,3 butadiene, polycyclic aromatic hydrocarbons (such as benzo {a} pyrene), and many other toxic organic compounds (2), that can manifest from a simple cough to lung cancer (3). Other manifestations worth mentioning are miscarriage, stillbirth, low birth weight, early infant mortality, damage to the eye lens, cataract and disruption of endocrine function (4,5,6).

According to research done in India and outside India, exposure to the fumes produced as a result of burning of biomass used for cooking is considered a cause of chronic bronchitis, chronic airway obstruction and chronic obstructive pulmonary disease (7). Research has also shown that there is derangement of pulmonary function of women who are exposed to these fumes (8). However in a study conducted by AIIMS (INDIA), there was no any significant effect of biomass fumes on pulmonary functions from which they concluded that it was possibly due to better ventilation in the kitchens (9). Hence, a study in this field was necessary to determine whether cooking in closed rooms really produced derangement in the lung function of the women who cook on chulhas.

MATERIAL AND METHODS:

The subjects for the study were women (104) from Agashivnagar village of Karad Taluka, Dist – Satara (Maharashtra) and who were cooking for more than eight years on biomass fuels. The control group of women (50) was selected from the same residential area, but using fuels for cooking other than biomass such as LPG, kerosene and who were cooking for more than eight years. The control group was age matched with study group. Women having

pulmonary disorder (not related to the effect of biomass fumes) or heart disorder were excluded from the study. In addition women from control group were rejected if their standard of living was much higher than the subjects.

Women from both the groups were brought in the department of Physiology of Krishna institute of Medical Sciences, DU, Karad. Approval from Institutional Ethical Committee (IEC) was taken before starting the study. Informed written consent was also obtained from each participant woman including control ones. Initially general and systemic clinical examination was carried out to exclude gross pulmonary and heart disease, nervous system disorder etc.

Each subject was interviewed using, a modified ATS-78 questionnaire (10). Anthropometrical measurements were also taken.

Additional questions were asked to reveal the type of fuel used, duration of exposure per day for cooking and total duration of exposure in years. Lung functions were measured by Computerized Spirometer- “MEDSPIROR” (RMS Chandigarh, INDIA). Each subject was shown a demonstration of the test before actual test was carried out on her. A minimum of three readings were recorded of each test performed on every subject and the best of the three was selected having reproducibility and validity of the recorded parameters. The lung function parameters included were FVC (Forced Vital Capacity), FEV1 (Forced Expiratory Volume in one second), EFV1/FVC ratio, PEFR (Peak Expiratory Flow Rate) and MVV (Maximum Voluntary Ventilation). The actual values of all tests were taken.

STATISTICAL ANALYSIS: The data collected was summarized by computing mean and standard

deviation of each study variable. Analysis was done by applying paired 't' test and significance of difference was studied. The difference was said to be significant if $p < 0.05$.

RESULTS:

There were 104 individuals in the study group and 50 in the control group, who had no reason to be rejected. The data obtained from both these groups was analyzed. Anthropometrical measurements

(Table 1) showed that there was no significant difference in the age between control and study group ($p > 0.05$).

Table I: Anthropometrical and Demographic variables

Variable	Control group Mean ± SD N= 50	Study group Mean ± SD N= 104
Age (yrs)*	37.16 ± 8.62	37.92 ± 12.41
Height (cms)	155.58 ± 6.55	152.43 ± 5.57
Weight (kgs)	53.82 ± 11.19	47.07 ± 10.04

* $p > 0.05$

Table II: Results of pulmonary function tests in control and study group

Test	Control group Mean ± SD N = 64	Study group Mean ± SD N= 101	P value
FVC (L)	1.94 ± 0.37	1.62 ± 0.38	<0.0001
FEV1 (L)	1.74 ± 0.33	1.44 ± 0.36	0.0002
FEV1/FVC (%)	90.74 ± 6.31	98.15 ± 9.55	0.35
PEFR (L/S)	4.19 ± 1.17	3.11 ± 1.05	<0.0001
MVV (L/min)	69.48 ± 14.70	49.70 ± 14.11	<0.0001

FVC: Forced Vital Capacity; FEV1: Forced Expiratory Volume in first second; PEFR: Peak Expiratory Flow Rate; MVV: Maximum Voluntary Ventilation

The findings of pulmonary function test (Table 2) showed that values of FVC, FEV1, PEFR and MVV all were reduced in the study group compared to the control group, and the difference was statistically

significant. But there was no significant difference in FEV1/FVC ratio among two groups.

Out of 104 subjects, 10 % had complaints like dry cough and breathlessness. There were six cases of Asthma, out of which five cases had a family history.

DISCUSSION: Earlier studies done on this topic have shown some sort of derangement in the lung function of women who cook with biomass fuels compared to the women who cook with other fuels. In our study, women from both group, i.e. study group and control group were from the same geographical area of the country. There was no significant difference in their ages ($p>0.05$). The average exposure time to biomass fumes in study group was 3.5 hours a day. The duration of exposure was ranging from 8 to 30 years.

The selected study group was of non-smoking women, of a village free from all sorts of air pollution produced by industries. The subjects chosen lived in a one-room house without any windows and cooked on chulha, indoors only. This condition ensured that these women were only exposed to the polluting effect of the biomass fumes, which could probably be the only cause for derangement in their lung function, in any.

The control group selected was also of non-smoking women from the same village and residing in similar houses but using L.P.G. or other fuels (such as kerosene) for cooking. Selection of this control group reduced the bias to minimum, as other living conditions were the same.

When we compared the results of the pulmonary function tests, it was found that values of all test parameters (FVC, FEV1, PEFV and MVV) were significantly reduced ($p<0.05$) in the study group compared to the control group. After analyzing the

results for type of lung dysfunction it was found that the reduction in FVC was more than that in FEV1.

In the study group, FEV1/FVC ratio was normal in all women. This finding indicates that a parenchymal (restrictive) lung disease. Earlier studies done in India also indicated the same (11). Most women had mild and a few had moderate type of disease. Mild impairment was detected in those women who were exposed for duration ranging from 8 to 15 years and moderate impairment was detected in those having exposure for more than 15 years. In a study done at AIIMS New Delhi no adverse effect of the biomass fumes on lung function was found which they concluded, was due to better ventilation of houses (9). In other studies done in India (8, 12) a considerable lung dysfunction was found in women using biomass fuels, which correlates to the findings of our study.

Various studies have looked at air pollution inside dwellings from wood, dried cow dung, straw and plant residues for cooking in non-developed and developed countries. WHO? IDRC International Study Group on air pollution and childhood pneumonia, have suggested that harmful gases and particles reach a high level inside the dwellings owing to the use of these biomass fuels for cooking(13).

In India especially in the rural areas biomass fuels such as dried cow/ buffalo dung and wooden sticks are widely used as cooking fuels. Women are exposed to biomass fumes as they do the cooking. In rural and the suburban areas of developing countries where biomass fuels are used, air pollution inside the dwellings usually reaches up to $1000 \mu\text{g}/\text{m}^3$ and during cooking it reaches up to $10000 \mu\text{g}/\text{m}^3$. Thus it can be concluded that when biomass fuels are used in

traditional chulhas/ stoves the risk of developing lung dysfunction increases very high (14).

CONCLUSION: The exposure of women to fumes of biomass, used for cooking causes lung dysfunction. The type of dysfunction of lungs is of restrictive type. The degree of deterioration of lung function correlates with duration of exposure.

RECOMMENDATION: These fuels are used in stoves inside homes without chimney and without sufficient air circulation. So, use of more advanced stoves with chimneys and using fuels that do not produce such fumes should be introduced to avoid

exposure of these women. This will help them to avoid lung dysfunction.

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