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SHORT COMMUNICATION

EFFECT OF INDOOR AIR POLLUTION DURING COOKING ON PEAK EXPIRATORY FLOW RATE AND ITS ASSOCIATION WITH EXPOSURE INDEX IN RURAL WOMEN

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Abstract : Routine exposure to domestic cooking fuels is an important source of indoor air pollution causing deterioration of lung function. We conducted a community based cross-sectional study in 760 non-smoking rural women involved in household cooking with four types of cooking fuels i.e. Biomass, Kerosene stove, Liquid Petroleum Gas (LPG) and Mixed (combination of two and more cooking fuels). Peak Expiratory Flow Rate (PEFR) less than 80% of the predicted was considered as abnormal PEFR. The overall prevalence of abnormal PEFR was found to be 29.1% with greater predominance among biomass fuel users (43.3%) with high risk ratio (1.86) as compared to kerosene (0.63), LPG (0.75) and mixed (0.66) fuel users. However the pair wise comparison of different groups of cooking fuels by Marascuilo procedure reported significant differences within different groups except kerosene - mixed group. The study also demonstrated a negative correlation between observed PEFR and exposure indices in different cooking fuels (r=–0.51). Our results indicate that prolonged exposure to cooking fuels particularly biomass fuels as a source of cooking adversely affects PEFR in nonsmoking rural women.

Key words : indoor pollution biomass fuel cooking fuels peak expiratory flow rate (PEFR)

INTRODUCTION

According to the World Health Organization, Indoor Air Pollution (IAP) from solid fuels ranks fourth amongst risks to human health in developing countries and ranks still higher in India (third), just below malnutrition and lack of safe sanitation and drinking water. Specifically, IAP every year is responsible for the death of 1.6 million

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people i.e. one death every 20 seconds with the overall disease burden exceeding the burden from outdoor air pollution fivefold. As compared to other countries, India has among the largest burden of disease and 28% of all deaths due to IAP in developing countries occur in India alone (1). Many rural populations in many developing countries are regularly exposed to biomass smoke inside their houses. The incomplete combustion of biomass fuels like wood, coal, cow dung cakes and crop residues releases byproducts like carbon monoxide, carbon dioxide, sulphur dioxide, polycyclic and polyaromatic hydrocarbons which are known to produce adverse health effects particularly on lungs. Among these conditions are acute respiratory infections in children and chronic obstructive pulmonary diseases in adults (2, 3). There have been only few studies of the respiratory effect of such exposure on health in rural population of central India where the use of various domestic cooking fuels is so rampant. Hence we endeavored to conduct this project for analyzing the respiratory health effects of non-smoking rural women routinely exposed to domestic cooking fuels.

METHODS

A community based cross-sectional study was conducted on 760 women in Raipura village of Hingna tehesil, district Nagpur. Raipura village is a field practice area of rural health training centre, Hingna, under the administrative control of department of Preventive and Social Medicine, Indira Gandhi Government Medical College (IGGMC), Nagpur. Demographic data of Raipura village was obtained from health survey register of primary health centre, Hingna. Accordingly, total population of Raipura was 7635. Out of these, rural health training centre adopted 500 families covering approximately a population of 2,500. The area is totally free from industrial and atmospheric pollution. Eligibility criteria for this study were: i) age>15 years; ii) principal cook of family; iii) non-smoker; and iv) an informed consent. On the basis of pilot study done on 100 study subjects, the estimated prevalence of abnormal PEFR was found to be 40%. Taking p = 40%, 95% Confidence Interval (CI) and assuming 10% allowable error; the minimum sample size required was calculated as 576. But in our study sample, the number of women aged 15 years and above was found to be 760. Therefore the final study constituted 760 women who spend considerable time near the fireplace and were consistently using the same type of cooking fuels throughout the study period. The study was conducted in 2004 over a period of two years and was approved by the Institutional Ethics Committee of IGGMC, Nagpur.

Women were interviewed by house to house survey. After obtaining informed consent from women, they were subjected to detailed socio-demographic profile as well as place of cooking, type of ventilation in the kitchen, number of windows, presence or absence of smoke vent (chimney) in the kitchen, culinary profile like type of cooking fuel used including fuel used in the parent's house before marriage as per the pre-designed proforma. Cooking variables included the time spent in hours in household cooking per day and the number of years of cooking. Accordingly, hour-years of exposure (exposure index) was calculated by multiplying the number of hours spent in a day for cooking and the number of years of cooking (4, 5, 6).

Complete clinical examination, including general and systemic examination was done. Anthropometric measurement like height was measured in standing position and without shoes and weight was recorded with minimal clothing. Finally, abnormal pulmonary function of the study subjects was assessed by peak expiratory flow rate (PEFR) according to standards recommended by American Thoracic Society (7). Peak expiratory flow rate was measured in liters per minute with a calibrated Mini Wright's Peak Flow Meter after explaining and demonstrating the procedure to each study subject. Overall, three readings were recorded in each study subject and the highest of these three readings was considered as a representative value. Observed PEFR was calculated on the basis of age in years and height in centimeters. Expected PEFR was calculated as 3.310*height (cms) – 1.865*age (years) – 81.0. Abnormal PEFR was defined as PEFR less than 80% of the predicted (8).

Statistical analysis

Percentages were calculated. The pair wise comparison of different groups of cooking fuels was determined by Marascuilo procedure. If the absolute difference was greater than its critical range, the proportions were termed as significantly different. Pearson's correlation coefficient was calculated to test the correlation between exposure index and different types of cooking fuels with observed PEFR. The level of significance was set at $P<0.05$ throughout the study.

RESULTS

Depending on the use of cooking fuels, our study subjects were classified into one of the following four groups: biomass fuels (n=252); kerosene stove (n=73); LPG (n=192) and mixed fuel (n=243). PEFR distribution of study subjects (Table I) showed that out of total 760 study subjects, 539 (70.9%) had normal PEFR and 221 (29.1%) had abnormal PEFR. On comparison amongst study subjects using different types of cooking fuels, proportion of biomass users with abnormal PEFR was more 109 (43.3%) as compared to kerosene users 15(20.5%), LPG users 45 (23.4%) and mixed fuel users 52 (21.4%). Also, the risk ratio was found to be highest for biomass users (1.86) as compared to kerosene (0.63), LPG (0.75) and mixed (0.66) fuel users. Moreover the pair wise comparison of different groups of cooking fuels by Marascuilo procedure reported significant differences within different groups except kerosene – mixed group.

The correlation of lung function parameter (observed PEFR) with exposure

TABLE I: PEFR distribution among study subjects.

Abnormal PEFR	*Biomass (n=252)*	*Kerosene (n=73)*	*LPG (n=192)*	*Mixed (n= 243)*	*Total (n=760)*
Yes	109 (43.3)	15 (20.5)	45 (23.4)	52 (21.4)	221 (29.1)
No	143 (56.7)	58 (79.5)	147 (76.6)	191 (78.6)	539 (70.9)
Risk ratio	1.86	0.63	0.75	0.66	–

Figures in parentheses indicate percentage.

indices in different cooking fuels (as shown in Fig. 1) showed a negative correlation of observed PEFR with exposure index in biomass, kerosene, LPG and mixed fuels (r = –0.51) respectively.

DISCUSSION

This study emphasizes the strong association of abnormal PEFR and indoor air pollution caused by domestic cooking fuels particularly biomass fuel for cooking associated with high hour-years of exposure (exposure index) in rural non-smoking women.

Overall the prevalence rate of abnormal pulmonary function amongst non-smoking women using bio-mass fuel was found to be 43.3%. This high prevalence is primarily due to the fact that they sit most of the time near the fire place in the dwellings which are overcrowded but not well ventilated and as such is much more exposed to domestic smoke. These observations are consistent with the findings of other investigators. Studies carried out in North India (5, 6, 9) reported PEFR to be lowest in the biomass fuel users when compared with kerosene, LPG and mixed fuel users and also showed a negative correlation with age and exposure index. Reddy TS et al., (4), also reported that the peak expiratory flow rate as a percentage of predicted (PEFR %) in women using biomass was significantly lower than in women using LPG for cooking (P<0.01). These findings correlate with our observations indicating that duration of exposure in years as well as use of biomass fuels for cooking are important determinant factors in deterioration of lung function.

Domestic smoke emissions, particularly from biomass contains many noxious components like carbon, nitrogen, oxygen,

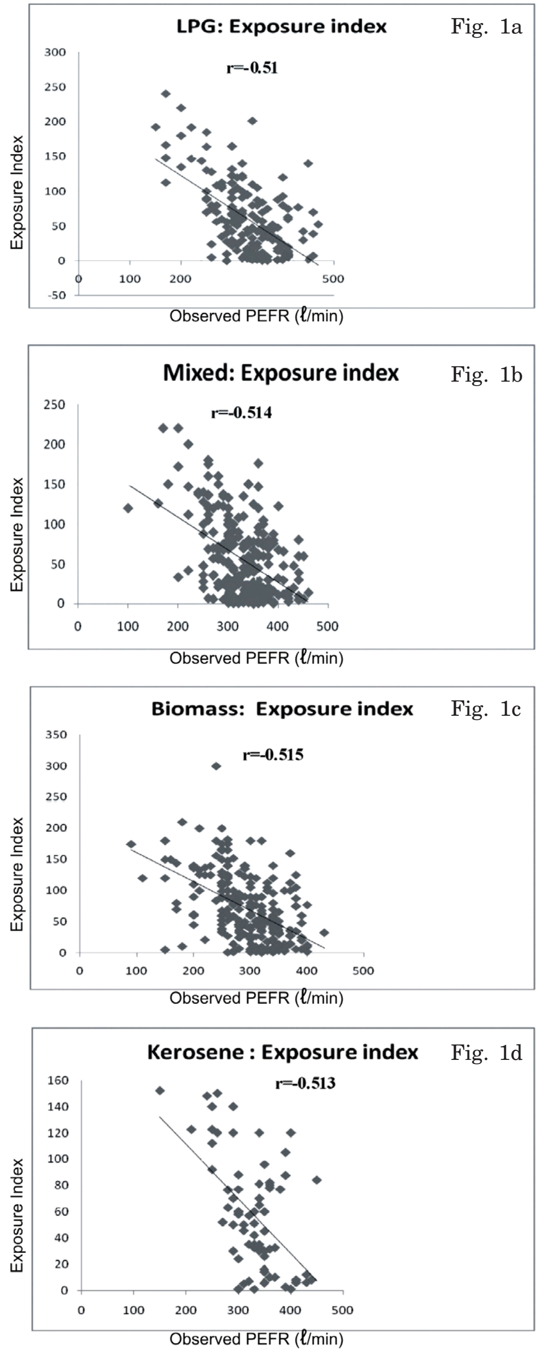

Fig. 1: Showing correlation of observed PEFR with exposure index and regression equation as follows.

Fig. 1a : Biomass ($y = -0.462x + 206.7$; $R^2 = 0.251$)

Fig. 1b : Kerosene ($y = -0.415x + 194.3$; $R^2 = 0.275$)

Fig. 1c : LPG ($y = -0.476x + 218.3$; $R^2 = 0.311$)

Fig. 1d : Mixed ($y = -0.409x + 190.5$; $R^2 = 0.216$)

hydrogen, oxides of nitrogen, carbon monoxide, sulphur dioxide, unburnt suspended particulate matter (SPM), polycyclic organic matter (POM) which includes a number of known carcinogens called Benzo (a) Pyrene as well as poly aromatic hydrocarbons which compromises the pulmonary immune system that triggers the development of abnormal PEFR. It could also facilitate the spread of infection by bringing about respiratory symptoms like coughing, phlegm, breathlessness and nasal irritation. Domestic smoke and other pulmonary irritants have been repeatedly shown to be risk factors in the development of abnormal PEFR and plausible biological mechanisms have been identified. Bronchial irritation from smoke exposure appears to disrupt the mucociliary defenses of the lungs, and decrease both cellular immunity and humoral immunity (10).

Thus the present study indicates that prolonged exposure to cooking fuels particularly biomass fuels as a source of cooking adversely affects PEFR in nonsmoking rural women. The results of our study and the support of the available literature on indoor air pollution and respiratory health effects suggest a clinical and statistically significant association between domestic cooking fuels and abnormal PEFR.

The slow pace of development in many countries indicates that dangerous, smoky cooking stoves will remain in widespread use for decades throughout most parts of the developing world. Interventions to control indoor air pollution resulting from combustion of solid fuels have been limited and show only mixed results. To reduce the morbidity and mortality from indoor air pollution, countermeasures have to be developed that are practical, efficient, sustainable and economical with involvement from the government, the commercial sector, and individuals. Further research is required to develop practical, robust and valid methods for measuring exposure levels and patterns for both field studies of health risk and the evaluation of interventions.

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