EFFECTS OF EXPOSURE TO INDOOR AIR POLLUTION FROM BIOMASS FUEL SMOKE ON PULMONARY HEALTH IN WOMEN OF RURAL-URBAN INDIAN VILLAGES

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Chapter 5

CONCLUSIONS AND FUTURE SCOPE

This chapter deals with the conclusions and future scope of work. It reviews the outcomes of present study and explores the scope for further research in the environment and public health domain. As an extension of the current research work, suggestions on future direction of the work are also elaborated in the chapter.

The findings of present research work could help in strengthening the existing policies and implementing the management strategies regarding switching to alternative cleaner sources of energy for cooking purposes, and reduction of air pollution load in urban and rural villages for decreasing the prevalence of respiratory morbidities in these areas.

The work presented in this thesis was undertaken to estimate the prevalence of respiratory morbidities in rural and urban villages of Northern India and characterise the fuel use pattern for cooking in these locations.

The prime importance of the work relates to the ability of carbonaceous aerosols and hazardous gases released from biomass smoke to impact the lung function of women

due to constriction of the airway smooth muscles and irritation of the mucous glands, leading to wheezing and overproduction of sputum.

5.1. Rural Village

5.1.1. Indoor air quality assessment

The study shows higher exposure concentrations of particulate matter (PM_{10}, $PM_{2.5}$ as well as PM_1) and black carbon (BC) aerosols generated from biomass fuel smoke while cooking on traditional cook stoves. The data was analysed to investigate the nine hour average and peak concentration including morning cooking hours in houses of rural village. The results showcased that primary cook (women) and other inhabitants were exposed to a greater concentration of PM, than prescribed by WHO standards internationally (25 μg/m3 24-h mean) and CPCB standards nationally.

It was also observed that the pollutant levels returned to pre-cooking levels after almost 3 h in households cooking on biomass fuel as opposed to just one hour in the households cooking on LPG. This was attributed to their persistence because of poor ventilation in the kitchen.

5.1.2. Baseline Characteristics

The study also provides information on the baseline characteristics of all the women participants to comprehend their living conditions and personal demographics. Majority of women cooking on biomass fuel were older as compared to women cooking on LPG, showing their reluctance in switching from conventional cooking practices. Verbal communications to the household inhabitants also revealed that there were aesthetic values attached to the food cooked on traditional stoves.

Where it was felt that women in middle socio-economic group had switched to LPG under various schemes provided by the government but, lower socio-economic group continued using biomass fuel as their primary cooking fuel. However in majority of the houses, even after availing the subsidies on LPG connections, procuring recurrent LPG cylinders was cited as concern. Women in both the groups were exposed to environment tobacco smoke.

5.1.3. Respiratory symptoms

The study provided detailed information on the respiratory symptoms of women in both the groups. There were significant differences in the respiratory symptoms of the women in both the groups, with percentage of women cooking on biomass fuel complaining more respiratory difficulties as compared to women cooking on LPG. While dyspnoea measured on mMRC scale ≥Grade 2 was significantly different in both the groups, women also exhibited symptoms like wheezing, chronic cough, chronic sputum production as well as nocturnal cough. Many of the women cooking on biomass fuel also inhaled therapies and the differences were found statistically significant. It could be inferred from the study that women cooking on biomass fuel were at significantly higher risk of reporting difficulties in respiratory functions.

5.1.4. Pulmonary Function Test results

The study also involved performing spirometry on women participants to obtain data on lung function indices. In general, the participants in biomass fuel group had lower lung function than women cooking using LPG.

While the spirometry results were obstructive, restrictive and mixed in both the populations, significantly higher number of women cooking on biomass fuel had pure obstructive defect. It was inferred from the study that a significant decline in

the respiratory indices was seen in the group using Biomass fuel as compared to the one using LPG.

5.1.5. Correlation between respiratory indices, particulate matter and duration of exposure to biomass

To check the relation between the respiratory indices and particulate matter along with the duration of exposure correlation was performed. A significant negative correlation between the respiratory indices and number of years spent on cooking suggested higher decline in lung function with increase in years of exposure.

Furthermore, negative correlation with particulate matter concentration and respiratory indices suggested risk of having poor lung function with increased concentration of particulate matter due to exposure to biomass fuel.

5.1.6. Factors associated with abnormal spirometry

The study highlights the Odds of having abnormal spirometry due to exposure to biomass fuels after adjusting the potential confounders. It was inferred from the results presented in the study that odds of having abnormal spirometry increased with the use of biomass fuel and its duration of exposure in years. It was also seen that the increase in the PM_{10} and $PM_{2.5}$ concentrations by 100 $\mu g/m^3$ increased the risk of having an abnormal PFT by approximately 36% and 39%, respectively.

The current study shows that household using BMF have higher levels of PM and have more respiratory complaints and reduced lung function. The use of BMFs increases the Probability of a reduced lung function. It is important to use safer alternative fuels and/or develop techniques to mitigate the deleterious effects of indoor air pollution.

5.2. Urban Village

5.2.1. Indoor air quality assessment

The study uncovers the exposure concentrations of particulate matter (PM_{10}, $PM_{2.5}$ as well as PM_1) and black carbon (BC) aerosols in indoor environment of kitchens of houses cooking on LPG and having unplanned haphazard construction of an urban village. The study focussed on ventilation characteristics of the houses and kitchen and divided them in two groups.

The results showcased that primary cook (women) and other inhabitants in poorly ventilated households were exposed to a higher concentration of PM, than prescribed by WHO standards internationally (25 $\mu g/m^3$ 24‑h mean) and CPCB standards nationally. Surprisingly, even after using cleaner fuel like LPG the pollutant concentration was found high in these houses which could be attributed to the unplanned poorly ventilated constructions causing retention of these pollutants indoors.

5.2.2. Baseline Characteristics

The study also provides information on the baseline characteristics of all the women participants to comprehend their living conditions and personal demographics. Significant differences in the age distribution, education status of individual women as well as family was found. The total income of the family was also significantly different in both the groups suggesting a quite lower socio-economic status of the women residing in houses with poor ventilation where mostly cooking space was common with the bedrooms.

5.2.3. Respiratory symptoms

The study provided detailed information on the respiratory symptoms of women in both the groups studied. There were significant differences in the respiratory

symptoms of the women in both the groups, with percentage of women in poorly ventilated and congested settings complaining more respiratory difficulties as compared to women cooking on LPG.

While dyspnoea was presented as most prevalent symptoms in poorly ventilated group the difference was significantly different in both the groups and wheezing was not found statistically significant. Women also presented symptoms like chronic cough and chronic sputum production.

5.2.4. Pulmonary Function Test results

The study also involved performing spirometry on women participants to obtain data on lung function indices. In general, the participants in poorly ventilated group had lower lung function than women belonging to adequately ventilated group. However, the fuel used for cooking was LPG in both the groups.

The primary spirometry abnormality observed was restrictive in nature. It was inferred from the study that poor ventilation and unplanned haphazard construction of houses have a significant impact on pulmonary health of household women.

5.2.5. Relationship between PM levels and respiratory symptoms

In our study, a significant association of respiratory symptoms was found with $PM_{2.5}$ and $PM_{1.}$ This suggested that finer particles released from LPG and that were retained due to poor ventilation and unplanned construction had significant bearing on respiratory health of women dwellers.

Our study found higher number of women with airway restriction and obstruction in poorly ventilated households than in adequately ventilated households. Significant differences were observed between the two groups of households for assessed air quality parameters. Also, it was observed that wheezing, cough in the

morning, phlegm for at least 3 consecutive months were associated with higher PM2.5 and PM1 concentrations.

Restrictive pattern observed in the study was hypothesised to be associated with the inhalation of fine particles like PM1 and PM2.5 that could have been generated due to LPG and other sources of indoor air pollution as also suggested by previous studies (Corbo *et al.*, 2001; Moran *et al.,* 1999). Furthermore, the retention of these particles inside the houses could be associated with the poor ventilation characteristics and unplanned construction of the houses in an urban village.

5.3. Future Scope of work

Although our study measured the concentration of PM_{10}, $PM_{2.5}$, PM_1 and Black Carbon (BC) other pollutants such as volatile organic compounds and gases such as carbon monoxide were not studied. Furthermore, a detailed PFT including diffusion capacity and body plethysmography could not be performed to further categorize the participants with an abnormal PFT.

Although the adverse effects of indoor air pollution include long-term extra pulmonary manifestations, the current study did not attempt to study them. We suggest that in future, studies focusing on interventions to mitigate the ill effects of BMF and their long-term impacts need to be conducted. Such interventions can include engineering methods to reduce exposure to PM, provision of ventilation, and shifting to cleaner cooking fuels.

Future studies should be conducted with larger areas and improved long term PM monitoring methodology to provide trends on PM levels by emphasizing on variables such as time of exposure and professional exposure to PM.