Effects of Biomass Fuel Generated Indoor Air Pollution on Prevalence of Self-reported Asthma among Adult Women in North Indian Rural Villages

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Abstract

Background: Biomass and solid fuels are major contributors to Indoor Air Pollution (IAP) in developing nations and have high associated mortality risks as reported by WHO. A number of studies have focused on ambient air quality and its associated risk of asthma attacks, but fewer studies focus on health impacts from IAP.

Methods: A cross-sectional population survey including 310 women participants was conducted in rural villages of western Uttar Pradesh to record self-reported prevalence of asthma. Indoor air quality for PM₁₀ and PM₂.₅ was assessed and recorded for eight hours, per each household of these women residents. Regression models were generated to estimate the effects of cooking smoke on self-reported asthma.

Results: Average concentration of PM₁₀ and PM₂.₅ was significantly higher in the houses cooking using biomass fuel (BMF) as opposed to the ones cooking using LPG (p<0.01). Finding of this study suggest that women exposed to biomass fuel smoke are at a higher risk of reporting asthma than the ones using cleaner fuels like LPG (OR: 1.32; 95%CI 1.082-1.53; p<0.01).

Conclusions: Self-reported asthma was more prevalent in women that were found using BMF as a major cooking fuel. Results from this study may have important implications in terms of policy intervention at national and international level for developing nations like India, where majority of population rely on BMF as a cooking solution.

Keywords: Asthma, Biomass fuel, Indoor air pollution, Particulate matter

Introduction

About half of the world and almost all developing countries rely on biomass as an energy source for cooking and heating purposes. This reliance is as high as 80% in the developing countries of South Asia and sub-Saharan Africa.¹ Burning of these solid fuels indoor in open fires or in traditional cooking stoves (chulhas) results in high levels of toxic air pollutants like PM₁₀, PM₂.₅, VOCs and obnoxious gases like CO, SO₂, and NO₂ in the kitchen area. Exposure to this indoor air pollution (IAP) produced from traditional cooking practices that utilize biomass fuel (BMF) like dung cake, wood and coal, poses a significant health threat to the inhabitants.²³

Traditional cooking settings typically burn BMF in a U-shaped
mud constructed stoves or three pieces of bricks stove that burn these unprocessed fuels partially and are often not adequately vented with flues or hoods. Even when such settings are vented to the outside, combustion of these solid fuels produces enough pollution to considerably affect the air pollution levels of immediate surroundings, adding on to the total exposure. In most of the cases, cooking stoves are used for long hours in a day, thereby increasing the exposure effectiveness that leads to higher percentage of pollutants reaching people's breathing zones. The average and peak concentration of pollutants in BMF settings, usually exceed the guideline levels of 24 h concentration recommended by WHO. Various studies from countries like India have shown a higher prevalence of non-communicable respiratory diseases (NCDs) like Chronic obstructive pulmonary disease (COPD), asthma and reduced lung function associated with solid fuel use, both in children and in adults, particularly in females involved in cooking. Use of these fuels has also been recently linked with various cardiovascular morbidities and other respiratory infections like acute lower respiratory infection (ALRI) in the exposed group. NCDs such as asthma is often characterized by sudden attacks of, chest tightness, laboured breathing and coughing, particularly at night or in the early morning. International variations in asthma prevalence, together with recent increases in many countries, have focused the attention on the role of air pollution. Also, exposure to several specific air pollutants, such as respirable particulate matter like PM$_{10}$, CO, O$_3$, SO$_2$, and NO$_x$, has been related with increased asthma symptoms. Although prevalence of Asthma has been much studied in urban areas and well linked to urban air pollution, it has been little studied in poor rural communities of less-developed countries. Amongst the limited studies that have reported data on this issue, few have reported a positive association between the exposure to biomass fuel and asthma, while others did not find any significant positive association. In current cross-sectional study, we examined the effects of exposure to indoor air pollution from biomass fuel smoke on the prevalence of self-reported asthma among these rural women of North-India.

**Methodology**

**Study Design and Population**

A population based cross-sectional study was conducted in a rural village of western Uttar Pradesh, India. Households were sequentially visited to identify the primary cooking fuel and were divided into two groups 1) Biomass fuel group and 2) LPG group, using a stratified random sampling technique. Out of the 220 households surveyed, only 164 households agreed for indoor air quality measurement and 310 women inhabitants participated in the questionnaire survey.

**Indoor Air Quality Measurement**

Indoor air quality for PM$_{10}$ and PM$_{2.5}$ was measured at an interval of 5 min in 164 households from morning 9 AM till evening 5:00 PM, including morning cooking hours, using GRIMM aerosol spectrometer (model number 1.108, Germany). Instrument was placed at a height of 2 meters above the ground in the kitchen area to measure the direct exposure among inhabitants.

**Questionnaire Survey**

An Indian Council of Medical Research (ICMR) validated questionnaire survey was administered by the interviewer among 310 women participants, to obtain the data on smoking, cooking details, history of cooking fuel, respiratory symptoms. History of asthma was obtained with the questions confirming ever asthma attack, asthma attack in last six months, inhalation of bronchodilators and nebulisers etc.

**Statistical Analysis**

Independent t-test was used to determine the difference between the concentration of PM$_{10}$ and PM$_{2.5}$ and baseline characteristics of the two groups. Logistic regression model was used to estimate the effects of cooking smoke (biomass vs LPG) on the prevalence of self-reported asthma after adjusting for potential confounders. Results were presented in the form of ODDS ratio with 95% Confidence Interval. All the analysis was done using SPSS 21. Ethical approval for the study was obtained from Institutes Ethics Committee of Vardhaman Mahavir Medical College and Safdarjung Hospital, New Delhi.

**Results**

Baseline characteristics suggested that women cooking on LPG were comparatively younger to the women cooking on Biomass and had a significant difference in the body mass index (BMI) of two groups; p <0.0001 (Table 1). Majority of the women in both the groups were also exposed to environmental tobacco smoke with no significant difference; p=0.982. The 9-h average value of PM$_{2.5}$ was found to be 728.90±50.20 µg/m$^3$ in biomass group vs 99.76±41.80 µg/m$^3$ in the LPG group (p <0.001). Average PM$_{10}$ concentration was found to be 890.26±59.59 µg/m$^3$ in biomass group vs 148.66±31.97 µg/m$^3$ in the LPG group. A significant difference between the number of women reporting the history of asthma was obtained between the two groups with 7.05% in biomass group and 0% in LPG group; p=0.0001. Around 11.18% of women in the biomass group reported a family history of asthma compared to only 3.57% in LPG group; p=0.013. Regression analysis suggested that effects of cooking on the risk of asthma increased with the use of biomass fuel in adult women of northern rural Indian village (OR 1.32; 95%CI 1.082-1.53; p<0.01). Positive association was also obtained between the duration of exposure to the reporting of asthma (OR: 1.68; 95% CI 0.65-4.33; p=0.03) (Table 2).
Discussion

Results from this study suggest that exposure to indoor air pollution from biomass fuel smoke is associated with the prevalence of asthma in adult women of this rural village. Further, a positive association with the duration of exposure to biomass fuel is suggestive of progression of disease with its continuous long-term exposure. Also, the extent of association was found coherent with that observed in previous other studies. Study also found a few percentages of women in the LPG group reporting asthma in their family history, this could be attributed to the previous use of biomass fuel in these households and a gradual shift to cleaner cooking practices. With a much higher number of women reporting asthma in the Biomass group compared to just 1 in the LPG group, strongly suggests the influence of biomass use on the risk of developing asthma. A significantly high percentage of women that were found using bronchodilators at some point in their life than the reported prevalence could be associated with possible prognosis of other non-communicable diseases like COPD, as supported by previous studies that reported the risk of COPD with cooking fuel. In a country like India, where clinical data on asthma is very weak, there could be bias in the study due to non-reporting of symptoms and ignorance of health of women in rural community, thereby not reporting the diseases in many cases. It is also important to mention here that accuracy of self-reported asthma is not as stout as clinical measures of asthma, but as asthma diagnosis has no such golden standard, perhaps one can rely on validated questionnaires over clinical measures.

Future studies with a larger sample coverage and better clinical measures of asthma are required to support the present findings and for further understanding the pathogenesis of disease.

Conclusion

This study raises an overlooked public health concern and strongly suggests the imperative need for public health awareness campaigns and intervention programmes in the rural population. Higher risk of asthma in the exposed women strongly recommends the substitution of traditional cooking practices with other cleaner cooking solutions like improved biomass cook-stoves and LPG. Also, an alarmingly high PM concentration in these houses, as compared to the WHO guidelines, demands focus on the community education of deleterious effects of using these traditional cooking practices with other cleaner cooking solutions like improved biomass cook-stoves and strategies to reduce their harmful impacts on health.

Conflict of Interest: None

References


Table 1. Baseline characteristics of the two groups

<table>
<thead>
<tr>
<th></th>
<th>Biomass group 170</th>
<th>LPG Group 140</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>42.52 ± 10.22</td>
<td>37.36 ± 10.78</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Age (years); mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body mass index (kg/m²); mean (SD)</td>
<td>22.74 ± 1.9</td>
<td>23.94 ± 3.02</td>
<td>&lt;0.01*</td>
</tr>
<tr>
<td>Smoking status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ever suffered from asthma</td>
<td>6 (3.52)</td>
<td>4 (2.85)</td>
<td>0.982</td>
</tr>
<tr>
<td>Environmental exposure</td>
<td>86 (50.59%)</td>
<td>71 (50.71%)</td>
<td></td>
</tr>
<tr>
<td>PM₁₀ (Mean ± SD), μg/m³</td>
<td>890.26 ± 59.59</td>
<td>148.66 ± 31.97</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>PM₂.₅ (Mean ± SD), μg/m³</td>
<td>728.90 ± 50.20</td>
<td>99.76 ± 41.80</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>Family history of asthma</td>
<td>12 (7.05%)</td>
<td>1 (0.71%)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Inhaled bronchodilators/ steroids</td>
<td>58 (34.12%)</td>
<td>4 (2.86%)</td>
<td>&lt;0.0001*</td>
</tr>
<tr>
<td>E (0.05%)</td>
<td></td>
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</tbody>
</table>

Table 2. Binary logistic regression to check the association of cooking on self-reported asthma

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio*</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking fuel</td>
<td>1.32</td>
<td>1.082-1.53</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>No. of years cooked on biomass</td>
<td>1.68</td>
<td>0.65-4.33</td>
<td>0.03</td>
</tr>
<tr>
<td>Hours spent in kitchen</td>
<td>0.67</td>
<td>0.21-2.09</td>
<td>0.498</td>
</tr>
</tbody>
</table>

*p<0.05.

*Adjusted effects (odds ratio (OR) and 95% confidence interval (CI) of cooking smoke).