Assessing Public Health Vulnerability due to Poor Indoor Air Quality: A Case Study of Rural Population of Rajasthan

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Abstract

Background: In the present day, indoor air pollution is a global issue affecting more than 3 billion lives due to the extensive use of solid biomass fuels. Indoor air pollution has been a major cause of cardiorespiratory illnesses in low- and middle-income countries, majorly affecting women and young children. There is a greater need to understand the drivers of rural health vulnerability associated with indoor air pollution.

Methods: A cross-sectional study was conducted in Indian rural setting to assess the impact of indoor biomass combustion on the respiratory health of households. A framework was designed and implemented to evaluate exposure source and risk factors associated with poor respiratory health in the subject population. A primary survey was conducted for 540 rural households belonging to different socio-economic strata. Three types of questionnaires (air quality assessment, socio-economic, health assessment) were used to investigate the determinants of health vulnerability due to exposure to indoor air pollution.

Results and Conclusion: A robust analysis displayed vulnerability of the exposed population. Risk estimation showcased high association between biomass combustion and morbidity. The findings suggest a rural ethos health determinant. The overall prevalence of chest illness is significantly affected by socio-economic indicators and environmental parameters.

Keywords: Biomass combustion, Indoor air pollution, Public health, Respiratory diseases, Women

Introduction

In the present day, indoor air pollution (IAP) is a global issue affecting more than 3 billion lives due to the extensive use of solid biomass fuels. Indoor air pollution (IAP) due to use of energy inefficient solid biomass fuels results in morbidity and mortality in vulnerable groups such as women and children. Prolonged exposure results in various cardiorespiratory diseases, eye-related diseases, stillbirth, low birth weight and acute lower respiratory infections (ALRI). Indoor air pollution is accountable for a substantial public health burden in low- and middle-income countries (LMICs). Heterogeneity in the health alters with determinants of exposure and duration.

Following this, the study establishes the linkages among health risk determinants in a heterogeneous population. After contemplation, a framework was designed and implemented to evaluate exposure source and risk factors associated with poor respiratory health in the subject population.

Materials and Methods

Study Area

The census data of 2011 for India showed that the overall socio-economic indicators and healthcare have worsened for the state of Rajasthan in the past few years. The Annual Health Survey report of Rajasthan (2012) revealed that...
Karauli district in Rajasthan (Figure 1) showed the highest number of cases registered for Tuberculosis and Acute Respiratory Infection in the Karauli district with comparable numbers among males and females.

The study was carried out from November 2016 to May 2017 in Kemla village, Karauli, Rajasthan. The study used a perception-based approach to evaluate air quality of the region. Simultaneously, the determinants of exposure and vulnerability were investigated to establish health risk vulnerability in exposed population.

A total of 540 households were sampled and individual face-to-face interviews were carried out with 2328 individuals. To estimate the extent of respiratory diseases prevalent in rural background, factors that link exposure with health were identified and significance of each of these confounding factors on the health of exposed population and inter-relationship among each other were determined. The air quality assessment survey questionnaire was developed and carried out to identify pollution sources, contribution and assess people's perception about the air quality. The socio-economic questionnaire determined correlation between different sub-systems such as physiological characteristics, behavioral characteristics, prevalence of disease, and expenditure on health. For health assessment, the British Medical Research Council (BMRC) questionnaire for respiratory symptoms was used. Similar survey questionnaires designs have been used in a study conducted in Rajasthan by Laxmi et al., 2003. Additionally, risk in exposed population was evaluated through stochastic estimations.

### Statistical Analysis

The study used various statistical tools and techniques to contemplate relationship between health and socio-economic variables. One of the most common and oldest multivariate data analysis tool is Principal Component Analysis (PCA). It provides an approximation of a data table, where ‘A’ being the data matrix is represented as a product of ‘B’ and ‘C’ matrices. Both these smaller matrices capture the patterns within matrix A. Columns of B would give dominant object patterns of A whereas plotting rows of C give complementary variable pattern. In general, in the data table obtained, the described variables are inter-correlated and this information is expressed as orthogonal variables, we refer to as ‘principal components’. This technique can be used to display inter-relationship between variables and unveil patterns hidden in the dataset. In this study, health outcomes and contributing factors are studied by the means of Principal Component Analysis (PCA) using IBM SPSS Statistics 21.0 software. This was performed by using principal component analysis as the extraction method with Oblimim with Kaiser Normalization as rotation and Eigen values above one were considered. Another technique used in the study is risk estimation. Relative risk, which is the measure of association between a disease and plausible risk factor was calculated. Further, portion of incidence of disease in the population due to exposure factor has also been calculated. This risk attributable to exposure in the population is called as the population attributable risk.

### Results

The air quality assessment survey revealed that the perception of indoor air quality in the region was poor owing to biomass combustion (Figure 2), mining, and smoking. About 58% of the population felt that the air quality is extremely poor and not suitable for their health. 71% people felt that biomass combustion during cooking is responsible for the poor indoor air quality. Despite the bad influence of poor air quality on the health of individuals, almost none of the households invested in preventive measures like installation of chimneys, using protective masks etc to protect themselves from exposure to pollution on a day-to-day basis.

Moreover, on an average, a women spent 1.8 hours in a day cooking in the kitchen, adding to the plight of rural women. Further, in a typical household, women spent a major portion of the day doing household chores like collecting and transporting fuelwood, extracting water and cleaning the house. Chief fuel requirement for the household was achieved by gathering tree branches from nearby ranch. Also, seasonally available crop residue was also used in traditional cookstoves by farmers/ agricultural laborers. About half of the village households had LPG connection, but, no means to buy refill cylinders due to budget constraints.
The BMRC health assessment survey (BMRC) showed high variability in respiratory health among different household. Cough and phlegm were found to be more prevalent among chief cooks of the households. Additionally, level of breathlessness varied within different fuel users while conducting activities like hurrying on ground level or walking up slight hill, walking with similar aged individuals etc. Also, tobacco smoking added to the poor respiratory health among smokers.

### Table 1. Principal component analysis of various drivers of chest illness in the subject population

<table>
<thead>
<tr>
<th></th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Type</td>
<td>-0.730</td>
<td>-0.197</td>
<td>0.120</td>
</tr>
<tr>
<td>Phlegm</td>
<td>0.686</td>
<td>0.185</td>
<td>0.279</td>
</tr>
<tr>
<td>Cough</td>
<td>0.622</td>
<td>0.262</td>
<td>0.325</td>
</tr>
<tr>
<td>Past Illness</td>
<td>0.372</td>
<td>-0.278</td>
<td>0.095</td>
</tr>
<tr>
<td>Chest Tightness</td>
<td>0.327</td>
<td>0.074</td>
<td>0.090</td>
</tr>
<tr>
<td>Running Nose</td>
<td>-0.321</td>
<td>0.175</td>
<td>0.107</td>
</tr>
<tr>
<td>Primary Occupation</td>
<td>-0.191</td>
<td>0.802</td>
<td>-0.011</td>
</tr>
<tr>
<td>Gender</td>
<td>0.237</td>
<td>-0.774</td>
<td>0.045</td>
</tr>
<tr>
<td>Education</td>
<td>-0.251</td>
<td>0.588</td>
<td>-0.021</td>
</tr>
<tr>
<td>Health Expenditure</td>
<td>-0.199</td>
<td>-0.233</td>
<td>0.622</td>
</tr>
<tr>
<td>Breathlessness</td>
<td>-0.219</td>
<td>-0.086</td>
<td>-0.558</td>
</tr>
<tr>
<td>Annual Income</td>
<td>-0.513</td>
<td>-0.009</td>
<td>0.514</td>
</tr>
<tr>
<td>Wheezing</td>
<td>-0.011</td>
<td>-0.144</td>
<td>-0.479</td>
</tr>
<tr>
<td>Indoor Air Quality</td>
<td>0.150</td>
<td>0.041</td>
<td>-0.343</td>
</tr>
</tbody>
</table>

Extraction method: Principal Component Analysis; Rotation Method: Direct Oblimin with Kaiser Normalization; values equal to or above 0.30 are considered.

The primary survey found associations between the occurrence of respiratory illness and various socio-economic indicators (Table 1). All principal components scores (above 0.3) were considered. The factors dissociated into three components after principal component analysis depending on the social, economic and environmental parameters. The annual income and fuel type loaded onto component 1 along with various upper respiratory disorders. Similarly, poor indoor air quality along with income and expenditure loaded onto component 3 with more pronounced lower respiratory disorders. The component 2 comprised of social determinants such as gender, education and occupation. Findings suggest that gender is inversely associated with education. Further, gender and education influence the primary occupation of an individual. Further, the ability to spend on health is governed by the household income. An individual earning less, will spend less on health, pushing the household into deprivation and poor health. Similarly, poor indoor air quality is associated with the type of fuel used in the household. Exposure, in such cases, results in various diseases, primarily affecting the respiratory system; both upper and lower respiratory disorders are observed in the subject population depending on the severity of exposure.

Moreover, according to the study conducted by Tigala S et al. in Kemla village, the rate of incidence of respiratory disorder was found to be very high (73%) among the biomass users. The relative risk of chest illness was found to be 2.03 in tobacco smokers and 1.52 among biomass fuel users. A similar study by Ramírez-Venegas (2005) in Mexico, reported severe airflow obstruction resulting into chest illness in both tobacco smokers and biomass users. Additionally, the population attributable risk percent (PAR%) was used to calculate risk portion of the incidence of disease in the mixed population that is due to exposure was found to be 78.94%.

### Discussion

The study highlights the relationship between environmental parameters and respiratory symptoms and disorders, taking into consideration the socio-economic factors. The present study demonstrates that the region’s poor indoor air quality adversely affects the health of the subject population. Findings suggest that socio-cultural dimensions and economic stratification plays a vital role towards the health vulnerability of the population. Susceptibility due to exposure varied across social, economic and environmental parameters. The principal component scores can be viewed as a measure of how unhealthy the subject population is due to poor air quality resulting from solid fuel combustion. The social components also show shared properties among each other.

A study by Sezer et al. (2006), reported similar findings in Sivas, Turkey, where exposure to biomass combustion led to development of symptoms of chronic obstructive pulmonary disease (COPD) in women. Poor literacy leads to reduced awareness about the adverse health impacts and further reduction in work opportunities leading to lowered contribution to household income. A gender bias exists within rural communities such that women of the household are less educated and have limited work than men. Furthermore, a very strong correlation is observed between economic costs and chest illness. A similar study by Dufo et al. (2008) depicted associations between income and health expenditure. The annual income reduced and health-associated expenditure increased in households with disabled/diseased individuals. On the contrary, households with increased income had better respiratory health and therefore, reduced health expenditure.

Further, the relative risk was found to be greater than unity, indicating higher association between risk factors and disease occurrence. Additionally, the fraction of deaths resulting from a respiratory disease that would not have occurred in the absence of exposure was found to be as high as 0.56 in the exposed population.
Conclusion
The given study can be extrapolated to assess health vulnerability based on stochastic relationship between various social dimensions, economic determinants, environmental parameters and physiological factors to establish inter-linkages. Partly and in entirety, these factors moderate exposure, hence detailed understanding is required to cognize health impact.

Conflict of Interest: None

References