Original Article

A Preliminary Study on the Impact of Household Air Pollution on Adult Respiratory Health in Urban and Rural Settings of Jaipur, India

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Abstract

Background: This study aimed to investigate the association between household air pollution and chronic respiratory illness (CRI) in Jaipur, India. **Materials and Methods:** A total of 147 participants over 18 years of age from 45 households were randomly included in the study, and follow-up visits were conducted once every fortnight over a three-month period. Spirometry tests were conducted using a portable hand-held digital spirometer. A self-designed, pretested, semi-structured questionnaire was utilized to collect socio-demographic information from the participants. Statistical tests, such as t-tests were used to analyze the association between household air pollution and CRI. **Results:** The prevalence of COPD and bronchial asthma was 2% and 4%, respectively. Various risk factors for CRI were identified within households, and only 4 episodes of acute exacerbation of chronic respiratory illness were observed, resulting in no incidence density calculation. The mean values of forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) were significantly lower in females ($P < 0.001$) Also, the mean values of FVC and FEV1 were significantly lower in rural areas ($P < 0.005$) than urban areas. **Conclusion:** Our findings highlight the importance of government and stakeholder action to implement clean air policies and protect respiratory health. Further studies are needed to expand on these findings and delve deeper into understanding the complex interactions between various risk factors and respiratory health in this population.

Keywords: Biomass, chronic respiratory illness, household air pollution, pulmonary function test, respiratory health effects

Background

The World Health Organization (WHO) estimates that household air pollution (HAP) caused 3.2 million deaths annually in 2020,[1] Only 14% of Chronic Obstructive Pulmonary Disease (COPD) deaths and 19% of COPD DALYs lost in India are now attributable to tobacco use, indicating that non-smoking risk factors are the main causes of COPD in this country.[2] The Global Initiative for Obstructive and Lung Diseases (GOLD) guideline lists a number of risk factors for COPD, including tobacco use, indoor and outdoor air pollution, occupational exposure, age, gender, and socioeconomic status.[3] Jaipur is struggling with growing urbanization, industrial emissions, traffic congestion, and poor road conditions, just like other Indian towns due to which pollution levels in the city have gone up.[4]

Hence, it is likely that respiratory illnesses due to air pollution should be widely prevalent but to the best of our knowledge, there is no study that has examined the pollution levels and prevalence of chronic respiratory illness in Jaipur city. Therefore, this study was conducted with the objective to study risk factors in detail.

Materials and Methods

Study design

This study was a prospective longitudinal study.

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Study area

Jaipur, a city in Rajasthan of western India, served as the study area. Jaipur district has urban and rural areas. For the study households were selected from urban as well as rural areas. The approval for the study was granted by the Institute's ethics committee vide it's letter dated 2 March 2023.

Study sample

A total of 45 households randomly were selected for the study, with 9 households also randomly chosen from each area adjacent to the IAQ monitoring site. Assuming an average family size of four adult members per household, the expected sample size was 180 individuals (n = 180).

Convenience sampling was chosen due to paucity of time and limited resources.

Study participants

The study participants included all residents above 18 years of age from the selected households. Prior to recruitment, the participant information sheet was read out to the respondents, providing details about the study, associated risks, and benefits, and ensuring informed consent. Each participant was required to provide consent before their inclusion in the survey and follow-up of the study.

Study Population: Residents of the city selected.

Inclusion criteria – 1) Residing in the city for at least six months, age above 18 years

2) Agreed to participate in the study and willing to sign the informed consent form.

Exclusion criteria – 1) a person with an altered mental state

2) Individuals with disabling diseases of the respiratory system that could hinder performing spirometry (cystic fibrosis, chronic heart diseases, kyphosis, scoliosis etc.).

Study tools

A self-designed, pretested, semi-structured questionnaire was utilized to collect socio-demographic information from the participants. A screening questionnaire based on GOLD (Global Initiative for Chronic Obstructive Lung Disease) criteria was administered to screen all participants for chronic respiratory illness (CRI), including COPD (chronic obstructive pulmonary disease) and bronchial asthma. The latitude and longitude coordinates of each household were recorded using the google maps application available on an android mobile phone.

The exposure assessment was conducted through a questionnaire and spirometry test

Questionnaire - Part One: The first part of the questionnaire focused on household information, including household structure, cross ventilation, presence of dust, solid and organic waste disposal, presence of insects, type of fuel used in the kitchen, and kitchen type.

A checklist was used by the researcher to assess cross ventilation, the presence of dust, animal waste, and the type of fuel used in the kitchen.

Biographical information of the participants, such as length of stay in the city and housing conditions, was also recorded. An empirical assessment of potential exposure to risk factors for chronic obstructive pulmonary disease (COPD) was conducted by asking questions about current and past jobs, modes of transportation used for commuting to the workplace, nature of work, air quality at the workplace, and exposure to active and passive smoking.

Questionnaire - Part Two: The second part of the questionnaire was administered to individuals displaying symptoms and signs suggestive of chronic respiratory illness. It included a modified version of the Global Initiative for Obstructive Lung Disease (GOLD) screening criteria for COPD, consisting of seven items with a scoring range of 0-5 for each item.[5] A score of 10 or above on the COPD assessment test (CAT) indicated the presence of COPD.

Spirometry test

Spirometry, a lung function test, was conducted using a portable hand-held digital spirometer (Spiromin®) with disposable sterile mouthpieces. (The UNI-EM PC Based Spiromin spirometer, manufactured by Universal Medical Instruments Delhi, is used along with its Windows® based software for capturing lung function parameters used).[6]

The test was performed without the administration of a bronchodilator. All consenting participants were informed about the test procedure prior to its execution. The trained investigators conducted the spirometry tests themselves. The validity of handheld digital spirometry has been reported by Barr *et al*.[7]

Data collection

During the first visit, the air quality status in each household was assessed by observing ventilation, house type, condition of walls, and the presence of any polluting industry/activity in a radius of 1 km Ambient air pollution data were obtained from the field monitoring stations of the State Pollution Control Board of Rajasthan. Each household was visited once every fortnight for three months to identify any new cases of chronic respiratory illness (such as COPD, bronchial asthma, and lung cancer) and to follow up on existing cases of chronic respiratory illness for any episodes of acute exacerbation.

Data and statistical analysis

The data collected were summarized using mean and standard deviation values. Statistical test, such as t-test was performed to compare different groups using SPSS software version 28.0

Calculation of number of episodes and incidence density

A respiratory episode was defined as any acute exacerbation of COPD or bronchial asthma that occurred between two consecutive visits. The data were collected over a period of 92 days (March, April, May).

Incidence Density: The rate of acute respiratory episode was expressed as the number of episodes/100-person fortnight.

Results

Out of a total of 180 eligible residents in 45 households, 147 participants consented to participate in the study out of these 57% were male. More than 75% of interviewees had college level education. In all 14 surveyed individuals were found to have chronic respiratory illness (CRI), as indicated in Table 1. Out of these, one had pulmonary tuberculosis and in 3 cases no confirmed diagnosis was available.

We found that chronic obstructive pulmonary disease (COPD) and asthma prevalence were 2% and 4% respectively in our study.

Spirometry was done on 81 participants, and the findings are shown in Table 2. A t-test was used to compare the means of the spirometry parameters (FVC, FEV1, FVC/FEV1, PEFR, and FEF) between males and females. It was found that the difference between the male and female FVC mean values was statistically significant ($P < 0.001$) and the male FEV1 mean value was higher than the female FEV1 mean. This difference was also statistically significant ($P < 0.001$)

It was found in our study that the mean FVC among residents of urban areas was higher than that of the rural areas at a significance level of 0.005. Similarly, mean FEV1 was also higher in urban areas. Additionally, the mean values for FEV1/FVC, PEFR, and FEF were all higher in urban than rural areas however these differences were not statistically significant.

In about 20% of households, biomass fuels were used for cooking, 49% of homes lacked adequate ventilation, 22% of respondents smoked, and 13% of people were exposed to passive smoking. In addition, 49% of households disposed of their waste hygienically, 15% had to labor in difficult conditions, 71% had animals and animal droppings inside their homes, and 75% of homes, especially those in rural areas, had dust as shown in Figure 1.

Discussion

The Institute for Health Metrics and Evaluation (IHME), University of Washington, and the Ministry of Health and Family Welfare, Government of India, jointly conducted a study. According to this study, the prevalence of asthma and COPD in India were 2.7% and 4.9% respectively.[8]

There is wide variation in the prevalence of CRIs in India, Rajasthan, and Uttar Pradesh having the highest DALY rates for both COPD and asthma.[9]

According to Gupta *et al*.,[10] the total asthma prevalence in Jaipur district was estimated to be about 2%, in contrast with a previously reported figure of 0.96%.

Our findings are incongruous with the estimates of the Global Initiative for Chronic Obstructive Lung Disease (GOLD), which reported the global prevalence of COPD in individuals aged 30-79 years to be 10.3% in 2019. The Western Pacific region had the highest prevalence of 11.7%, while the Americas had the lowest prevalence of 6.8%.[11]

The small sample size of our study may be the reason for the difference we noticed. In all three COPD cases were present and all three were in rural areas only. In contrast, asthma patients were found in all areas except commercial areas. The use of biomass fuel for cooking and the presence of dust and inadequate ventilation may have been responsible for COPD in the rural area compared to the urban area. Respiratory allergens are more likely to be found in urban areas due to various sources namely vehicle exhaust, industrial chemicals, and general pollutants.

In contrast to the Global Burden of Disease study, which relied on a combination of data sources, including surveys and administrative records, and may have had differing inclusion criteria, our study in Jaipur employed a survey

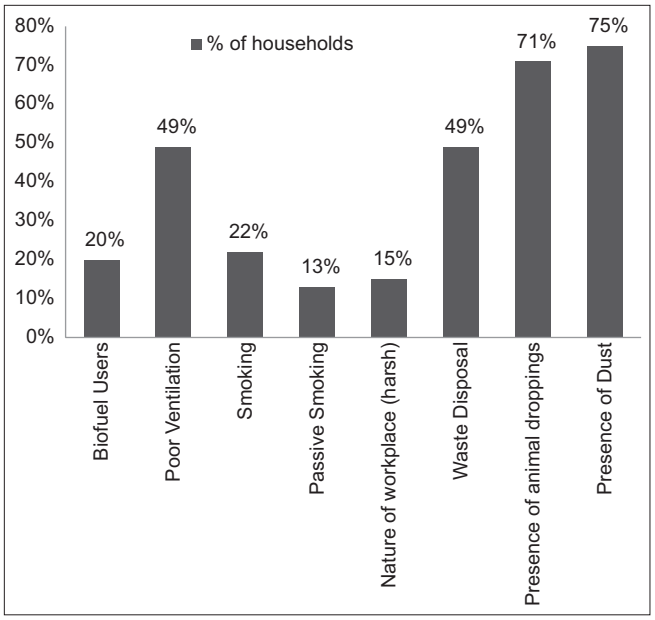

Figure 1: Distribution of Risk factors inside households

Table 1: Disease profile of the studied population

Study Areas	Total ($n=147$)	Female ($n=63$)	Male ($n=84$)	CRI ($n=14$[a])	COPD ($n=3$)	Bronchial Asthma ($n=6$)	TB ($n=2$)
Commercial	31	11	20	1	0	0	1
Residential	29	15	21	3	0	1	1
Industrial	21	10	8	3	0	2	0
Slum	31	13	18	1	0	1	0
Rural	35	14	17	6	3	2	0

CRI: Chronic respiratory illnesses. COPD -Chronic Obstructive Pulmonary Disease. TB - Tuberculosis. [a]Three cases were undiagnosed

Table 2: PFT values (mean+S.D) with respect to gender

	Male (n=32) Mean±S.D.	Female (n=49) Mean±S.D.	Significance (P)
FVC	2.5294±0.56	2.0531±0.61	0.001
FEV1	2.3381±0.60	1.7700±0.52	0.000
FEV1/FVC	90.1947±7.59	86.956±10.9	0.119
PEF	5.1366±2.10	4.6163±1.51	0.232
FEF	3.0891±1.49	2.4894±1.04	0.053

coupled with spirometry and covered both urban and rural areas.

It would be necessary to do more research to investigate and ascertain the degree to which they are responsible for the observed variations in the prevalence of CRIs.

The community's effective care of respiratory disorders, including the use of medication, may be responsible for the low prevalence of acute exacerbations of COPD.[12]

In our study, medications being used by the patients were effective in preventing exacerbation or reducing their severity, which is a positive finding. The small number of participants in the study may have contributed to the low number of observed acute exacerbations. Further, the study had a follow-up period of three months and that was not sufficient to capture many episodes of acute exacerbations.

The results of our investigation are comparable to those of the study conducted by Das *et al*,[13] which showed a significantly lower TV, IRV, ERV, VC, MVV, and PEFR in female individuals, possibly as a result of differences in body composition between male and female subjects.

A different study found that males had higher values of PFT parameters than females.[14]

Different occupational exposures can also have an impact on lung function. Since women spend more time indoors and engage in more domestic chores like cooking and cleaning, exposure to risk factors like smoke from biomass fuel and dust from brooming and dusting is longer compared to that in men thus adversely affecting lung physiology.

Similarly, PFT values were reported to be higher in residents of urban areas than in rural areas.[15,16] Our findings are in conformity with this observation. But the reason for the same cannot be established through cross sectional studies like ours. Further, the complex character of the effect of exposure to pollutants, genetic makeup, gender, physical activity, and environment makes it too difficult to untangle the difference in PFT values between rural and urban residents in a generic manner. Hence studies on local populations, that besides measuring the lung function parameters, should also effectively measure the affecting parameters through longitudinal studies to establish the urban rural differences in a locally contextual and population specific scenario.

Additionally, there is a need to create regionally specific standards with adequate representation of urban and rural populations, as in the study done by Christopher *et al*.[14] mentioned that populations can be affected by the environment and that there are significant biological differences between urban and rural populations living in different regions.

We found that participants from rural locations had significantly lower spirometry values than their urban counterparts, also the spirometry values were lower in females as compared to males. Despite the fact that our study did not offer a conclusive explanation for this finding, it is possible that it can be linked to elements like the use of biomass fuel for cooking, a dustier environment, and a higher incidence of tobacco use in rural homes.

These results underscore the necessity for gender-specific reference values in spirometry testing and have significant consequences for clinical practice. Additionally, it can assist medical professionals and policymakers in developing better strategies for the prevention and treatment of respiratory infections, particularly in rural areas where these issues are more prevalent.

According to a NFHS data based analysis, Rajasthan has a significant proportion of households, second only to Punjab, that use solid fuel for cooking in comparison to other regions in North India.[17]

Furthermore, a study by Mahmood *et al*.[18] revealed that a sizable portion of COPD cases occur in non-smokers, highlighting the importance of additional factors in the progression of the illness. In rural Jaipur, nearly all households (97%) cook with biomass fuel, the majority (93.5%) using wood, and the remainder 6.5% using crop leftovers. In Rajasthan, in a study conducted by Parikh *et al*.[19] in 2019, it was found that after adjusting for age and education, there was a significant association between respiratory symptoms and the fuel used for cooking.

The accumulation of indoor allergens and poor air quality can both be a result of improper organic waste disposal processes.

The inference made was that additional elements, such as poor ventilation, passive smoking, and the use of biomass fuels, may be causing home air pollution and ultimately harming the respiratory health of the city's residents. The study's distinctive methodology of simultaneously analyzing the indoor environment and chronic respiratory disorders is its key strength.

Limitations

One of the limitations of the study is the small sample size, which prevents the generalization of the findings to the entire population. The observation period was very short. Reluctance to participate and inability to perform spirometry in the correct manner by some of the participants reduced the sample size to some extent, thus compromising the power of the study.

Recommendations

Prospective longitudinal cohort studies should be conducted to establish the association between exposure to risk factors

of chronic respiratory illnesses in indoor environments and analyzing the findings in the context of weather, seasonality, and land use patterns is strongly recommended to get deeper insights.

Similar studies should be carried out in various urban and rural locations to analyze the disease burden, and risk profile, and design tailored therapies based on regional needs because the distribution of COPD risk factors differs by location. Since the combination of risk factors may vary from one group to another due to a variety of factors such as geographical location, cultural practices, socioeconomic status, and environmental conditions.

In order to create a comprehensive framework for practical recommendations, access to data on COPD patients should be increased and shared with the researcher.

Conclusion

Although preliminary, this study highlights the presence of COPD and Asthma in the community. The role of indoor air pollution and its links to respiratory health is empirically evidenced in this study. Analysis of lung function parameters threw light on the gender and rural urban differences in lung capacities.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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