ORIGINAL ARTICLE

Determination of Lung Health Amongst Children Living in Slums of Gurugram, Haryana, India

Shibal Bhartiya, Tarundeep Singh, Manoj K. Goel, Meenakshi Wadhwani, Athulya V Ajith
[1]Department of Ophthalmology, Marengo Asia International Institute of Neuro & Spine
[2,5]Department of Community Medicine & School of Public Health, Postgraduate Institute of Medical Education and Research, Chandigarh, India
[3]Department of Pulmonology, Fortis Memorial Research Institute, Gurugram, Haryana, India
[4]Department of Ophthalmology, Guru Nanak Eye Centre, Delhi, India

CORRESPONDING AUTHOR
Dr. Tarundeep Singh, Additional Professor, Department of Community Medicine & School of Public Health, Institution: Postgraduate Institute of Medical Education and Research, Chandigarh, India
Email: Tarundeep.singh@gmail.com
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Abstract

Introduction: Household air pollution (HAP) contributes to morbidity and mortality not only in adults but also in children. There is little evidence of the effects of HAP amongst out-of-school children living in the slums. **Objectives:** To determine the effect of HAP and presence of ventilation on lung health of out-of-school children from urban slum clusters in North India. **Methods:** Cross-sectional analytical study was conducted in December 2022 in urban slum clusters of Gurugram, Haryana, India. We interviewed parents for demographic information, type of fuel used for cooking, presence of ventilation, place of cooking. We conducted lung function tests on children using forced expiratory volume in first second (FEV1) to forced vital capacity (FVC) ratio to test the pulmonary function of the children. **Results:** 280 parents and 339 children were enrolled for the study. Chulha was used for cooking in 21.8%, no ventilation in 29.5%, and no separate kitchen for cooking in 79.4% of the households. FEV1/FVC was found to be lower amongst the children of those households where chulha was used for cooking with P = 0.091. **Conclusion:** Chulha is still being used in households. We found a lower FEV1/FVC ratio, in children from households using chulha as fuel.

Keywords

Children, Household Air Pollution, Pulmonary Function, Slums

Introduction

According to the World Health Organization, household air pollution (HAP) was responsible for an estimated 3.2 million deaths per year in 2020, including over 237,000 deaths of children under the age of 5 years. India accounts for almost a quarter of these deaths amongst developing countries, making it a critical environmental risk factor.(1,2) This also resulted in an estimated loss of 86 million healthy life years in 2019, especially for women living in low- and middle-income countries. The Pradhan Mantri Ujjwala Yojana Programme, the Indian government's attempt to meet the sustainable development goal to provide clean energy for cooking, has ensured a declining use of solid biomass fuels Despite this fact, more than 80 million households still depend on these solid fuels. More than a quarter of these households are in urban India, mostly in the slums.(3)The fuel choice for these homes depends on costs and subsidies, distribution networks, and access to clean fuel, as well as user awareness(3).

The most commonly used three-stone and U-shaped mud stoves called the chulha, are inefficient in terms of both thermal performance and particulate and gaseous emissions per unit of fuel burnt.(4,5)Moreover, shanties in densely populated urban slums lack sufficient ventilation, and women and children are exposed to these emissions, making them increasingly susceptible to

HAP.(6) Very little is known about the lung functions of children living in slums.

Aim: To study the effect of HAP due to chulha compared with gas stoves on the pulmonary functions of the children. **Objectives:** To determine the effect of HAP and the presence of ventilation on the lung health of the extremely vulnerable out-of-school children from urban slum clusters in North India, using standardised pulmonary function tests.

Material & Methods

Study design: Community-based cross-sectional analytical study

Study setting: Three non-formal After-School-Clubs, situated within urban slum clusters in Gurugram, Haryana, India. These Clubs, run by Vision Unlimited, a not-for-profit organization, aim to provide early childhood care, as well as remedial classes for foundational learning (literacy and numeracy) to out-of-school children. They also aim to ensure that these vulnerable children can get assimilated into age-appropriate classes in government schools and the public health system. Since all of the children attending these clubs are from the lower socio-economic strata, regular health check-ups and immunisation support are provided to the students to promote their health and also to increase retention of the students in the educational program.(7) Health-related interventions are routinely offered to the parents of these children, and the children, usually in partnership with the local Primary Health Centre, Anganwadi, or volunteers from local, private hospitals, as a part of early childcare and education protocols in underserved communities.

Study duration: It was conducted from June to August 2023

Study population: Out of school children living in urban slums of Gurugram, Haryana

Study participants: All children above registered under these after school clubs who satisfied inclusion and exclusion criteria were considered as the study participants. Children included were above the age of 6 years and those with pre-existing respiratory illnesses were excluded from the study.

Data collection: A validated questionnaire in Hindi with eight questions and three subsections was administered to the students after obtaining written consent from their parents in the presence of their parents over 2 days before the screening camp. For the parental interview, any of the parent who was available during the interview was included in the survey. The teachers were trained in survey techniques including a detailed explanation of the three parts of questionnaire administration, eliciting, and recording the response. The duration of the training session was 2 h, and the teachers were also assured of the availability of the trainers (RG, SB, and TDS) for any additional support. The training session comprised a PowerPoint presentation, the importance of explaining and recording consent, role-play that targeted itemised answer elicitation, question-answer round, and tell-ask-tell method of comprehension. After the training was completed, the teachers were asked to administer the questionnaire to the students. The questionnaire consisted of three parts:

Part A: Demographic information

Demographic information recorded included the age, gender, and religion of the students. Household income, educational status, and occupation of parents were filled in by parents if literate; or recorded by teachers, as told by the parents.

Part B: Information about the homes Information collected included the kind of stove being used (liquefied petroleum gas [LPG], kerosene, and solid biomass chulha), the presence of ventilation in the kitchen (window or chimney), and whether the cooking was done indoors or outdoors.

Part C: Respiratory health-related information

The children and their parents were asked if the children were experiencing any breathing difficulties. Their height and weight were recorded by teachers, just before the PFT, in the presence of the parents. A pulmonary function test was performed after written informed consent from the parents in their presence. Pulmonary function test Spirometry was performed using the MIR Spirolab Spirometer A23-0J, Rome, Italy, by two trained respiratory technicians, according to standardised recommendations.(8-10) Three forced vital capacity (FVC) manoeuvres were performed, and the best value of FVC and forced expiratory volume in the first second (FEV1) was recorded. Only efforts graded as C or better were used for analysis. For the final analysis, we used the FEV1 to FVC ratio (FER) to report the pulmonary function of the children.

Ethical consideration: Ethical clearance for the above study was obtained as per the institutional guidelines. The study abided by the ethical principles of the Declaration of Helsinki.

Statistical analysis: The data were collected using a Microsoft Excel spreadsheet. The quantitative variables, such as age and pulmonary functions, were expressed in mean and standard deviation, whereas the qualitative variables, such as gender, family income, the method of cooking, presence of ventilation, and breathing problems, were expressed in frequencies and proportions. An Independent t test was performed to compare the lung functions of the children based on different variables. A P value of less than 0.05 was considered to be statistically significant.

RESULTS

Demography We interviewed 280 parents in the present study by recruiting one family per household for the survey and enrolled 339 children for the study. The mean age of the children was 8.95 ± 2.62 years. There were 180 girls and 159 boys in the study. The parents of the majority of the children were found to be illiterate. Very few parents had skilled jobs. All children belonged to the lower social class according to Modified Kuppuswamy Sale. The demographic details of the family are described in Table 1.

Tables 1: Demographic details of the children and their family (n = 339)

Variables	No of participants		Percentage
Age in years (Mean ± SD)	8.95 ± 2.62		
Gender (*n* = 339)	Girls	180	53.1
	Boys	159	46.9
Education of father (*n* = 278)	Primary school	64	23
	High school	25	9.0
	Senior secondary School	8	2.8
	Graduate	6	2.3
	Illiterate	175	62.9
Education of mother (*n* = 276)	Primary school	43	15.6
	High school	25	9
	Senior secondary School	8	2.8
	Graduate	2	0.7
	Illiterate	198	71.9
Occupation of father (*n* = 278)	Unskilled	132	47.6
	Semi-skilled	111	39.8
	Skilled	35	12.6
Occupation of mother (*n* = 276)	Unskilled	19	6.8
	Semi-skilled	249	90.3
	Skilled	8	2.9
Annual income of father (INR) (*n* = 278)	Less than 10,000	183	66.0
	Equal and above 10,000	95	34.0
Annual income of mother (INR) (*n* = 276)	Less than 10,000	232	84.0
	Equal and above 10,000	44	16.0
Siblings	0	43	12.7
	1	82	24.3
	2	84	24.9
	3	69	20.4
	4	43	12.7
	5	7	2.1
	6	5	1.5
	7	5	1.5
Cooking fuel (*n* = 280)	Chulha	61	21.8
	Gas stove	219	78.2
Type of ventilation (*n* = 280)	Nil	83	29.5
	Window	197	70.5
Place of cooking (*n* = 280)	Inside the house	222	79.4
	Outside the house	58	20.6

Pulmonary function tests: For conducting pulmonary function tests, we recruited children above the age of 8 years whose parents consented on behalf of their children to undergo the test. A total of 103 children had undergone pulmonary function tests. The mean age of the children was 10.81 ± 1.95 years. There were 45 girls and 58 boys who underwent the test. The cooking practices of the households of these 103 children were described here in detail.

Household air pollution

We observed that the households used either chulha or gas stoves as a method of cooking. The use of gas stoves was predominant in the households (83.5%). Overall, the majority of the households had a designated place for cooking inside their houses (85.4%) and 40% of these households had no ventilation source in the kitchens. Of 88 households without a separate kitchen, 68% of these households (n = 27) had no ventilation source. Comparing children based on gender, we found girls to have better pulmonary functions than boys (P = 0.003). Chulha was used amongst 17 out of 103 households, of which only 4 (23.5%) houses had windows or chimneys for ventilation. There was no difference in the pulmonary functions of the children based on the type of cooking methods, place of cooking, and the type of ventilation present at the place of cooking. Only one child was found to have breathing problems but there was no difference in the pulmonary functions between boys and girls [Table 2]. We also calculated the correlation of pulmonary function concerning age, height, weight, and body mass index (BMI) of the children. We classified underweight as BMI less than 18.5 kg/m2 and observed that seven children had normal BMI, whereas the rest were underweight.

Tabel 2: Comparison of FEV1 to FVC ratio according to different variables (n = 103)

Variables	FER*	P value
Gender		
Boys (*n* = 58)	89.3 ± 5.2	**0.003**
Girls (*n* = 45)	91.9 ± 2.9	
Cooking method		
Chulha (*n* = 17)	85.2 ± 12.8	0.091
Gas stove (*n* = 86)	89.5 ± 8.7	
Place of cooking		
Inside (*n* = 88)	89.2 ± 8.8	0.221
Outside (*n* = 15)	85.9 ± 13.3	
Type of ventilation		
Nil (*n* = 40)	90.1 ± 9.4	0.274
Window (*n* = 63)	87.9 ± 9.7	
Breathing problem**		
Yes (*n* = 1)	82.2 ± 0	0.494
No (*n* = 102)	88.8 ± 9.6	

**Observed FEV1/FVC; **Mann–Whitney U test applied*

Discussion

In the present study, we wanted to determine if there was an association between the type of cooking fuel used in the household and pulmonary functions of the children living in slums. Although statistically insignificant, the FER that is, FEV1/FVC was found to be lower amongst the children of those households where chulha was used as the cooking fuel. This is probably due to the small sample size of children with the lung function tests done Kurti et al.(11) reported that even though elevated HAP exposure was associated with increased reported respiratory and non-respiratory symptoms in Belizean adults, its impact in children was not significant. Similarly, Teng et al.(12) also reported an inverse trend in FVC, FEV1, and FEF25−75 values with increasing air pollution levels. Even though they did not correlate lung functions with HAP, like in our study, they also reported that the prevalence of poor lung function was generally insignificant regardless of the increased odds ratio in children with increased exposure to air pollution in China.(12) It is also important to note that physical activity is known to reduce the risk of obstructive airway diseases, bronchial hyperreactivity, and respiratory symptoms. Physical activity mitigates the oxidative stress and inflammation induced by HAP.(13) The active lifestyle of children, with hours of unrestricted play outdoors may be the reason why the lung functions of the children remain relatively unaffected despite exposure to high HAP. However, it may be interesting to explore how outdoor physical activity in areas with high outdoor pollution, such as urban slums, in the current context impacts respiratory health. Chulha was still being used in 21.8% of the households living in the slum, which was in contrast to the use of clean fuel in 99% in the Delhi national capital region according to the report of National Family Health Survey-5, 2019–2021,(14) whereas only 29.5% of those households using chulha as the mode of cooking had windows for ventilation, which corroborates with the findings of Dutta et al.(15) in the slums of West Bengal that used kerosene oil as the primary fuel for cooking. The food was cooked inside the houses in nearly 80% of the households having no separate kitchen. A separate kitchen was observed in only 32% of the cases where food was being cooked inside the houses. Dutta et al.(15) reported the presence of smoke outlets in 25% of the households where a separate kitchen was present. No association was established between the breathing problems amongst the children and ventilation in the present study. This was in contrast with a study conducted by Rana et al.(16) where the authors reported higher mortality and morbidity amongst infants and under-5-year children due to HAP. Bassani et al.(17) reported a rise in child mortality risks due to solid fuel exposure over time, where 6% of all deaths at age less than 4 years, and 20% of deaths between 1 and 4 years in India in 2004 could be attributed to the same.(17) This is probably due to the reason that children below 5 years of age tend to stay close to their mothers most of the time while indulging in cooking, whereas children of older age tend to stay away from any cooking activities. In our study, however, we did not evaluate lung functions in children younger than 8 years of age because most of them were unable to perform the test accurately. The Global Initiative for Obstructive Lung Diseases recommends using the fixed ratio of FEV1/FVC less than

0.70 as a cutoff value for diagnosing chronic obstructive lung disorders.(18) In the present study, 5 (4.8%) of the children were found to have FER less than 0.70. All these cases were also asymptomatic, even though FER < 0.70 was known to be the threshold for clinical significance. We believe that there may be a possible subclinical impact on respiratory function, which may be cumulative over time, manifesting in the later years. A study conducted by Patel et al.(19) reported FER below the lower limit of normal amongst 9% of the children and demonstrated that HAP was associated with subnormal lung function amongst children in southern India. In another study by Oguonu et al.,(20) contrary to our findings, 60.5% of the children living in the urban slums and rural areas exposed to cooking fuels were found to have limited airflow functions. The particles of wood smoke have an accumulation mode size of more than 10 mm with only 14% of it in the nucleation mode, that is, conversion of gas into particles compared with 50.14% in the case of kerosene oil, Despite this fact, it causes emissions that will produce more toxic inhalable particulate matter.(21) On the other hand, gas stoves using LPG have finer particles, but the amount that escapes during cooking is small and is, therefore, less likely to affect the lungs.(22)

Conclusion

We conclude that chulha is still being used in 21.8% of households. In 29.5% of the chulha-containing households, no ventilation was observed. We observed that the change in FEV1/FVC ratio was not showing statistically significant association with type of fuel used or presence and absence of ventilation.

Recommendation

Future research is required to ascertain the impact of physical activity on respiratory function in children with high exposure to HAP.

Limitation of the study

Given that the health camp was held over the day, there was no "familiarization day" with the pulmonary function tests. The study has not limited one child from each household if more than one child above 6 years was present in the same family. The tests were administered as per the American Thoracic Society guidelines,[9] and we only included tests consistently within 10% of one another to minimize variability and used the best result for analysis. Measurement of the size of particulate matter would have been useful in determining the severity of air pollution in the respective communities. The objective assessment of the duration of exposure would have helped determine the impact of various cooking fuels. Our study also does not evaluate the impact of high carbon monoxide levels, the most common symptoms of which are headaches and burning eyes, which may be a more direct and immediate consequence of HAP.

Relevance of the study

In an era of rapid urbanisation, which is only likely to increase, this study adds to the growing body of literature on adverse lung health in slum dwellers.

Authors Contribution

All authors have contributed equally.

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Conflict of Interest

There are no conflicts of interest.

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Declaration of Generative AI and AI Assisted Technologies in the writing Process

The authors haven't used any generative AI/AI assisted technologies in the writing process.

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