

A cross-sectional study on determinants of indoor air pollution and its perceived impact among the residents of urban field practice area of AMCH, Salem, Tamil Nadu

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ABSTRACT

Background: Over the past 20 years, indoor air pollution (IAP) has received much attention as the quality of the indoor air is affected a lot. IAP means the presence of substances which are redundant in the indoor air at concentrations toxic to health. Very few studies have addressed the determinants of indoor air pollutants in places like urban slum areas in Tamil Nadu. To reduce this research gap, this study has been undertaken. **Aim:** To study the determinants of IAP and its perceived impact on health. **Settings and Design:** This was a community-based cross-sectional study. Complete information from 440 households consisting of 1606 individuals was collected through a semi-structured questionnaire. **Materials and Methods:** Residents of an urban field practice area of Annapoorana Medical College and Hospitals (AMCH) were the study participants. The study period was from April 19 to March 2020. The study area was an urban field practice area around Department of Community Medicine, Karungalpatty, AMCH. Frequency, proportions, and Spearman test were used to find out the significance between various household environmental conditions and the respiratory diseases using Epi Info software. **Results:** Results showed that 52.3% of the participants were using incense sticks at home in the evening during pooja and 17.7% of the houses were using mosquito coil in the evening and at night. Also, 29.5% houses reported overcrowding and 66.4% of the houses were not having chimney or exhaust. Results also showed that 71.4% households were practicing opening their windows while cooking. One hundred and fifty-two (34.5%) female respondents had perceived the symptoms like dizziness (12.3%), eye irritation (10.2%), difficulty in breathing (4.5%), dry cough (3.06%), running nose (1.4%), and nasal congestion (1.1%) due to IAP. Among under-five respondents, 1.6% reported having acute respiratory infections in the last 15 days and 10.5% reported the same in the last 1 year 10.5%.

Keywords: Determinants, indoor air pollution, respiratory infections

Introduction

Over the past two decades indoor air pollution (IAP) has gained much attention because the quality of the indoor air is affected a lot. There is rule of 1000, which denotes that there will be

1000 times more chances of reaching a person's respiratory tract when the pollutant is released indoors rather than outdoors, as stated by the World Health Organization (WHO).^[1] WHO also reported that every year, around 3.8 million deaths occur due to IAP.^[2]

In our country, the mortality is more than 1.5 million due to IAP every year.^[3] Disability-adjusted life years (DALY) in India is attributed as the fourth leading cause for IAP.^[4] Indoor

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combustion sources are solid fuels (coal, peat, and wood) used for cooking or heating and tobacco smoke.

The major sources of IAP are bioaerosols, combustion of fuel used for cooking, materials used for construction, and, to an extent, outdoor air pollution.^[1] In the developing countries which use unclean fuels like biomass, wood, and kerosene that may produce various detrimental pollutants such as carbon monoxide, sulfur dioxide, NO₂, fine particles, benzene, and many others, it has become a major public health concern.^[5-7] Other contributory factors which play a role in IAP include ill-ventilated houses, houses with damp walls, and poor cleanliness.^[8,9]

The indoor and outdoor air pollutants are more or less the same, for example, SO₂, NO, CO, polycyclic organic matter, asbestos, particulates, and formaldehyde. In some situations, the concentration of pollutants is high indoors than outside, for example, NO concentration within home is nearly 5 times higher than outside.^[10] In most of the houses, though these pollutants are emitted in a small amounts, they reach a high level as they cannot escape out easily from the buildings due to lack of proper ventilation. IAP poses a greater health hazard because of prolonged exposure indoors.

Millions of particles are emitted while cooking through the burning of oil, wood, and food, and most of them are ultra-fine particles. These fine particles get distributed not only to the kitchens, but also to the living rooms and other areas in the building, which results in various adverse effects to the occupants' health.^[11]

It is documented that IAP plays an important role in human health. In the developed world, people spend majority of their quality time by staying indoors,^[12] where vulnerable groups such as young children and the elderly can spend up to 100% of their time.^[13] Exposure concentrations vary and depend on a number of factors including individuals' behavior and activities, pollutant sources, and geographic location.

Adverse effects caused due to indoor air pollutants may be short term or long term. Short-term adverse effects are the environment becomes odorous and stuffy and it causes symptoms like irritation of eyes, headaches, and irritation of skin. The factors attributed for the duration and magnitude of health effects are duration of exposure, time of exposure, concentration of the pollutant, existence of unhealthy conditions, and age. On the whole, poor air quality could be responsible for a reduction in work performance, perception of ill health, reduced ability to concentrate, and sickness.^[14]

Further, compared to the north and west, relatively few studies have been carried out in southern and eastern India, which have a significant proportion of the national population. In particular, there are substantial climatic and socio-cultural differences between the northern and southern regions, including different food habits and the use of biomass fuels for heating, which could

have an important bearing on household exposures. Majority of the indoor air pollutants can be reduced or eliminated by improving the housing conditions and adopting pollutant-free cooking practices. It is vital to work out the quality of air present inside our very own home. Health problems due to IAP have not been addressed earlier in this study population. Hence, this study is an eye opener for the primary care physicians and for the MBBS students. It also helps to create awareness on IAP among the study population.

With this background, the current study has been conducted to find out the determinants of IAP and their perceived health impact among the females who reside in the urban field practice area of Annapoorana Medical College and Hospitals (AMCH).

Materials and Methods

Ethical Approval and Recruitment

Ethical approval (AMC/IEC/Proc.No. 89/19) for the study was obtained from the Institutional Ethical Committee of the AMCH, Salem. Before the study was carried out, informed consent was obtained from the participants after explaining the study in their vernacular language. Recruitment of households took place between April 2019 and March 2020.

Households were recruited in and around the urban health center of Department of Community Medicine, Karungalpatty, AMCH. Households were excluded if they were found to be locked during the survey. Those who were not willing to participate were not enrolled in the study.

Questionnaire

The data was collected mainly from the households. The questionnaire was developed by to a similar study done in Kolkata, India.^[15] After conducting a pilot study minimal modifications were made according to the local needs. Data was collected by using a pretested questionnaire that contained the following information:

- i. Sociodemographic characteristics: age, sex, education, occupation, income, family type, socioeconomic status by using modified B. G. Prasad scale;^[16]
- ii. Sources of IAP: sources were enumerated as reported by the respondents;
- iii. Checklist for contributory factors to IAP:
 - Humid conditions – damp roof or walls
 - Cleanliness of the house
 - Overcrowding (assessed by using person per room criteria)^[17]
 - Poor ventilation (cross ventilation or window area <20% of the floor area)^[17]
- iv. Cooking practices:
 - Cooking area (separate kitchen/in verandah/outside the house)
 - Cooking fuels (firewood/kerosene/liquified petroleum gas [LPG])

- v. Smoke from neighborhood (yes/no);
- vi. Passive smoking (yes/no);
- vii. Acute respiratory infections (ARI) episodes among children under 5 years of age;
- viii. Acute respiratory tract infections (ARTI): cough and breathlessness as reported by the mother;
- ix. Perception of women regarding IAP; and
- x. Symptoms related to IAP: self-reported.

Field survey

Field practice area is located in the heart of the city and is densely populated. Majority of the people are residing in a slum environment. Purposive sampling had been done keeping in mind that the households selected represented the study area well. Data was collected from each household with the help of the questionnaire. The survey was conducted from April 2019 to March 2020. Female respondents were chosen for the interview, as they are at home most often. A household consists of all those persons who occupy a housing unit collectively and who reside in that area for not less than a year. The surveyed data were tabulated and simple percentage was calculated. Further, the tabulated data was processed in Epi Info for testing significance by Spearman between various household environmental conditions and respiratory diseases.

Results

The total population surveyed was 1606. The mean number of family members was 3.61 ± 1.486 , the mean number of rooms was 2 ± 1.029 , and the mean number of windows was 0.95 ± 0.796 . About 49.8% were females. Also, 80%, 14%, and 6% of the families belonged to nuclear type, joint family, and three-generation families, respectively. Regarding the number of family members, majority of the families were having four members (32.7%) and three members (24%). Around 21.2% of the respondents have studied up to degree. Among the study population, 48.2% have a monthly income around Rs. 6000. About 98.1% (1575) of the respondents were Hindus. Of the 440 households, 41.4% and 10.5% were semi-pucca and kutcha houses, respectively. About 79.8% and 14.3% of the families were nuclear and joint families, respectively [Table 1].

Housing Details

Out of 440 households, seven (1.6%) were using kerosene as the cooking fuel predominantly. Indoor smoking was reported by 6.6% and passive smoking by 6.8%. Majority (52.3%) of the participants were using incense sticks at home in the evening during pooja regularly. Also, 17.7% of the houses were using mosquito coil in the evening and at night, since mosquito breeding was heavy in the surveyed area as perceived by the respondents. Results also showed that 41.4% and 10.5% of the houses were semi-pucca and kutcha houses, respectively; since it is an urban area, the remaining houses were pucca. About 29.5% houses reported overcrowding. Very few houses were made up of clay or mud floor (0.5% and 0.9%, respectively) [Table 1].

Table 1: Sociodemographic characteristics of the study population

Sociodemographic characteristics of the study population	Frequency	Percentage
Age distribution (years)		
≤5	71	4.4
6-14	189	11.8
15-24	268	16.7
25-34	229	14.3
35-44	265	16.5
45-54	266	16.6
55-64	177	11.0
≥65	141	8.8
Sex		
Male	807	50.2
Female	799	49.8
Religion		
Hindu	1575	98.1
Muslim	16	1.0
Christian	15	0.9
Marital status		
Student	11	0.7
Married	978	60.9
Unmarried	533	33.2
Widow/widower	83	5.2
Education		
Preschooling	40	2.5%
Illiterate	295	18.4
Primary	338	21.0
High school	419	26.1
Higher secondary	174	10.8
Deg/dip/PG	340	21.2
Work		
Students	289	18.0
Unemployed	359	22.4
Textile	64	4.0
Handloom worker	65	4.0
Daily wager	193	12.0
Others	341	21.2
Homemakers	295	18.4
Income (in rupees)		
≥6000	401	48.2
3200-6000	221	26.6
1900-3200	140	16.8
900-1900	67	8.1
≤900	3	0.4

The mean age of the study participants was 31.45 ± 7.3 years with 8.5 ± 3.8 mean years of schooling. About 71.7% were Hindus. Of the 120 households, 67.5% lived in households at the ground floor. Among the study participants, 45% belonged to lower socioeconomic class (IV and V together). Of 120 households, 39 households had under-five children; out of these 39, four households had two under-five children each. Majority of the participants were Hindus (1575 [98.1%]).

Outdoor cooking practices were followed by only 11 (2.5%) of the households. Majority (66.4%) of the houses were not having chimney or exhaust. Around 40% of the houses did not have windows in the kitchen. Cross ventilation, which is the major determinant of IAP, was not present in 72.5% of the houses. Majority of the households had the practice opening their windows (71.4%) and doors (83.4%) while cooking. It has been observed that very small proportion of the houses were

Table 2: Contributory factors for IAP in the surveyed population

Contributory factors for IAP	Frequency	Percentage
Floor material		
Clay	2	0.5
Mud	4	0.9
Cement	434	98.6
Wall material		
Thatch	2	0.5
Mud	46	10.5
Stone	16	3.6
Brick	376	85.5
Roof material		
Thatch	105	23.9
Asbestos	7	1.6
Tiles	209	47.5
Iron	119	27.0
Source of lighting		
Lantern	2	0.5
Gas	6	1.4
Electric	432	98.2
Cooking fuel		
Biomass	4	0.9
LPG	423	96.1
Firewood	6	1.4
Kerosene	7	1.6
Stove		
Enclosed chamber	396	90.0
Open combustion	44	10.0
Cooking place		
Inside	429	97.5
Outside	11	2.5
Type of family		
Nuclear	351	79.8
Joined	63	14.3
Three generation	26	5.9
Type of house		
Pucca	212	48.2
Semi-pucca	182	41.4
Kutchra	46	10.5
Overcrowding		
Present	130	29.5
Absent	310	70.5
Presence of chimney/exhaust		
Yes	148	33.6
No	292	66.4
Windows in kitchen		
Present	270	61.4
Absent	170	38.6
Ventilation		
Infiltration	22	5.0
Natural	224	50.9
Artificial	194	44.1
Cross ventilation		
Present	121	27.5
Absent	319	72.5

IAP=indoor air pollution, LPG=liquified petroleum gas

exposed to pollutants from heavy vehicle traffic (13%), small-scale industries (8.4%), and smoke from neighborhoods (6.6%) [Table 2].

Sources of IAP

Major risk factors of IAP identified were poor Ventilation 184 (41.8%), Over crowding 121 (27.5%) poor house keeping 96 (21.8%) [Table-3]. Major Sources IAP in this study Settings found to be heavy vehicle traffic 57 (13%), Second hand Smoke 52 (11.8%) occupation inside house 51(11.6%), vehicular exhaust 50 (11.4%) Neighbourhood pollution 41(9.3%) and using kerosene 27 (6.1%) [Table-3].

Regarding health issues, 152 (34.5%) female respondents perceived symptoms like dizziness (12.3%), eye irritation (10.2%), difficulty in breathing (4.5%), dry cough (3.06%), running nose (1.4%), and nasal congestion (1.1%) due to IAP. Only six respondents were having chronic respiratory infections. Among under-five respondents, 1.6% reported acute respiratory infections in the last 15 days and 10.5% reported the same in the last 1 year [Table 4]. 15 out of 25 variables which were studied, found to be significantly associated with indoor air pollution ($p < 0.05$) ie. over crowding, humid conditions, usage of kerosene, mosquito repellent using at home, poor ventilation and housekeeping, indoor smoking. Houses with less number of rooms have IAP, as linear by linear association is significant [Table.5].

Identified Risk Factors Associated with IAP

Household survey revealed that indoor air quality is affected by a variety of factors.

Risk factors associated with IAP are undesired consequences associated with activities that are likely to play a catalytic role. Out of 25 variables which were studied in the present study related to internal air pollution, 15 had some kind of association with IAP. The differences between the observed data and expected data were significant for the above list of variables at 95% confidence level. The above-listed variables, for example, type of house, overcrowding, houses without chimney, people who smoke inside the house, and so on, were found to be associated with the IAP, as the Chi-square test showed significant. Wherever IAP is present, some of the variables or conditions are also present in the house. Hence, they are considered as risk factors that cause IAP.

Discussion

Several studies have shown that indoor and outdoor air pollutants can damage children's lung tissues, predisposing them to viral or bacterial infections.^[18] There is also evidence that urban environmental factors associated with lower-income setting can aggravate, and perhaps even initiate, childhood asthma. Fuels that are used for cooking are the major sources of IAP.

Households using clean fuel for cooking in urban areas were around 87.4% in Tamil Nadu as per National family health survey (NFHS)- 4 (2015–2016). Present study found that about 96.1% of the households were using LPG. Only 4.9% were using unclean fuel and solid fuel for cooking. In contrast to this, a study conducted by Ellegard^[19] found that 35% of the respondents

Table 3: Sources of IAP among the surveyed population

Sources of IAP	Frequency	Percentage
Occupation inside the house		
Present	51	11.6
Absent	389	88.4
Heavy vehicle traffic		
Present	57	13.0
Absent	383	87.0
Neighborhood pollution		
Present	41	9.3
Absent	399	90.7
Small-scale industries nearby		
Present	37	8.4
Absent	403	91.6
New construction		
No	411	93.4
Nearby	26	5.9
Inside	3	0.7
Using kerosene		
No	413	93.9
Yes	27	6.1
Second-hand smoke		
Absent	388	88.2
Present	52	11.8
Smoke from neighborhood		
Absent	411	93.4
Present	29	6.6
Vehicular exhaust		
No	390	88.6
Yes	50	11.4
Mosquito repellent use		
All out	90	20.5
Coil	78	17.7
Nil	272	61.8
Air freshener		
Present	35	8.0
Absent	405	92.0
Humid condition		
No	342	77.7
Leaky water pipe/roof/damp wall	98	22.3
Poor housekeeping		
Absent	344	78.2
Present	96	21.8
Overcrowding		
Absent	319	72.5
Present	121	27.5
Poor ventilation		
Absent	256	58.2
Present	184	41.8
Cross ventilation		
Present	118	26.8
Absent	322	73.2

IAP=indoor air pollution

cook their food either on wood, coal, saw dust, or kerosene oil. It has become all the time more apparent that IAP is often the source of more personal exposure than outdoor air pollution, particularly but not entirely in homes where biofuels are used.

Table 4: Presence of IAP and its perceived impact among the surveyed population

	Frequency of respondents	Percentage
IAP		
Not present	378	85.3
Present	65	14.7
Presence of respiratory symptoms in the homemakers		
No symptoms	288	65.5
Dizziness	54	12.3
Eye irritation	45	10.2
Difficulty in breathing	20	4.5
Dry cough	16	3.6
Nasal congestion	5	1.1
Running nose	6	1.4
Chronic respiratory illness	6	1.4
ARI in <5 years in the last 15 days		
Yes	7	1.6
No	433	98.4
ARI in the last 1 year		
Yes	46	10.5
No	394	89.5

IAP=indoor air pollution

Incense sticks are used for pooja as a ritual in traditional Indian families and it is having a number of health hazards if it is used in poorly ventilated houses and in the presence of susceptible individuals. Burning incense sticks will generate air pollutants, mainly CO, and may lead to inflammation of lung tissues; it also increases the risk of respiratory complications, and this also heightens the risk of lung cancer, particularly in the upper respiratory tract. There was increased prevalence of chronic obstructive pulmonary disease (COPD) and asthma in the families that had been using incense sticks regularly. In the present study, it was found that indoor smoking was reported by 6.6% and passive smoking by 6.8% of the households. Majority (52.3%) of the participants were using incense sticks at home in the evening during pooja regularly. Households may be educated to open their windows while doing pooja with incense sticks.

Present study found that only 17.7% of the houses were using mosquito coil in the evening and at night, since mosquito breeding was heavy in the area. As it is a semi-urban area and the drainage facility and the solid waste disposal are not adequate, they act as mosquito breeding sites. In contrast to this, higher incidence was noted by Maharana.^[15] Out of 120 households, 62.5% were using insecticide repellents (IR) and a major portion of the households had IAP due to dust and smoke from outer sources (vehicular exhaust). A similar higher incidence was reported by Sarkar *et al.*^[8] They reported that in urban areas, 90% used IR; but as ventilation was adequate, the IAP was nullified.

Maharana *et al.*^[15] found that 61.7% houses were overcrowded and 70% households had no cross ventilation. These findings are similar to those of a study done by Choi *et al.*^[20] in a slum

Table 5: Test of association (Chi-square test) between the variables and the presence of IAP

Variable	Chi-square value	df	P	Significance
Overcrowding	24.5	1	0.0005	Yes
Humid condition	93.4	1	0.0005	Yes
Cross ventilation	18.7	1	0.0005	Yes
Mosquito repellents	12.2	2	0.002	Yes
Cattle in the house	0.121	1	0.728	No
Neighborhood pollution	0.000	1	0.987	No
Small-scale industry nearby	0.453	1	0.501	No
New construction	7.17	2	0.028	Yes
Usage of kerosene	26.13	1	0.0005	Yes
Smoke from neighborhood	17.98	1	0.0005	Yes
Vehicular exhaust	29.4	1	0.0005	Yes
Poor housekeeping	56.9	1	0.0005	Yes
Poor ventilation	33.8	1	0.0005	Yes
Type of cooking stove	4.3	1	0.038	Yes
Occupation inside the house	0.06	1	0.806	No
Pet animals in the house	2.2	1	0.138	No
Doors opened while cooking	4.1	1	0.041	Yes
Windows opened while cooking	2.8	1	0.09	No
Windows present in kitchen	4.08	1	0.043	Yes
Mode of ventilation	2.68	2	0.264	No
Chimney/exhaust fan	4.64	1	0.031	Yes
Cooking fuel	6.22	1	0.101	No
Smoking inside the house	17.98	1	0.0005	Yes
No. of rooms	18.88	2	0.004	Yes
Type of house	18.37	1	0.0005	Yes

df = degree of freedom, IAP = indoor air pollution.

of Bangalore. Less number of overcrowded houses were found in the present study; only about 29.5% houses reported overcrowding and 41.4% and 10.5% houses were semi-pucca and kutcha houses, respectively. Being in the slum area, the houses were all packed together with common walls, which left no space for windows. Many houses did not have separate rooms and a single room acted as living room and kitchen. These findings demand an urgent need of intervention to protect the well-being of the slum dwellers by providing them well-designed houses.

Children may be more exposed to the environment than adults, and because of their developing systems, they are especially susceptible to its effects. In this present study regarding health problems, 152 (34.5%) respondents felt symptoms such as dizziness (12.3%), itchy eyes (10.2%), shortness of breath (4.5%), dry cough (3.06%), runny nose (1.4%) and stuffy nose (1.1%) due to IAP. Only six respondents had chronic respiratory infections. Among respondents under 5 years of age, reported acute respiratory infections were 1.6% in the past 15 days and 10.5% in the past year. Similar results were also observed by Sarkar *et al.*^[8] and Makri *et al.*^[21] that half of the respondents complained of itchy eyes, which, as various studies have suggested, include being indoors for short periods of time while cooking and other procedures cause indoor pollution.

These people may be at risk of contracting COPD or other airway diseases. Similar findings were also observed by

Nandasena *et al.*^[22] About half of the women alleged IAP to be a major health problem, but due to economic constraints, they could not take authoritative measures. About 80.8% women rightly alleged the presence of IAP in their homes, which indicates that they are aware of IAP in their house, but only 45% women realized it is a major health problem. This gap must be filled. Forty-two women took some temporary corrective measures against the problem. Twelve (22.5%) women arranged their cooking stove and cooked in the corridor, outside their house. Others tried to keep the door unlocked, but it is not of use to a great extent. They mentioned that though they kept the door open, vehicular smoke and fumes from neighboring houses entered their houses.

In the present study, it was concluded that the generation of IAPs is mainly from household products and activities and less ventilation in the urban slum area. After the survey conducted with the help of questionnaire, it was found that the perceived health symptoms may be due to the generation of IAPs and lesser ventilation facilities in the survey buildings.

Limitations

The present study had some limitations. The presence of IAP was measured using a questionnaire, whereas the ideal measure of IAP is particulate matter of about 2.5 μm concentration. The lung function has to be assessed by spirometry. Since it was a cross-sectional study, causation cannot be established. Chances of recall bias are there since some data were self-reported.

The current study's strength was in its research setting, which was urban impoverished people living in slums. The presence of IAP sources is accentuated by the poor housing and ill-ventilated housing conditions in slums. In addition, most of the households use kerosene fuel for cooking with no separate kitchen. Various environmental researchers have shown evidence that the level of fine particles can be 100 times higher in ill-ventilated houses, which leads to inadvertent health problems.

Recommendations

IAP and its harmful effects are preventable. The urban poor living in slums should be provided with better housing conditions. The policymakers should promote the use of clean fuel (LPG) as it is beneficial and cost-effective. Smoking indoors is having negative impact upon the health of vulnerable groups such as women, elderly people, pregnant women, and children. Hence, smokers should be encouraged to quit smoking. This study helps the primary care physicians to educate the women and make them aware of the detrimental effects of IAP on their own health and also on their children, so that they can raise healthy children.

Conclusion

In conclusion, pollutants in the indoor air environment are major contributing causes of human diseases. IAP and its detrimental

effects are easily preventable. To reduce IAP's impacts, many strategies and approaches for the control and reduction of pollutant concentrations have to be taken. Clinicians should be aware of the increased risk of respiratory diseases and malignancies of the aerodigestive tract in patients who are actively being exposed to IAP or have been exposed at any point in their lives, including *in utero* exposure.

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Conflicts of interest

There are no conflicts of interest.

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