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Research Article

Indoor Air Pollutants and Respiratory Problems among Dhaka City Dwellers

Abstract

Background: Indoor air pollutants becoming a great concern for public health. Indoor air pollution can cause more harmful health impacts than that of outdoor air pollution.

Objectives: The study was conducted to investigate some selected indoor air pollutants and respiratory problems among the households of Dhaka city.

Materials and methods: This was a cross sectional study conducted among the households in Dhaka city. A total of 97 households from the selected areas of Dhaka city were included to measure some selected indoor pollutants and 288 individuals from these households were investigated for any respiratory problems. The indoor pollutants were carbon dioxide, carbon monoxide, hydrocarbon, formaldehyde and nitrogen dioxide.

Results: The indoor air the pollutants which were found to be at higher levels in the studied households were carbon dioxide (≥600ppm) in 67.0% households, formaldehyde (≥0.1ppm) in 35.1% households, carbon monoxide (1-5ppm) in 17.5% households and hydrocarbon (≥600ppm) in 9.3% of the households. In most of the households (92.8%) nitrogen dioxide could not be detected. However, hydrocarbon, formaldehyde and carbon monoxide also could not be detected in 7.2%, 30.9% and 73.2% households respectively. The respiratory problems were found to be more in the households with increase concentration of pollutants in the indoor air. In addition, the average concentration of carbon dioxide, formaldehyde and hydrocarbon are found to be significantly ($p<0.05$) high with the occurrence of respiratory problems. The common respiratory manifestations suffered by the household members were chronic cough (34.4%), cough and chest pain (33.7%); breathlessness and chest tightness (33.3%); running nose and sneezing (30.6%) and wheeze and asthma (26.4%).

Conclusion: The study revealed that the concentrations of some indoor air pollutants were higher in the studied households of Dhaka city. The members of these households were found to suffer more from respiratory diseases, particularly households having significantly higher concentration of carbon dioxide, formaldehyde and hydrocarbon.

Introduction

Recently, indoor air pollution has become a great concern for human being. It has been found that indoor air pollution can cause harmful health impacts more than health impacts due to outdoor air pollution. People spend 65 to 90 percent of their time in indoor and maximum of that time in home. According to the U.S. Environmental Protection Agency (EPA) humans are exposed to indoor air pollutants two to five times more even 100 times higher than the levels of outdoor pollutants. As people spend maximum time in the home, the higher levels of air pollutants in indoor are causing more threat to human health. Indoor pollution cause more respiratory disorders compared to outdoor pollution. Besides these impacts, indoor pollution leads to a significant cost burden to the economy. It was estimated in Australia that the cost of poor indoor air quality might be as high as $12 billion per year. On the basis of recent studies, EPA ranked indoor air pollution among the top five environmental risks to public health [1-3].

It has been reported that indoor air may contain more than 900 different organic compounds, in addition to particles, microbes, and allergens. These pollutants are emitted during cooking, cleaning, and heating and from other sources such as building materials. Among these sources cooking is considered as major sources of indoor pollutants in the dwelling houses. Burning of fuels like gas, oil and biomass may cause emissions of carbon dioxide, nitrogen dioxide, sulfur dioxide, hydrocarbons and particulate matters. The recent trend of constructing sealed dwelling houses allow little or no exposure to the external environment, but prolongs exposure to higher concentrations of the pollutants discharged from various indoor sources. Besides the cooking stoves, the Indoor air quality can be adversely affected by other pollutants such as microorganism, toxic gases like formaldehyde, radon from construction materials and furniture, toxic chemicals like insecticides, cleaning and deodorizing agents etc. The common adverse health effects that result from various indoor pollutants are mainly respiratory disorders like cough, rhinitis, asthma, in addition to these there may occur irritation to the skin, eyes and throat; neurotoxic symptoms; headache, dizziness, drowsiness, hypersensitivity reaction, immunodeficiency, cardiovascular diseases, adverse pregnancy outcomes and cancers [4-8].

WHO Fact sheet-292 [9] on indoor air pollution and health, reported that every year indoor air pollution is responsible for the death of 1.6 million people, which contributes to one death in every

20 seconds. Assessment of the contribution of various risk factors to the burden of disease by WHO, revealed that indoor air pollution ranked the 8th most important risk factor and contributes to 2.7% of the global burden of disease. Further in developing countries where mortality rate is high, the indoor smoke is responsible for an estimated 3.7% of the overall disease burden. In the recent update, WHO reported that 4.3 million people die due to illnesses which are attributable to indoor air pollution, it was estimated that in developing countries, nearly 2 million excess deaths might occur due to exposure to indoor air pollution. In low and middle income countries like Bangladesh the total burden of disease associated with indoor air pollution was estimated to be 3.6% [9-12].

Various measures have been undertaken to protect outdoor air pollutants as well as to eliminate or reduce it and already much progress has been achieved to mitigate these pollutants. On the other hand to tackle indoor pollutant not much work has been progressing. In many countries the limit value of indoor pollutants yet to be adopted. However, currently while dealing with the outdoor pollutants, importance has also been given to handle indoor pollutants. Now good Indoor Air Quality (IAQ) is considered as an important factor for a healthy indoor environment, particularly for the children, pregnant women and elderly people, because they are more vulnerable to develop the disease by the indoor pollutants [1,6,7]. In Bangladesh to reduce emission by cooking with biomass fuel in the rural areas, use of improved stove for cooking purpose has been promoted by different agencies. There were also some studies related to use of biomass fuel by the rural people and respiratory problems and it was revealed that respiratory problems were more common among the females who used biomass fuel [13,14]. However, no such activities have been noticed among the urban households. Moreover, there is a lack of study, which explored the extent of indoor air pollutant in urban areas as well as their impact on human health. The present study tried to find out the concentration of some selected air pollutants in the indoor environment of the households in selected areas of Dhaka city and to assess the occurrence of respiratory problems among the household members.

Materials and Methods

It was a cross sectional study carried out to investigate the concentration of some selected indoor air pollutants and respiratory problems among the households of different areas in Dhaka city. Sampling technique was convenient. For the purpose of the study 97 households which had been occupied by residents at the time of the study for at least one year and who were agreeing to participate in the study were included. In addition to 97 households 288 residents were included as study participants. For data collection a pretested questionnaire and checklist were used. Trained interviewers collected information relating the households and their occupants. Any individual having a previous physician diagnosis of chronic cough or were reported to have cough that occurs almost every day and lasts for 3 months was considered as having chronic cough. Anyone having whistling or rattling sound in chest while breathing was considered to have wheezing. Participants previously diagnosed as having asthma, or taking bronchodilators, or found by the study physician to have breathing problems with rhonchi were considered to have asthma. Other respiratory problems were ascertained by the study physician by the history of illness of last three months as well as physical examination of the household members. A trained technician measured the concentration of the selected air pollutants (carbon monoxide, carbon dioxide, nitrogen oxides, formaldehyde and aliphatic hydrocarbon) in the households by using a Gas Pumps and Gas Detector Tubes. The concentration of the air pollutants in the indoor environment of the households was measured in the main living room. As per manufacturer instruction, all the five selected gases were measured and recorded on the checklist for each household.

Results

This study was conducted in 97 households and from these households 288 members were included to assess the respiratory problems. The gases which were examined for detecting indoor pollutants in the households were nitrogen dioxide (NO_2), carbon monoxide (CO) carbon dioxide (CO_2) are inorganic chemical substances, and formaldehyde (HCHO) and hydrocarbon are organic chemical substances. All these examined gases were detected in the studied households. However, higher concentration of carbon monoxide (1-5ppm) was found in 17.5 % of households, carbon dioxide (≥600ppm) in 67.0% households, formaldehyde (≥0.1ppm) in 35.1% households and hydrocarbon (≥600ppm) in 9.3% households. While, nitrogen dioxide (0.2ppm) could be detected only in 7.2% of the households. Moreover, the average concentration of carbon monoxide, carbon dioxide, formaldehyde, hydrocarbon and nitrogen dioxide in the households was 0.24ppm, 664.9ppm, 0.158ppm, 270.0ppm and 0.014ppm respectively (Tables 1,2).

Table 1: Distribution of different indoor air pollutants in the households.

Pollutants (ppm)	Frequency (n=97)	Percent
Carbon monoxide		
0	71	73.2
< 1	9	9.3
1-5	17	17.5
Carbon dioxide		
< 600	32	33.0
≥ 600	65	67.0
Formaldehyde		
0	30	30.9
<0.1	33	34.0
≥0.1*	34	35.1
Hydrocarbon		
0	7	7.2
< 600	81	83.5
≥ 600	9	9.3
Nitrogen dioxide		
Nil	90	92.8
0.2 *	7	7.2

***** More than normal limit in the indoor air.

Regarding socio-demographic characteristics of the household members, it was found that majority (39.2%) of them were in the middle age group (21 years to 40 years) and one fourth (25.3%) of them were children and young adults (20 years and below). Female (54.2%) was more than male (45.8%). Majority of the household members had the Bachelor (26.0%) and Master degree (21.5%). Only a few (12.5%) had primary level of education and there was none who had no academic education. Almost two third (64.9%) of the households had a family size of 4 to 6 members. The monthly income of the households varied below Taka-10,000/- to over Taka- 40,000/- and majority (59.8%) had the income up to Taka- 20,000/-. Almost all the household members (97.6%) lived in *pucca* house (Table 3).

Among the study participants, 48.6% were found to have been suffering from respiratory problems in last three months. Higher proportion of males (51.5%) than females (46.2%) were found to suffer from the respiratory problems (Table 4) but the difference was not statistically significant (p=0.364). The respiratory problems (Table 5) suffered by them were chronic cough (34.4%), cough with chest pain (33.7%); breathlessness and chest tightness (33.3%); running nose and sneezing (30.6%) and wheeze and asthma (26.4%). While comparing the occurrence of different respiratory manifestations between male and female, only cough with chest pain was found to be significantly (p=0.033) higher in males (40.1%) than in females (28.2%). The common respiratory problems suffered by the household members aged up to 20 years were wheeze and asthma (30.1%); running nose and sneezing (27.4%) and irritation of nose (24.6%) and among the elderly members the common problems were breathlessness and chest tightness (83.4%) and chronic cough (75.0%) (Table 6). Among the households having respiratory problems, the average concentration of all the examined gases were found to be high in comparison to that of houses having individuals with no respiratory problem. However, the higher level of average concentration of carbon dioxide (690.5±163.7ppm), formaldehyde (0.183±0.20ppm) and hydrocarbon (300.4±185.4ppm) was statistically significant (p<0.05) (Table 7).

Discussion

Indoor air pollution is one of the major contributors to the global burden of disease. Indoor cooking and heating with various fuels produce high levels of indoor smoke which contains several pollutants that may cause many serious health effects. In dwelling houses with poor ventilation, the indoor air may contain particulate matter produced by indoor smoke 100 times higher than acceptable levels. The exposure to the indoor pollutants is particularly high among the women and young children, who spend most of their time in the house. Cooking with biomass fuels such as agricultural residues, dung, straw, wood or coal are usually mentioned as the sources of varieties of indoor air pollutants. These pollutants are reported to be responsible for causing many diseases particularly respiratory diseases [1-5]. On the other hand it has been also reported that cooking with natural gas emits several air pollutants, which can deteriorate the quality of indoor air and thereby increase many health risks. It was reported that cooking with natural gas emits nitrogen dioxide (NO_2), carbon monoxide (CO), formaldehyde (HCHO) and hydrocarbon, which are responsible for the occurrence of many

Table 2: Average concentration of different air pollutants in the households.

Pollutants	Households	Mean (ppm)	Std Dev	Minimum	Maximum
Carbon monoxide	26	0.24	0.45	0.15	0.33
Carbon dioxide	97	664.9	204.1	623.8	706.1
Formaldehyde	67	0.158	0.187	0.121	0.196
Hydrocarbon	90	270.0	197.5	230.2	309.8
Nitrogen dioxide	7	0.014	0.052	0.004	0.025

Table 3: Socio-demographic characteristics of household members.

Characteristics	Frequency n=288	Percent
Age group (years)		
Upto 20	73	25.3
21-40	113	39.2
41-60	90	31.2
61 and above	12	4.2
Sex		
Male	132	45.8
Female	156	54.2
Education		
Masters	62	21.5
Bachelor or Diploma	75	26.0
HSC/equivalent	28	9.7
SSC/equivalent	39	13.5
Secondary level	48	16.7
Primary level	36	12.5
Family size (HH-97)		
< 4	28	28.9
4-6	63	64.9
> 6	6	6.2
Monthly family income in Taka (HH-97)		
< 10000	26	26.8
10000 – 20000	32	33.0
20000 – 30000	9	9.3
30000 – 40000	4	4.1
> 40000	26	26.8
Type of house (HH-97)		
Pucca	281	97.6
Semipucca	7	2.4

Table 4: Distribution by suffering from respiratory problems.

Respiratory problems	Male n=132	Female n=156	Total n=288	Chi-square p value
Yes	68 (51.5%)	72 (46.2%)	140 (48.6%)	χ^2=0.823; p=0.364
No	64 (48.5%)	84 (53.8%)	148 (51.4%)	

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Table 5: Distribution by manifestations of respiratory problems.

Manifestations of different respiratory problems *	Sex		Total (n=288)	Chi-square; p value
	Male (n-132)	Female (n=156)		
Chronic cough	44 (33.2%)	55 (35.3%)	99 (34.4%)	χ^2 =0.117; p=0.732
Cough with chest pain	53 (40.1%)	44 (28.2%)	97 (33.7%)	χ^2 =4.568; p=0.033
Wheezing and asthma	28 (21.2%)	48 (30.8%)	76 (26.4%)	χ^2 =3.362; p=0.067
Breathlessness & Chest Tightness	38 (28.8%)	58 (37.2%)	96 (33.3%)	χ^2 =2.266; p=0.132
Running nose/sneezing	41 (31.1%)	47 (30.1%)	88 (30.6%)	χ^2 =0.0 29; p=0.864
Irritation of nose	28 (21.1%)	36 (23.1%)	64 (22.2%)	χ^2 =0.144; p=0.704

* Multiple Responses.

Table 6: Distribution of household members by age group and respiratory problems.

Respiratory Problems *	Age (years) of the household members				Total (n=288)
	Upto 20 (n=73)	21 – 40 (n=113)	41-60 (n=90)	61+ (n=12)	
Chronic cough	14 (19.2%)	38 (33.6%)	38 (42.2%)	9 (75.0%	99 (34.4%)
Cough with chest pain	17 (23.3%)	36 (31.9%)	37 (41.1%)	07 (58.3%)	97 (33.7%)
Wheezing and Asthma	22 (30.1%)	25 (22.1%)	26 (28.9%)	03 (25.0%)	76 (26.4%)
Breathlessness & chest tightness	08 (10.9%)	38 (33.6%)	40 (44.4%)	10 (83.3%)	96 (33.3%)
Running nose/sneezing	20 (27.4%)	34 (30.0%)	30 (33.3%)	04 (33.3%)	88 (30.6%)
Irritation of nose	18 (24.6%)	24 (21.2%)	19 (21.1%)	03 (25.0%)	64 (22.2%)

* Multiple Responses.

Table 7: Average concentrations of different gases and Respiratory problems.

Gas (ppm)	Respiratory problems		Statistical Test	
	Yes (n=140)	No (n=148)		
Carbon dioxide	690.5±163.7	632.1±229.0	t= 2.473	p= 0.014
Carbon monoxide	0.282±0.48	0.229±0.47	t= 0.925	p= 0.356
Formaldehyde	0.183±0.20	0.140±0.17	t= 1.743	p= 0. 044
Hydrocarbon	300.4±185.4	251.5±208.7	t= 2.100	p= 0.037
Nitrogen oxides	0.016±0.05	0.011±0.05	t= 0.797	p= 0.426

illnesses including various respiratory disorders [8,16-18]. The current study was conducted in Dhaka city and in Dhaka city the main fuel for cooking stove is natural gas. For which all the studied households used natural gas for cooking. As evident in other studies, the sources of the examined gases (carbon dioxide, carbon monoxide, nitrogen dioxide, formaldehyde and hydrocarbon) in the studied households might be the smoke produced by cooking with natural gas. Other common sources of these gases in indoor which were also reported are tobacco smoking, plywood, paneling, particle board, artificial wood products; personal care products, paint, generators and building materials [7,8,18-20].

Among the examined gases in this study higher concentration of carbon dioxide (≥600ppm) was detected in two third (67%) households, formaldehyde (≥0.1ppm) was detected in one third (35.1%) households and carbon monoxide (1-5ppm) in 17.5% households, while hydrocarbon (≥600ppm) was detected in 9.3% households but nitrogen dioxide could not be detected in most (92.8%) of the households. The normal limit or recommended values for most of these gases varied in different organizations and agencies. The common values which were noted from different sources for carbon monoxide is 0.5-5 ppm; carbon dioxide less than 1000 ppm; formaldehyde less than 0.1 ppm; nitrogen dioxide 0.053-0.08 ppm and for hydrocarbon 1000 ppm in-terms of aliphatic hydrocarbons as TWA [6,21-24]. Accordingly, in this study formaldehyde and nitrogen dioxide in the indoor environment were found to exceed the normal limit.

Indoor air pollution is contributed by a mixture of complex pollutants and many of these are toxic and carcinogenic to human health. Numerous health problems including cancer have been reported in many studies due to exposure to these indoor pollutants. However, respiratory diseases are reported to occur more commonly which are cough, asthma, breathlessness, allergic rhinitis, nose and throat irritation, bronchitis and pneumonia [6-8]. In the current study almost half (48.6%) of the household members were found to suffer from respiratory diseases. And the respiratory problems were detected among the household members who had significantly a higher average concentration of carbon dioxide (690.5ppm), formaldehyde (0.183 ppm) and hydrocarbon (300.4 ppm) in the indoor air in comparison to that of household members who had no respiratory problems. The common respiratory manifestations suffered by the household members were chronic cough, cough with chest pain; breathlessness and chest tightness and running nose and sneezing. However, children and adolescents (aged up to 20 years) were found to suffer more from wheeze and asthma (30.1%) and running nose and sneezing (27.4%). Women were found to suffer more from breathlessness and chest tightness; chronic cough and wheeze and asthma in comparison to that of male household members. On the other hand the elderly people were found to suffer more from chronic cough (75.0%) and breathlessness and chest tightness (83.3%). In different studies, these groups of household members are mentioned to be potentially vulnerable to indoor air pollution and they are at risk of suffering from respiratory diseases more compared to other members of the household [7,8,25]. A study carried out in Bangladesh found that children under five years suffered more from nasal discharge, cough, shortness of breath, chest tightness, wheezing, or whistling chest, redness of eyes, itching of skin due to indoor pollution by cooking smoke [26]. Results of another study showed that women used gas for cooking significantly associated with increase respiratory symptoms, particularly wheeze and breathlessness [27]. Study reported from India found that the women exposed to indoor pollution had excess 50% risk of still birth [25].

Among the detected pollutants in this study, formaldehyde and hydrocarbon have been reported in several studies as carcinogen both in animal and human [28-36]. It was reported that formaldehyde at the level exceeding 0.1ppm in the household, some of the household members might experience adverse respiratory effects such as burning sensations in the nose and throat; coughing; wheezing and skin irritation [27,28]. In this study, one third (35.1%) of the households

had formaldehyde exceeding 0.1 ppm in the indoor air and all the manifestations as reported were evident among the members. Further, it was reported that long term exposure to formaldehyde more than the normal limit may cause cancer of nasopharynx, sinonasal and leukaemia [6,28-31]. Similarly, exposure to hydrocarbons also reported to be responsible for the development of various cancers, particularly in the skin and lungs. In the indoor air various types of hydrocarbons are found as pollutant and most of them are known as carcinogens from the ancient time. Percival Pott in 1775 noted scrotal cancer among chimney sweepers due to exposure to soot and later hydrocarbon was discovered as a chemical composition in the soot [36-37]. Some of the household members in this study had exposure to higher concentration of hydrocarbon and formaldehyde; therefore, if they are exposed to these pollutants for a long time might be at high risk of developing cancer.

Conclusion

It was evident in this study that the concentrations of some pollutants were in higher level in the indoor air of households of Dhaka city. The members of these households were found to suffer from respiratory diseases that were attributable to indoor pollutants detected in the households. Amongst these indoor pollutants, formaldehyde and hydrocarbons are known carcinogen. Therefore, it could be said that the household members who were living in the residence for a long time having higher levels of these two pollutants, might be at risk of developing cancer.

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