Air Quality and Respiratory Health: Prevalence, Knowledge, and Practices in Dhaka's Informal Settlements-A Cross-Sectional Study

Rabeya Akter

Batch: MPH 20th Cohort

ID number: 24167010

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Supervisor: Zahidul Quayyum

Professor (Health Economics) and Director Research

Co-Director Centre of Excellence for Urban Equity and Health (CUEH)

BRAC James P Grant School of Public Health, BRAC University

zahidul.quayyum@bracu.ac.bd

Co-supervisor: Priom Saha

Lecturer

Department of Applied Statistics and Data Science, University of Dhaka.

psaha@isrt.ac.bd

Farzana Sehrin

Research Fellow

Centre of Excellence for Urban Equity and Health

BRAC James P Grant School of Public Health, BRAC University

farzana.sehrin@bracu.ac.bd

Anisur Rahman Bayazid

Research Associate

Centre of Excellence for Urban Equity and Health

BRAC James P Grant School of Public Health, BRAC University

anisur.bayazid@bracu.ac.bd

Jinat Jahan Khan

Research Associate

Centre of Excellence for Urban Equity and Health

BRAC James P Grant School of Public Health, BRAC University

jinat.khan@bracu.ac.bd

Khadiza Tul Kobra Nahin

Research Associate

Centre of Excellence for Urban Equity and Health

BRAC James P Grant School of Public Health, BRAC University

Khadizatul.nahin@bracu.ac.bd

Baby Naznin

Senior Research Associate

baby.naznin@bracu.ac.bd

Centre of Excellence for Urban Equity and Health BRAC University

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1. Abstract

Background

Several studies suggest that air pollution causes morbidity and mortality, this problem is particularly severe in developing countries. However, little is known about the prevalence of respiratory symptoms among adults in informal settlements with varying air pollution and their practice and knowledge status regarding air pollution and its impact on health. The objective of this study is to explore the prevalence of respiratory symptoms in two informal settlements in Dhaka and the knowledge and practice status of the adult residents.

Methods

The study design was cross-sectional and was conducted in Shyampur and Dakshinkhan areas. These study sites were selected based on air quality data collected from a study conducted in BRAC JPGSPH in 2023. Shyampur was selected for having comparatively high air pollution, whereas Dakshinkhan was chosen for having comparatively low air pollution. A total of 316 adult residents were interviewed. This study used multiple sequential logistic regression models to examine the relationship between respiratory symptoms, sociodemographic, and environmental factors, and knowledge and practice status.

Results

The proportion of people having respiratory symptoms in Shyampur and Dashinkhan areas were 60.26% and 55.41% respectively. Knowledge status varied in the two areas, while the practice status was almost equal in Shyampur and Dakshinkhan. Results of the sequential multiple logistic regression revealed that the participants in Dakshinkhan had lower odds of having respiratory symptoms (OR= 0.61; 95% CI: 0.36-1.01) compared to Shyampur area. The odds of suffering from respiratory symptoms were significantly associated with individuals who are aged 50 years and above (OR= 2.31; 95% CI: 1.07-4.98); those who were aged 30-39 years old (OR= 2.05; 95% CI: 1.11-3.82); exposure to indoor smoking (OR= 1.53; 95% CI:0.93-2.50), higher income level (OR=1.91; 95% CI:1.04-3.49), knowledge status (Good level) (OR= 2.07; 95% CI: 1.06-4.05), knowledge status (moderate level) (OR = 2.07, 95% CI: 1.06-4.05). In stratified logistic regression analysis age, income, and exposure to smoking indoors showed a significant

association, while in Dakshinkhan resident's knowledge status was significantly associated with respiratory symptoms.

Conclusion:

The impact on respiratory symptoms is higher in areas with comparatively high pollution than in areas with comparatively low pollution. Along with socio-demographic and environmental factors, housing conditions, and participant's knowledge status emerged as significant variables in predicting respiratory symptoms in informal settlements.

2. Introduction

2.1 Background

Rapid urbanization poses significant threats to human health by contributing to environmental pollution, especially air pollution. Air pollution occurs due to both anthropogenic activities and natural phenomena. The rapid expansion of cities with a growing population and the increasing demand for resources have intensified activities like the construction of roads and buildings, usage of motor vehicles, and industrial production. All of these anthropogenic activities significantly contribute to air pollution. Air pollution is one of the major public health issues because multiple health problems are caused due to air pollution such as respiratory illness, heart disease, stroke, cancer etc. The World Health Organization (WHO) reported that in 2019, around 99% population of the world lived in areas where air quality failed to meet the WHO recommended levels (WHO, 2024). This highlights a pressing concern regarding poor air quality, by exposing a large number of people to air pollution and putting them at risk of illness and premature mortality. According to the United Nations Environment Programme (UNEP, 2021), globally over 8 million deaths occurred due to air pollution. Among these deaths in 2021, 48% were caused by chronic obstructive pulmonary disease (COPD) followed by lower respiratory disease which caused 30% fatality (UNEP, 2021).

Research highlights the health impacts of air pollution due to short- and long-term exposure. Short-term exposure is associated with health conditions such as chronic obstructive pulmonary disease (COPD), coughing, shortness of breath, pneumonia, asthma, wheezing, and respiratory

illnesses (Dibiya et al., 2023). Long-term exposure leads to more severe outcomes, including reduced lung capacity, clinical depression, and premature mortality (Kim et al., 2020; Kim & Radoias, 2022). These impacts of air pollution are disproportionately higher in low and middle-income countries. According to the WHO estimates of global death polls due to high levels of outdoor air pollutants, including fine particulate matter (PM2.5), around 89% of global deaths occurred in developing countries (Isenaj et al., 2024). WHO (2024) mentioned that the regions that experienced the greatest burden are Southeast Asia and the Western Pacific region.

In Bangladesh, air pollution is a major health challenge. According to a report regarding air pollution and its health impact mentioned that in the year 2021, 236,300 deaths were recorded due to exposure to outdoor air pollution, in Bangladesh (State of Global Air, 2024). It is further documented in the report that more than 40% of all deaths that occurred from lower respiratory tract infections in children under 5 are attributed to air pollution. Air pollution has an adverse health impact on pregnancy outcomes as well. A study found that low birth weight and preterm birth increased, with an increase in cumulative air pollution exposure (Nahian et al., 2023).

Dhaka, the country's capital, was ranked as the world's second most polluted city between 2018 and 2021 (World Bank, 2022). Levels of PM 2.5 have surpassed the WHO air quality guidelines and was 150% above the standard level. The rising level of different pollutants, which exceeded the standard limit, has led to various health concerns for city dwellers. A study mentions that PM2.5 causes respiratory infection among adults and children and is associated with an increased risk of respiratory infections (Croft et al., 2019). Given that 10–15 m3 of air is inhaled by an adult daily on average, exposure to air pollutants is unavoidable. Consequently, these pollutants can reach the bloodstream, and affect our health by causing local disorders (lung problems) and systemic disorders that affect other vital organs (Taghizadeh-Hesary, 2020). The authors further mentioned that components such as PM in the air contain polycyclic aromatic hydrocarbons and heavy metals which contribute to carcinogenic effects. Ambient air pollution is identified as the cause of lung cancer and is recognized as " the most widespread carcinogen" by the International Agency for Research on Cancer (IARC) (Loomis et al., 2014, as cited in Taghizadeh-Hesary, 2020). The current air quality condition poses a serious threat to the residents in urban areas in Bangladesh. Research conducted on air pollutants and their perceived health impacts in different

locations found that Carbon dioxide (CO2), Sulfur Dioxide (SO2) Nitrogen oxide, Particulate matter (PM 2.5 and PM 10), lead (Pb) significantly increased from 2016 to 2017 (Alam et al., 2018). However, this study on air pollutants conducted in different locations is limited to only air quality parameters at different locations in the megacity of Dhaka and their perceived impacts on health. Another study that investigated seasonal pattern trends in Dhaka from 2013- 2017 found that the concentration of PM is five to six times higher during the winter season compared to the monsoon season, and recognized it as a major air pollutant threat to human health (Rahman et al., 2018). In 2022, research showed that the air quality index in December reached 250 in Dhaka, implying very unhealthy air quality (Khatun et al., 2023).

A study conducted in Bangladesh on under 5 children attending hospitals found that 67% of the children had respiratory problems (Amin et al., 2014). A different study that investigated respiratory symptoms among traffic police, reveals that the prevalence of all types of respiratory symptoms was more than 50% among the study participants (Ahmed et al., 2022). A study on the relationship of acute respiratory infections (ARI) with household fuel among under-5 children in Bangladesh shows that the probability of occurrence of ARI is 69.2% higher in contrast with using clean fuel (Islam et al., 2022). There is a lack of investigation on air quality variation and its relationship with respiratory disease among adult residents in Dhaka City, despite much research done on respiratory disease and pollution. Moreover, the existing literature looked at respiratory symptoms among under-5 children. A previous study conducted in Dhaka among adult slum dwellers examined the frequency of respiratory symptoms, highlighted the differences in prevalence by gender and socio-demographic factors, and assessed their relationship with housing conditions (Zanuzdana et al., 2014) However, research on respiratory symptoms and its relationship with air pollution among this vulnerable community is limited. This leaves a gap in comprehending health impacts particularly respiratory symptoms that occur due to air pollution among this population.

On the other hand, residents of the urban informal settlements are one of the most vulnerable groups due to their unique living conditions, characteristics of the neighborhood they live in, and their socio-economic status. People belonging to lower socioeconomic backgrounds are particularly at risk of respiratory disease, due to the lack of the ability to protect themselves from

external pollutants like emissions from industries as well as the characteristics of their living conditions (Muindi et al., 2014). Environmental factors like overcrowding, air pollution, slum conditions, and waste management are significantly associated with respiratory disease and other adverse health outcomes (Rahman et al., 2023). According to the World Bank (2022), exposure to PM2.5 is associated with experiencing a lower respiratory tract infection (Raza et al., 2022) They further pointed out that people in the poorest socioeconomic background are found to have higher odds of having chronic coughing, higher probability of experiencing breathing difficulties, and lower respiratory tract infections. This underscores the importance of conducting a study on respiratory symptoms and their relation with air pollution in urban informal settlements.

Additionally, to reduce the health risks associated with air pollution it is essential to have knowledge and application of it to protect from the pollution. However, studies conducted in residents in Dhaka city found that a smaller percentage of people have a high practice level of protective measures against air pollution (Majumdar et al 2019). The urban poor being the most vulnerable group due to being exposed to several risk factors there is barely any research conducted on them assessing their knowledge of air pollution in urban areas (Muindi et al., 2014). Another study among the urban residents in Dhaka city assessed the knowledge attitude and practice about the inhalation of particulate matter emphasizing conducting a further study on the community level to help understand factors influencing people's practices (Majumdar et al., 2019). Although there is much research that was done on respiratory diseases and their associated factors, there is barely any study that examines the prevalence of respiratory symptoms in relationship with varying air pollution areas in informal settlements dwellers in Dhaka city (Hasan et al., 2019; Hossain et al., 2018; Kabir et al., 2021; Zanuzdana et al., 2014).

2.2 Justification

A World Bank report mentioned that air pollution was one of the second strongest risk factors attributing to deaths and disability in Bangladesh between the years 2009 and 2019 (Raza et al., 2022). Given the higher pollution in urban areas like Dhaka city and the lower socio-economic status of these vulnerable people living in slums, this study's findings are essential since it will give important insights regarding the prevalence of respiratory symptoms and knowledge about

air pollution and health impact and their practice status to protect themselves. Additionally, more than 52% of the urban population in Bangladesh lives in the urban slums which constitute a larger proportion of the population (World Bank, 2022). Therefore it is essential to take into account the larger population of this marginalized group for inclusive policy developments and interventions implementations. In Bangladesh, although the government. has initiated programs and plans regarding air pollution, the successful implementation of those strategies requires a comprehensive understanding both at the community and individual level regarding knowledge and protective practices from air pollution (Siddique et al., 2014). Hence, this study would fill in the gap by providing community-level information. Addressing this matter is crucial for the nation's sustainability and green growth as in 2019 respiratory illness related to air pollution cost the country around 3.9- 4.4 percent of the GDP of the country (World Bank, 2022).

2.3 Research Questions

Primary Research Question

1. What is the prevalence of respiratory symptoms among adults (18 years and above) residents in informal settlements with high—and low-air-pollution in Dhaka City?

Secondary Research Question

1. What is the knowledge level regarding air pollution and its health effects among residents in high—and low-air-pollution areas of informal settlements in Dhaka City?

2. What is the protective practice status regarding health problems related to air pollution among residents in high—and low-air-pollution areas of informal settlements in Dhaka City?

2.4 Research Objectives

Primary objective

To investigate the prevalence of respiratory symptoms among adult (18 years and above) residents in high and low-air pollution areas of informal settlements in Dhaka City.

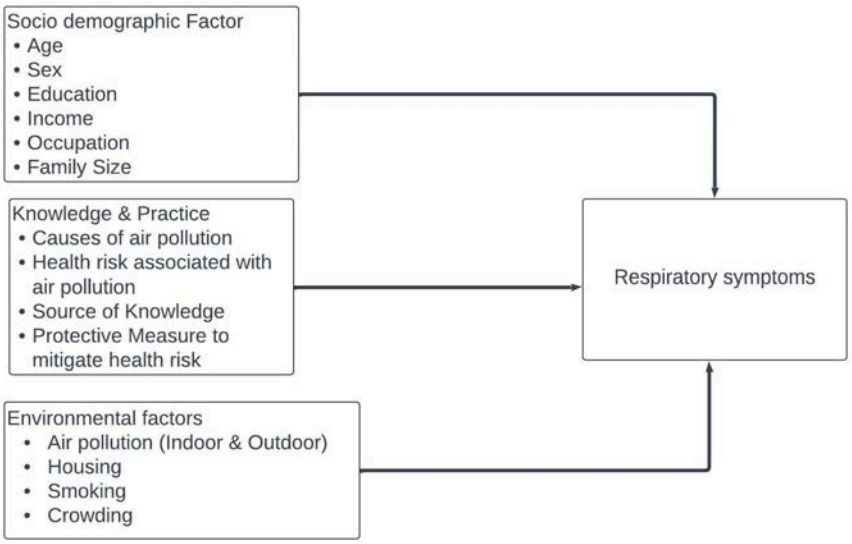
Secondary objective

To explore knowledge regarding the health impacts of air quality and their practices for preventing respiratory illnesses associated with poor air quality.

3. Conceptual Framework

Factors such as socio-demographic factors: age, sex, education, income, occupation, family size; environmental factors: air pollution, housing, crowding, and smoking were taken from other studies that analyzed Respiratory symptoms or infections and its associated factors (Alemayehu et al., 2019; Andualem et al., 2020; Raza et al., 2022, Wafula et al., 2023). Studies found that productive cough and breathing difficulty among children under 5 and elderly (65 years and above) have higher probability of such symptoms. Moreover, occupations are also important as exposure to locations such as traffic or construction sites showed significant associations with respiratory symptoms (Raza et al., 2022). Educational status is one of the important factors as it is one of the key indicators of socioeconomic status and is related to people's income. The educational level can influence people's knowledge and sometimes helps behavioral changes and causes the adoption of healthy practices. A study mentioned that a lower educational level showed a significant relationship with biofuel use which results in a higher risk of respiratory infection (Andualem et al., 2020)

Conceptual Framework: The factors and their relationship with respiratory symptoms



4. Methodology

4.1 Study design and Study site

This cross-sectional study purposively selected two informal settlements in Dhaka, Bangladesh, based on air quality (PM2.5) data. Area-specific air quality data were obtained from a study conducted in BRAC JPGSPH in 2023 titled 'Air and noise monitoring across Dhaka city' under the 'Pathways to Equitable Healthy Cities' project. The study monitored air quality across Dhaka city using 8 fixed sites and 62 rotating sites. The findings indicated that all areas of Dhaka exceed both the national (15 μg/m³) and WHO (5 μg/m³) guidelines for PM2.5 concentration (Department of Environment, 2021; WHO, 2021).

Based on these data, two informal settlements were selected, one with a comparatively higher PM2.5 concentration, and another with a comparatively lower PM2.5 concentration. The area Shyampur, with an annual average concentration of 166.32 μg/m³ was selected as a high-exposure area, and the second area Dakshinkhan, with an annual average concentration of 110.53 μg/m³ was selected as a low-exposure area. During the wet season (July-September), when air quality is slightly better, the average PM2.5 concentration was 89.70 μg/m³ and 29.76 μg/m³ respectively.

4.2 Sampling Strategy

A systematic random sampling method was used to select study households. Social mapping was initially conducted to determine the total number of households and their geographic distribution within each area. This mapping exercise was a collaborative effort involving local community leaders who provided estimates of household numbers. Assisted by these leaders, a research team systematically developed detailed maps for each designated area. These maps accurately marked the location of all households characterized as informal settlements. A total of 1,500 households in Shyampur and 450 households in Dakshinkhan were documented as part of the sampling frame. The selection interval was based on the total number of households documented during the social mapping exercise, with every tenth household selected in Shyampur and every third in

Dakshinkhan. The primary respondents were adult women, either as spouses of household heads or as female household heads.

Figure 1: Social Map of Shyampur Informal Settlement.

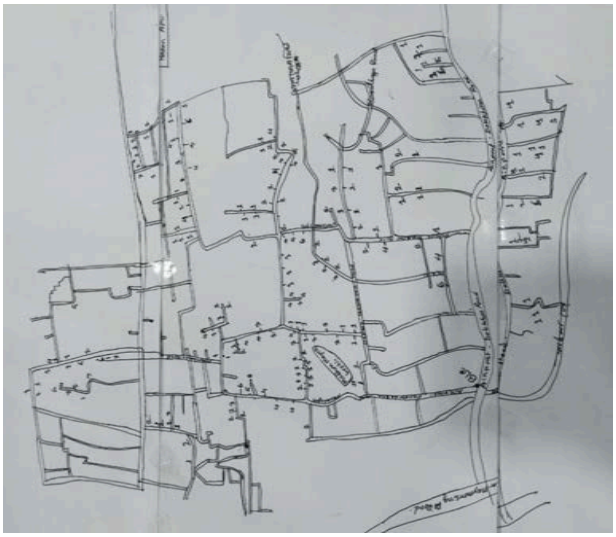
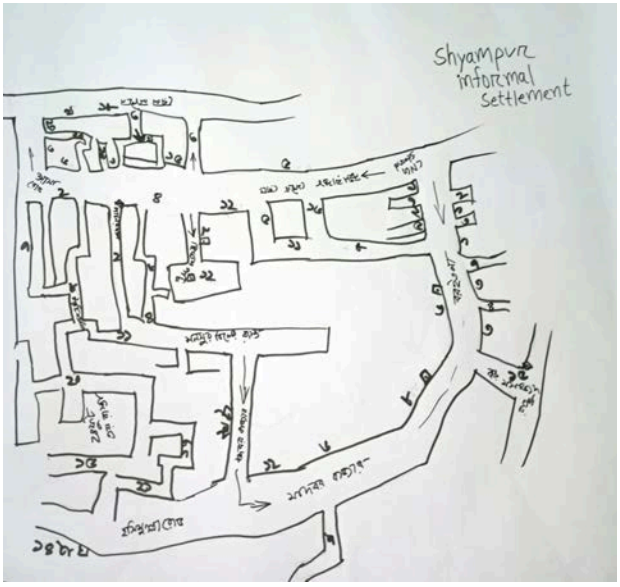


Figure 2: Social Map of Dakshinkhan Informal Settlements



4.3 Inclusion and Exclusion Criteria

The inclusion criteria for the study were as follows: individuals with 18 years and above; residents who had lived in the study sites for at least one year (Alim et al., 2014); those willing to participate in the study and able to give informed consent; and individuals who were mentally sound to participate in the study. On the other hand, the exclusion criteria included individuals aged below 18 years old, who had lived in the study sites for less than one year; those unable to provide informed consent.

A standard formula was used to calculate the sample size as given below:

$$n = \frac{Z_{\alpha/2} \times p \times (1-p)}{d^2}.$$

Sample size calculations assumed a 50% prevalence of respiratory symptoms, a 95% confidence level, and a 5% margin of error, adjusted for a design effect of 1.5 and anticipating a 10% non-response rate. This resulted in a required sample size of 158 participants per area, totaling 316 participants across both sites.

4.4 Data Collection

4.4.1 Study Tool

The survey used a structured questionnaire to assess respiratory symptoms as well as participants' knowledge and practice levels. To carry out the survey efficiently, we incorporated sociodemographic characteristics questions from the Household Income and Expenditure Survey (HIES) 2022, conducted by the Bangladesh Bureau of Statistics (Bangladesh Bureau of Statistics (BBS) & UNICEF Bangladesh, 2019; Preliminary Report, 2023). For adults, the prevalence of respiratory symptoms was investigated using the Respiratory Symptom Experience Scale (Shiffman et al., 2023). The knowledge and practice levels concerning air pollution and its health impacts were assessed using adapted questionnaires from prior studies (Siddiquie et al., 2024).

A one-day training session was conducted to ensure that data collectors were well-prepared and consistent in their approach. Data was collected using KoboToolbox. The questionnaire was

pre-tested in Korail slum to evaluate the acceptability and transparency of the questionnaire. Following the completion of pre-testing, a few minor corrections were made to refine and finalize the questionnaire. To ensure data quality, data collection and analysis procedures were constantly monitored and supervised by the supervisor, researchers, and statisticians.

4.4.2 Ethical Consideration

Ethical approval (MPH-2024-010) for the study was obtained from the Institutional Review Board (IRB) of BRAC James P Grant School of Public Health. Informed consent was taken from participants before proceeding with the interviews. Measures were taken to maintain the anonymity and confidentiality of the study participants.

4.5 Variable and Measurements

The outcome variable, respiratory symptoms, is defined as the presence of respiratory symptoms such as morning cough, frequent coughing, shortness of breath, winded feelings, and wheezing during the last 30 days. The dataset includes combinations of categorical and continuous variables, including sociodemographic, health, environmental factors, and knowledge and practice indices. Here, the indices of knowledge and practice have 11 and 10 items respectively (Siddique et al., 2024).The independent variable overcrowding is defined as if any household has more than three members living per room (Behr et al., 2021). Based on prior research, independent variables such as gender, area, income, occupation, employment status, crowding, smoking inside the house, knowledge, and practice were selected for analysis (Siddique et al., 2024; Croft et al., 2018; Majumder et al., 2019; Zanuzdana et al., 2014).

Knowledge and practice levels were measured using a traditional Likert scale. Where the knowledge index ranged from “strongly disagree” to “strongly agree” and the practice index from “never” to “always”. The total scores were calculated by summing responses across all items, with a threshold set at above 80% for a good level of knowledge, 60%-80% as a moderate level of knowledge, and below 60% as a poor level of knowledge. Practice scores below $< 50\%$ were considered to be of poor level, and $\geq 50\%$ was considered a good level of practice.

4.6 Data Analysis Plan

Descriptive analysis was conducted to summarize the data. A chi-square test was performed for bivariate analysis, to examine differences in respiratory symptoms between high and low-pollution areas. Three logistic regression models were used to examine the influence of covariates on respiratory symptoms. Model-1 includes demographic factors; Model-2 has both demographic and environmental factors,and Model-3 combines Model-1 and Model-2 with knowledge and practice status. The three sequential logistic regression Models were used to examine the impact of independent variables on the presence of respiratory symptoms. The goodness of fit of each model was tested using Akaike information criterion (AIC). Statistical analyses were conducted using STATA 17.0.

5. Findings

A total of 316 individuals were interviewed, with 313 participants enrolled after adjusting for missing variables. A majority of the participants fell within the 18-29 age group which accounts for 46.96% of the total cohort. This age group was consistently the largest proportion of the population studied in both study areas. Over half of the adult population surveyed were female, with a slight variation in gender distribution between the two areas. Marital status differed notably between locations. In Shyampur and Dakshinkhan informal settlements, the proportions of married individuals were 83% and 74% respectively, with fewer participants being unmarried or widowed/divorced/separated. The educational attainment of participants in Shyampur had a higher proportion of individuals with no education (35.90%) compared to those in Dakshinkhan(24.84%), whereas those with secondary education or above had higher levels in Dakshinkhan (38.85%). Employment status varied, with Shyampur having a higher proportion of employed individuals (52.68%) than Dakshinkhan (47.32%). The monthly household income showed that a higher proportion of Shyampur residents fell into the lowest income level (37.18%), whereas a higher proportion of the surveyed residents (40.76%) belonged to the highest income level in Dakshinkhan. Over 60% of the adults in Shyampur reported at least one of the respiratory symptoms, which was less than the proportion in the Dakshinkhan area.The percentage of residents who are exposed to indoor smoking is higher in Shyampur (40.48%) comapred to Dakshinkhan (43.95). A higher proportion of participants with a good level of knowledge was in Shyampur (62.82%), compared to Dakshinkhan (45.22%). In Dakshinkhan, a

higher prevalence of moderate level of knowledge was observed (39.49%), while the prevalence was only 19.23% in Shyampur. In both locations, the prevalence of the practice status was nearly evenly split, with half of the individuals showing a poor level of practice and the other half having a good level of practice (In Annex, Table 01).

Chi-square test results indicated significant associations between respiratory symptoms and a number of independent variables such as income, indoor smoking, age, and knowledge status. Respiratory symptoms were found to occur significantly in a higher proportion (37.57%) among individuals who were in the highest income levels. Notably, the adults 18-29 years age group had a higher prevalence of symptoms (39.78%) compared to those who were aged 50 years and above (18.28%), which showed a significant association. Indoor smoking also showed a statistically significant association with respiratory symptoms. The occurrence of such symptoms was higher among those who were exposed to indoor smoking (57.51%). The respondents with a good level of knowledge (54.70%) were found to experience more respiratory symptoms than those with a poor level of knowledge (11.20%), and the difference was statistically significant ($\chi2=11.49$; $p < 0.10$). On the other hand, variables including gender, area, employment, overcrowding, and practice levels were not found to be statistically significant with respiratory symptoms. There is a slight difference in the proportion of individuals who had a good level of practice and those with a poor level of practice is negligible(Table 02).

Table 02*:* Factors associated with the prevalence of respiratory symptoms in informal settlements in Dhaka

	Respiratory symptoms		
Variables	**Yes, n (%)**	**No, n(%)**	***χ2 test value***
Area			
Shyampur	94 (51.93)	62 (46.97)	0.75
Dakshinkhan	87 (48.0)	70 (53.03)	
Age			
18-29 years	72 (39.78)	75 (56.82)	
30-39 years	48 (26.52)	26 (19.70)	10.72**
40-49 years	28 (15.47)	19 (14.39)	
50 and above years	33 (18.23)	12 (9.09)	

Gender			
Female	93 (51.38)	93 (51.38)	0.67
Male	88(48.62)	88 (48.62)	
Overcrowding			
Yes	126 (69.61)	100 (75.76)	
No	55 (30.39)	32 (24.24)	1.44
Indoor Smoking			
Yes	86 (47.51)	46 (34.85)	
No	95 (52.49)	86 (65.15)	5.02**
Income			
Less than 18,000	54 (29.83)	52 (39.39)	
18000-25000	59 (32.60)	43 (32.58)	4.71*
Above 25000	68 (37.57)	37 (28.03)	
Employment			
Unemployed	60 (33.15)	48 (36.36)	0.35
Employed	121 (66.85)	84 (63.64)	
Knowledge			
Poor level	20 (11.05)	32 (24.24)	
Moderate Level	62 (34.25)	30 (22.73)	
Good Level	99(54.70)	70 (53.03)	11.49**
Practice			
Poor level	89 (49.17)	66 (50.00)	0.02
Good level	92 (50.83)	66 (50.00)	
** p-value < 0.10	* p-value < 0.10		

Table 03: Effects of demographic characteristics, environmental factors, knowledge, and practice status on respiratory symptoms based on sequential multiple logistic regression models.

	Model 1	**Model 2**	**Model 3**
Factors	**AOR [95% CI]**	**AOR [95% CI]**	**AOR [95% CI]**
Area			
Shyampur (Ref.)			
Dakshinkhan	0.70 [0.43-1.13]	0.69 [0.43-1.12]	0.61* [0.36-1.01]
Age			

18-29 years (Ref.)			
30-39 years	2.18** [1.19-3.98]	2.04** [1.11-3.75]	2.05** [1.11-3.82]
40-49 years	1.39 [0.70-2.78]	1.28 [0.64-2.58]	1.28 [0.63-2.59]
50 years and above	2.75** [1.30-5.82]	2.54** [1.19-5.41]	2.31** [1.07-4.98]
Gender			
Female (Ref.)			
Male	1.27 [0.74-2.19]	1.46 [0.69-2.08]	1.21 [0.69-2.12]
Income			
Below 18000 BDT (Ref.)			
18000-25000 BDT	1.48 [0.84-2.59]	1.46 [0.82-2.59]	1.39 [0.77-2.50]
Above 25000 BDT	1.89** [1.06-3.38]	1.92** [1.07-3.47]	1.91** [1.04-3.49]
Employment			
Unemployed (Ref.)			
Employed	0.97[0.55-1.71]	1.05 [0.59-1.87]	1.04 [0.57-1.89]
Overcrowding			
No (Ref.)			
Yes		0.69 [0.41-1.34]	0.72 [0.42-1.24]
Indoor Smoking			
No (Ref.)			
Yes		1.53* [0.94-2.48]	1.53* [0.93-2.50]
Knowledge Status			
Poor level (Ref.)			
Moderate Level			3.32** [1.57-7.06]
Good Level			2.07** [1.06-4.05]
Practice Status			
Poor Level (Ref.)			
Good Level			0.97 [0.59-1.57]
Akaike information criterion (AIC)	426.22	425.51	421.28

**p value < .05 *p value < .10

Table 03 shows the effects of demographic characteristics, environmental factors, knowledge, and practice status on respiratory symptoms from three sequential multiple logistic regression analyses. The Model-1 adjusts for demographic covariates. It has been further adjusted for housing conditions in the Model-2, and the Model-3 has been adjusted for knowledge and practice levels. To evaluate the goodness of fit of these three models, Akaike Information Criterion (AIC) has been used. It can be observed that the value of AIC has decreased from Model-1 to Model-3, showing a better fit for the later models. However, the Bayesian Information Criterion (BIC) test was not performed, as the BIC value could be quite biased when the sample size is not quite large. Hence, the AIC statistic has been used to determine the goodness fit of the models of this study.

Among the confounding variables, area, age, income, indoor smoking, the knowledge status are found to be significant factors. After adjusting for all the variables in Model-3, respiratory symptoms are found to be higher in Shyampur. The odds of having respiratory symptoms is 40% lower in Dakshinkhan than in Shyampur after adjusting for all the confounding variables (OR: 0.61 CI: 0.36-1.01). All three models show respiratory symptoms were significantly higher among the older age group. Compared to respondents aged 18-29, the odds of respiratory infection among the respondents aged 30-39 is almost 2 times (OR= 2.18; 95% CI: 1.19-3.98) in Model-1, (OR= 2.04 95% CI: 1.11-3.75) in Model-2 when environmental factors were taken into consideration, and (OR= 2.05: 95% CI: 1.11-3.82) in Model-3. Similarly, those aged 50 years and above showed significant association across all the models, although the odds of occurring respiratory symptoms is 2.75 times (OR= 2.75; 95% CI: 1.30-5.82) in Model-1, 2.54 times (OR= 2.54; 95% CI: 1.19-5.41) in Model 2, 2.31 times (OR= 2.31; 95% CI: 1.07-4.98) in Model-3, indicating a reduction in the odds of occurring respiratory symptoms.

Residents with the highest household income have significantly higher odds compared to individuals with the lowest household income level, with odds ratio of (OR = 1.89; 95% CI: 1.06-3.38) in Model-1, and (OR = 1.92; 95% CI: 1.07-3.47) in Model-2, and (OR = 1.91; 95% CI: 1.04-3.49) in Model-3. Results showed that exposure to indoor smoking is significantly

associated with respiratory symptoms. Compared to participants who were not exposed to indoor smoking, those who were exposed have 1.53 times the odds of having symptoms in Model 2 and Model 3 (OR= 1.53; 95% CI: 0.94 -2.48) and (OR=1.53; 95% CI: 0.93-2.50) respectively. Additionally, Model 3 showed that knowledge status is significantly associated with respiratory symptoms. Individuals having a good level of knowledge is 3.32 times [OR= 3.32; 95% CI:1.57-7.06] and those with a moderate level of knowledge is 2.07 times (OR= 2.07; 95% CI: 1.06-4.05) the odds of having respiratory symptoms compared to individuals with a poor level of knowledge. However, practice level did not show a significant relationship with respiratory symptoms.

Table 04: Results of logistic regression for respiratory symptoms (stratified).

	Dakshinkhan	**Shyampur**
Factors	**AOR [95% CI]**	**AOR [95% CI]**
Gender		
Female (Ref.)		
Male	1.67 [0.74-3.79]	0.87 [0.39- 1.97]
Age		
18-29 years (Ref.)		
30-39 years	1.55 [0.58-4.18]	3.13** [1.30-7.56]
40-49 years	1.08 [0.39-2.97]	1.67 [0.57-4.90]
50 and above years	2.25 [0.73-6.92]	2.89* [0.91-9.21]
Overcrowding		
No (Ref.)		
Yes	0.91[0.41-2.06]	0.67 [0.30-1.48]
Income		
Below 18000 BDT (Ref.)		
18000-25000 BDT	1.26 [0.54-2.91]	1.87 [0.73-4.79]
Above 25000 BDT	1.36 [0.54-3.43]	2.94** [1.18-7.33]

Employment		
Unemployed (Ref.)		
Employed	1.16 [0.48-2.81	0.91 [0.38-2.20]
Smoking Indoors		
No (Ref.)		
Yes	1.23 [0.59-2.58]	1.91* [0.94-3.89]
Knowledge Status		
Poor level (Ref.)		
Moderate level	8.22** [2.33-28.98]	1.79 [0.64-5.05]
Good level	3.33** [1.31-8.44]	1.26 [0.45-3.55]
Practice Status		
Poor level (Ref.)		
Good level	0.95 [0.45-2.00]	0.86 [0.41-1.79]
**p- value < 0.05	*p-value < 0.10	

Table 04 presents the results after stratifying by area. The stratified logistic regression analysis investigates the factors associated with respiratory symptoms across two areas. The result showed age was associated with respiratory symptoms in Shyampur. Compared to individuals aged 18-29 years old, the age group of 30-39 years have 2.13 times (OR=3.13; 95% CI: 1.30-7.56), and those aged 50 years and above have 2.89 times (OR:2.89; 95% CI:1.30-7.56) the odds of suffering from respiratory symptoms.

Individuals who belonged to the highest income group is 2.94 times (OR=2.94; 95% CI: 1.18, 7.33) the odds of experiencing symptoms than those with the lowest income level. In Shyampur, participants who were exposed to indoor smoking, the odds of having respiratory symptoms is approximately 91% higher than those who were not exposed (OR=1.91; 95% CI: 0.94, 3.89).

On the other hand, in Dakshinkhan only Knowledge level was found to be a significant factor. Compared to respondents with a poor level of knowledge, those with a moderate level of knowledge have 8.22 times (OR= 8.22; 95% CI: 2.33-28.98) and those who had a good level of

knowledge have 3.33 times (OR= 3.33; 95% CI: 1.31-8.44) the odds of having respiratory symptoms, respectively.

6. Discussion

For two-thirds of the year, the air quality in Dhaka city stays in unhealthy to severely unhealthy conditions (Nahian et al., 2023). PM2.5 is recognized as the main pollutant and its concentration is 35 times the WHO PM2.5 recommended levels (Dhaka Air Quality Index (AQI) and Bangladesh Air Pollution | IQAir, 2019). It is evident from studies that air pollution affects human health adversely by causing respiratory illness (Ahmed et al., 2022; Croft et al., 2018; Hasan et al., 2019; Khatun et al., 2023; Rahaman et al., 2023; Raza et al., 2022). Although air pollution is attributable to respiratory diseases, there is a limited study conducted in areas with comparatively low and high pollution to examine the difference in the prevalence of respiratory symptoms, particularly among the marginalized community. This study fills in the gap by comparing the differences in respiratory symptoms in two distinct areas. The insights obtained by analyzing the impact of respiratory symptoms and considering the knowledge and protective practice status of the affected community are crucial in developing tailored public health interventions and strategies.

For comparative analysis, areas with distinctly different air quality were investigated. To investigate the statistical significance of each independent variable in the regression model sequential multiple logistic regression method is applied in this study. The findings from the analysis provide insights regarding the relationship between various demographic and environmental predictors and the prevalence of respiratory symptoms. Demographic factors were examined in Model-1 and housing conditions in Model-2. The addition of housing conditions in Model-2 did not significantly impact respiratory health outcomes area-wise as expected. However, after adjusting for confounding factors, the result showed a significant association between respiratory symptoms and several independent variables including area, age, income, smoking indoors, and knowledge status. This sequential multiple logistic regression analysis was useful in explaining the impact of independent variables individually and determining which factors caused changes in the relationship between independent variables and respiratory

symptoms. Results from Model-3 showed that knowledge status significantly influenced the relationship between respiratory symptoms and other explanatory variables, particularly area. Furthermore, a stratified regression analysis was conducted to see which factors significantly impacted respiratory health area-wise. The result in the stratified regression model showed that the impact is more prevalent in Shyampur area compared to Dakshinkhan.

Notably, a high prevalence of respiratory symptoms was observed among the adult participants in Shyampur compared to those in Dakshinkhan. Although the area showed a statistically significant association with respiratory symptoms in Model-3, no significant relationship between respiratory symptoms and the area was found in either Model-1 or Model-2. Due to the higher pollutant concentration in Shyampur, it was expected that respiratory symptoms would be more prevalent in the area compared to Dakshinkhan, contradictory to our findings. It is possible that the recent urbanization initiatives such as the several massive development projects which have been going on in Dakshinkhan for the past six months may be responsible. As the air quality monitoring data was collected in the previous year, recent construction activities are likely to contribute to the dust and particulate matter in the air and exacerbate the respiratory health of the residents in that area. Prior studies revealed that rapid urbanization contributes to a decline in air quality and impacts the environment, which is associated with negative health outcomes including respiratory health issues (Rahaman et al., 2023; Raza et al., 2022)

The findings of the study are consistent with previous studies. This study results suggest that individuals aged 50 years and above are more likely to suffer from symptoms than the younger participants. This result is in line with the findings of a community-based study in rural Bangladesh and neighboring countries like India, conducted in urban slums (Brashier et al., 2012; Kabir et al., 2021). This might be explained by the fact that aging leads to physiological changes in organs, including poor respiratory muscle strength, and reduced lung function. Thereby, results in reducing lung capacity and increasing the risk of getting respiratory issues (González-Díaz et al., 2019). Interestingly, in Shyampur, the age group between 30 and 39 years showed a higher risk of suffering from symptoms. It may possibly happen that individuals within this age group in Shyampur were exposed to risk factors such as air pollution, occupational exposure to dust or fumes, lifestyle, etc. This finding is supported by a study in India, which

found that respiratory diseases were among individuals who are 30 years and above, and chronic cough was common among those 40 years and above (Brashier et al., 2012).

One interesting aspect of the study is that higher income levels played a significant role in the relationship between income level and respiratory symptoms across all the sequential logistic regression models. This result contradicts the existing literature. Studies in Bangladesh and in Ethiopia revealed that individuals with lower monthly income reported having higher odds of respiratory symptoms than those with higher monthly income (Girmaw Abateneh et al., 2024; Kabir et al., 2021). On the contrary, another research conducted in Bangladesh aligns with the findings of this study. The study found that the richest reported more illnesses such as breathing difficulties, fever, and eye problems than those in the poorest income group (Raza et al., 2022).

In addition to that, respiratory symptoms were higher among the respondents who were exposed to indoor smoking compared to those who were not exposed. This result is in agreement with the findings of the prior studies. A community-based study conducted in Bangladesh showed that respiratory illnesses such as nasal discharge, nasal block, and chronic cough were higher among the women who were exposed to secondhand smoking (Kabir et al., 2021). It is evident from the study that, adult individuals with increased exposure to passive smoking were associated with respiratory diseases including chronic bronchitis, and asthma (Flexeder et al., 2019). A study conducted in China among adults investigated the relationship between respiratory diseases such as cough, phlegm, shortness of breath, COPD, and duration of exposure to secondhand smoking. The result of the study showed that exposure to secondhand smoke at home and the workplace is statistically associated with suffering from any respiratory symptoms and COPD (Yin et al., 2007).

It was found from the study that the prevalence of a good level of knowledge was high among the participants, while the residents with a good level and poor level of practice were found to be equally distributed. The finding regarding practice status is inconsistent with that from a prior study. A study in Bangladesh on knowledge, practice, and attitude regarding air pollution health effects found that knowledge status is fairly good while practice status is not noteworthy. This difference in protective practice might be due to the “Purdah”/ veil customs of the Muslim

women, as many of the women adults were found to cover their faces by wearing “niqab”. Moreover, according to the analysis, respondents with a good and moderate level of knowledge had higher odds of reporting respiratory symptoms than the ones with a poor level of knowledge. Knowledge status emerged as a strong predictor of respiratory health outcomes. A possible explanation for this result might be that those with good knowledge are more aware of respiratory symptoms, showing a high reporting rate.

The stratified analysis revealed that age, income, and exposure to indoor smoking had a significant relationship with respiratory symptoms in Shyampur, whereas, in Dakshinkhan only knowledge status was significantly associated with respiratory symptoms. Given that, the air quality is comparatively better in Dakshinkhan area compared to Shyampur area, indicating the varying impact of air quality on respiratory symptoms. This aligns with a case-crossover study, which found that the concentration of PM2.5 exacerbates respiratory health outcomes and is associated with respiratory hospitalizations (Slama et al., 2020). Another study that investigated the health effects of outdoor air pollution found that exposure to it caused common respiratory conditions like asthma and other respiratory symptoms. Moreover, this result is supported by another study in Germany, which revealed that a reduction of ambient air pollution is associated with a weaker increase in respiratory symptoms (Schikowski et al., 2010).

6.1 Limitations

As this study was conducted using data from a cross-sectional study, the establishment of a causal relationship is not possible. There is a possibility of recall bias and reporting bias as the data collected for respiratory symptoms was self-reported. Seasonality was not considered in this study due to resource constraints. Real-time air quality data was not considered while selecting study sites. The study looked at the respiratory symptoms of the adult population only, looking at the prevalence of such symptoms among the children could tell us more about their association with poor air quality.

7. Conclusion

Addressing respiratory illness among the residents in informal settlements requires a multidimensional approach that encompasses socio-demographic, and environmental factors.

The study findings reveal that variables such as age, income level, indoor smoking, and knowledge status are associated with respiratory symptoms. However, socio-demographic factors alone are not enough to impact respiratory symptoms. Besides socio-demographic factors, housing conditions, environmental factors, and especially an individual's knowledge level are crucial in predicting respiratory symptoms in informal settlements. Association of knowledge status with higher odds of having respiratory symptoms may imply a greater awareness of health problems. Moreover, respiratory symptoms are more prevalent where air quality is substantially below the standard level than those places where air quality is comparatively better. Therefore, the findings of this paper emphasize reducing air pollution and focusing on protective practices against air pollution rather than focusing on initiatives to raise awareness while developing and implementing policies. Additionally, a further longitudinal study is recommended to establish the causality of air pollution and its impact on respiratory symptoms in urban populations of all age groups.

8. References

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9. Annex

Table 01:Demographic characteristics of the adult (18 years and above) study participants

Variables	Shyampur(N=156) n(%)	Dakshinkhan(N=157) n(%)	Overall(N=313) n(%)
Age (Years) (N=313)			
18-29 years	80 (51.28)	67 (42.68)	147 (46.96)
30-39 years	26 (16.67)	48 (30.57)	74 (23.64)
40-49 years	25 (16.03)	22 (14.01)	47 (15.02)
50 and above years	25 (16.03)	20 (12.74)	45 (14.38)
Gender (N=313)			
Female	82 (52.56)	85 (54.14)	167 (53.35)
Male	74 (47.44)	72 (45.86)	146 (46.65)
Marital Status (N=313)			
Single/Unmarried	13 (8.33)	20 (12.74)	33 (10.54)
Married	129 (82.69)	120 (76.43)	249 (79.55)
Widowed/Divorced/Separated	14 (8.97)	17 (10.83)	31 (9.9)
Education			
No Education	56 (35.90)	39 (24.84)	95 (30.35)
Primary	42 (26.92)	33 (21.02)	75 (23.96)
Secondary or above	54 (34.62)	61 (38.85)	143 (45.69)
Income			
Less than 18,000 BDT	58 (37.18)	46 (29.30)	104 (33.23)
18,000-25,000 BDT	57 (36.54)	47 (29.94)	104 (33.23)
Above 25,000 BDT	41 (26.28)	64 (40.76)	105 (33.55)
Employment			
Unemployed	48 (44.44)	60 (55.56)	108 (34.50)
Employed	108 (52.68)	97 (47.32)	205 (65.50)
Overcrowding			
Yes	114 (73.08)	112 (71.34)	226 (72.20)
No	42 (26.92)	45 (28.66)	87 (27.80)
Indoor Smoking			
Yes	63 (40.38)	69 (43.95)	132 (42.71)

No	93 (59.62)	88 (56.05)	181 (57.83)
Respiratory symptoms			
Yes	94 (60.26)	87 (55.41)	181 (57.83)
No	62 (39.74)	70 (44.59)	132 (42.17)
Knowledge Status			
Poor level	28 (17.95)	24 (15.29)	52 (16.61)
Moderate level	30 (19.23)	62 (39.49)	92 (29.39)
Good level	98 (62.82)	71 (45.22)	169 (53.99)
Practice Status			
Poor level	76 (48.72)	79 (50.32)	155 (49.52)
Good level	80 (51.28)	78 (49.68)	158 (50.48)