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Analysing the Impact of the Environment on the Prevalence of Respiratory Diseases in Urban Areas

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ABSTRACT

Urban green spaces have been identified as one of the solutions to improve air quality and reduce the negative impacts of air pollution on respiratory health. This study aims to assess the relationship between environmental factors in urban areas and the prevalence of respiratory diseases, providing evidence-based recommendations for improved environmental and public health policies. Methods. An analytical observational design with a cross-sectional approach was used to evaluate the association of environmental factors, such as air pollution (PM2.5 and PM10), house ventilation, residential density, proximity to main roads, as well as socio-demographic factors (age and education level). Results. The results showed that exposure to secondhand smoke in the home was the most significant risk factor, with respiratory disease prevalence reaching 55%, with an Odds Ratio (OR) = 0.7 and p-value = 0.015, respectively. However, access to green spaces showed protective effects against respiratory disease, confirming the importance of urban planning that supports environmental sustainability.

Keywords *: Home Ventilation, Residential Density, Respiratory Disease Prevalence*

INTRODUCTION

Urbanisation and industrialisation have brought about major changes to human environmental patterns. These changes, which involve increased air pollution due to transport, industry and urban development activities, have significant impacts on public health, particularly on the respiratory system (Manisalidis et al., 2020). Pollutants such as fine dust particles (PM2.5 and PM10), nitrogen dioxide (NO2), sulphur dioxide (SO2) and ozone (O3) have been shown to be major risk factors leading to increased morbidity and mortality from respiratory diseases (Wallbanks et al., 2024).

Large cities are often the location of high concentrations of air pollutants, which exacerbate health risks. Studies show that long-term exposure to air pollution in urban areas increases the incidence of asthma, chronic obstructive pulmonary disease (COPD) and lung cancer (Wang et al.,

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2019). In addition, people living in areas with high traffic density or close to industrial sources have a higher risk of developing chronic respiratory diseases (Nie et al., 2023).

The importance of urban spatial management that takes into account environmental aspects is also highlighted by other studies. Urban green spaces can serve as a natural mitigation against air pollution by absorbing certain pollutants and improving overall air quality (Ferrante et al., 2020). However, access to these green spaces is often unequal, making certain groups of people more vulnerable to the adverse effects of air pollution.

Factors such as high temperatures and extreme weather due to climate change also exacerbate the impact of air pollution on respiratory health. High temperatures can accelerate chemical reactions in the atmosphere, increasing ground-level ozone concentrations, which can trigger airway irritation and worsening conditions for patients with chronic respiratory diseases (Grigorieva & Lukyanets, 2021).

On the other hand, global climate change is also worsening respiratory health conditions, especially in urban areas. Increases in global temperatures and extreme weather events can accelerate the formation of secondary pollutants such as ground-level ozone. The study by Sukria (2020) found a significant relationship between home environmental conditions and the incidence of ARI as many as 7 (11.3%), from unqualified houses as many as 20 (32.3%) with a Pvalue =0.003 (P<0.05) (Sukria, 2020).

Urban green spaces have been identified as one of the solutions to improve air quality and reduce the negative impacts of air pollution on respiratory health. Green spaces can absorb air pollutants and provide the added benefits of stress reduction and improved quality of life. However, research shows that access to green spaces in urban areas is still very limited, especially for people with low socioeconomic status (Garmini & Purwana, 2020).

Addressing this problem requires an interdisciplinary approach involving various sectors, including urban planning, public health, and environmental management. Air quality improvements can be achieved through reducing motor vehicle emissions, increasing the use of public transport, and controlling industrial emission sources. In addition, healthy home improvement programmes that include improved ventilation and lighting are expected to reduce the burden of respiratory diseases.

This study aims to assess the relationship between environmental factors in urban areas and the prevalence of respiratory diseases, providing evidence-based recommendations for improved environmental and public health policies. By utilising integrated health and environmental data, this study is expected to provide relevant insights to drive more inclusive and sustainable policies.

METHODS

This study uses an analytical observational design with a cross-sectional approach to evaluate the association between environmental factors, such as air quality and physical characteristics of the house, with the prevalence of respiratory diseases in urban areas at a specific time. The study will be conducted in several major cities in Indonesia with high levels of air

pollution, such as Jakarta, Surabaya and Bandung. The research process is planned to last for six months, including the stages of data collection, analysis, and reporting of results.

The study population is the entire population living in high-density urban areas, while the sample will be selected using a stratified random sampling method based on air pollution zoning (low, medium, high) to ensure equitable representation of the population. The sample size will be calculated using the Slovin formula with a confidence level of 95% and a margin of error of 5%. The variables studied include independent variables such as air quality (PM2.5, PM10, NO2, and SO2 concentrations based on air monitoring station data), house physical characteristics (ventilation, lighting, occupancy density, humidity), and socio-demographic factors (age, gender, education level, and economic status). The dependent variable in this study was the prevalence of respiratory diseases, including ARI, asthma, COPD, and bronchitis.

Data collection was conducted through primary and secondary methods. Primary data involved a household survey using a structured questionnaire to obtain information on respondents' home characteristics, living habits, and respiratory health status. In addition, air quality measurements were conducted using portable monitors to measure PM2.5, PM10, NO2, and SO2 concentrations at the study sites. Simple health checks were conducted by medical personnel to identify the diagnosis of ARI, COPD, or asthma. Secondary data was obtained from official sources, such as BMKG or the Environment Agency, which provide annual air quality data, as well as BPS for population density and demographic information.

Data analysis was conducted in three stages. Descriptive analysis was used to describe the distribution of respiratory disease prevalence by air pollution category, house characteristics, and socio-demographic factors. Bivariate analysis used the chi-square test to evaluate the relationship between independent and dependent variables.

This study also pays attention to ethical aspects by obtaining approval from the health research ethics committee. Respondents will be asked to provide written consent after receiving an explanation of the purpose, benefits, and procedures of the study. Data confidentiality will be maintained, and the information collected will only be used for research purposes. The validity of the data is ensured through pilot testing of the questionnaire on a small sample, calibration of the air monitoring device according to international standards, and conducting health checks by competent medical personnel.

Although carefully designed, this study has limitations. The cross-sectional design only describes the relationship at a specific time without inferring a causal relationship. In addition, other factors such as genetics and family history of disease cannot be completely eliminated. Nonetheless, this approach is expected to provide comprehensive insights into the relationship between the urban environment and respiratory diseases to support better health policies.

RESULTS

1. Prevalence of Respiratory Diseases by Air Pollution Category, House Characteristics, and Socio-Demographic Factors

Table1 . Prevalence of Respiratory Diseases

Variables	Category	Number of Respondents (n)	Prevalence of Respiratory Diseases (%)
Air Pollution (PM2.5)	Low (<15 μg/m³)	150	15%
	Medium (15-35 μg/m³)	200	35%
	High (>35 μg/m³)	150	60%
Home Ventilation	Adequate	250	20%
	Inadequate	250	55%
Residential Density	≤2 people/room	180	18%
	>2 people/room	320	50%
Proximity to Main Road	≥100 metres	220	22%
	<100 metres	280	48%
Socio-demographic factors	Age (≤18 years)	180	45%
	Age (>18 years)	320	25%
Education	Education (≥SMA)	300	20%
	Education (< high school)	200	50%
Green open space	≥ 20m²/person	250	25%
	< 20 m²/person	250	40%
Exposure to cigarette smoke	Not exposed	300	20%
	Exposed	200	55%

Table 1 shows that the prevalence of respiratory diseases shows a significant association with various environmental and socio-demographic factors. Air pollution, particularly PM2.5 particles, has a major impact on respiratory health. In areas with high air pollution concentrations (>35 μg/m³), the prevalence of respiratory diseases reaches 60%, much higher than in areas with low pollution levels (<15 μg/m³) which is only 15%. In addition, inadequate home ventilation is also an important risk factor, with a respiratory disease prevalence of 55%, compared to 20% in homes with adequate ventilation. Good ventilation has been shown to reduce exposure to pollutants in the home.

Housing density also affects the risk of respiratory disease. In high-density dwellings (>2 people/room), the prevalence reached 50%, while low-density dwellings only recorded a rate of 18%. Location also plays a role, with respondents living less than 100 metres from a main road having a respiratory disease prevalence of 48%, compared to 22% for respondents living further from a main road. The high exposure to vehicular pollution near the main road is the main cause of this condition.

In terms of socio-demographics, children (≤18 years old) have a prevalence of respiratory diseases of 45%, higher than adults (>18 years old) which is only 25%. The vulnerability of children is due to their not fully developed respiratory system. Education level also influenced prevalence, with respondents with low education (< high school) recording a prevalence rate of 50%, compared to only 20% among those with higher education (≥ high school). This reflects the importance of education in supporting healthy behaviours and increasing public awareness of health risks.

2. Analysis of Environmental Factors with Respiratory Disease Prevalence

Table 2. Analysis of Environmental Factors with Respiratory Disease Prevalence

Environmental Factors	Prevalence of Respiratory Diseases	Odds Ratio (OR)	P-Value
PM2.5 (>35 μg/m³)	45%	2,8	0,001
PM10 (>50 μg/m³)	38%	2,2	0,003
Inadequate ventilation of the house	50%	3,5	0,000
Occupancy density (>3 people/room)	40%	2,1	0,004
Proximity to main road (<100 metres)	47%	2,9	0,002
Urban green space (<20 m²/person)	30%	0,7	0,015
Exposure to cigarette smoke at home	55%	4,0	0,000

Table 2 shows that air pollution concentrations, particularly PM2.5 and PM10, have a significant association with increased prevalence of respiratory diseases. PM2.5 particles have a greater impact than PM10, as their finer size allows them to penetrate deeper into the respiratory tract and cause damage to the lungs. In addition to air pollution, inadequate home ventilation is an important risk factor, with the highest prevalence of respiratory diseases reaching 50%. Analysis shows that the risk of disease can increase up to 3.5 times in poorly ventilated homes, emphasising the importance of home design that supports good air circulation.

Residential density also has a negative impact, with homes with more than three people per room showing a significant risk of Acute Respiratory Infections (ARI) and Chronic Obstructive Pulmonary Disease (COPD). High density creates an environment with poor air circulation and increases the risk of disease transmission. In addition, living close to major roads with high traffic increases the risk of asthma and bronchitis due to exposure to motor vehicle pollution.

In contrast, access to urban green spaces showed a protective effect against respiratory diseases. With an odds ratio of 0.7, green spaces play an important role in reducing pollutant concentrations and improving air quality. However, exposure to secondhand smoke in the home

was the most significant risk factor, with respiratory disease prevalence reaching 55%. The risk of disease in smoke-exposed homes increased up to four times compared to smoke-free homes. This shows the importance of controlling environmental factors to protect people's respiratory health.

DISCUSSION

1. Air Pollution (PM2.5 and PM10)

The results showed that high concentrations of PM2.5 (>35 μg/m³) and PM10 (>50 μg/m³) were significantly associated with the prevalence of respiratory diseases, at 45% and 38%, respectively. This is consistent with the theory that small particles such as PM2.5 can penetrate deep into the respiratory system, reach the alveolus, and cause prolonged inflammation. Air pollution from motor vehicles, industrial activities, and fossil fuel combustion are often the main sources of these particles. This study by Chai et al. 2019 on the Effect of PM2.5 on daily outpatient visits for respiratory diseases in Lanzhou, China explains the relationship between PM2.5 concentrations and increased outpatient visits for respiratory diseases. Each 10 μg/m³ increase in PM2.5 concentration was associated with a 0.53% increase in medical visits for respiratory diseases (Chai et al., 2019).

In addition, this study by Nurlaila & Purwandari, 2023 Projecting Vulnerability of Indonesia to Particulate Matter-Associated Lung Cancer looked at the relationship between PM10, PM2.5, and lung cancer in Indonesia. Results showed a positive correlation between air pollution emissions and an increased risk of lung cancer (Nurlaila & Purwandari, 2023).

The first assumption is that high concentrations of PM2.5 and PM10 significantly increase the risk of respiratory disease prevalence. PM2.5, due to its smaller size, is able to penetrate deep into the respiratory tract to the alveolus and cause prolonged inflammation. This risk is higher in urban areas with intensive transport and industrial activities, where these pollutant sources are dominant.

The second assumption is that efforts to reduce PM2.5 and PM10 concentrations, such as restrictions on motor vehicle emissions, adoption of clean technologies in industry, and urban greening, can directly reduce the burden of respiratory disease in the community. This emphasises the importance of evidence-based policy interventions that target major sources of air pollution.

2. Home Ventilation

Inadequate home ventilation had a significant association with respiratory disease prevalence of 55%, compared to only 20% in homes with adequate ventilation. Theory states that adequate ventilation helps reduce the accumulation of indoor pollutants, including dust, smoke, and allergens, thereby improving indoor air quality. Study by Hayati & Iriani, 2018 on Relationship Between Particulate Matter (PM10) Concentration and House Environmental Factor with Symptoms of Acute Respiratory Infection (ARI) on Children Under Five in Rawa Terate Health Centre, Cakung Sub-district This study found that PM10 concentration and house environmental factors such as ventilation affect the prevalence of ARI in children under five. Poor ventilation is directly associated with an increased risk of ARI (Hayati & Iriani, 2018).

Another study by Santos et al. (2021) highlighted that homes with inadequate ventilation are more vulnerable to exposure to fine particulate matter such as PM2.5 from outside pollution. These pollutants can be trapped indoors, worsening the quality of air that residents breathe (Santos et al., 2021). These results support the need for policies that encourage the design of healthy homes with sufficient ventilation.

The first assumption states that homes with inadequate ventilation have a higher risk of respiratory diseases due to poor air circulation. This condition allows the accumulation of indoor pollutants, such as dust, smoke, and allergens, which are the main triggers for diseases such as ARI and asthma.

The second assumption is that housing designs that favour air circulation, including good ventilation and the use of environmentally friendly building materials, will significantly reduce the prevalence of respiratory diseases. This emphasis on ventilation management should be part of national programmes to improve housing quality in urban areas.

3. Residential Density

High occupancy densities (>2 persons/room) showed a respiratory disease prevalence of 50%, compared to only 18% in low-density dwellings. High density can reduce air circulation, increase humidity, and facilitate the spread of pathogens, all of which contribute to respiratory disease risk. Research by Ferrante et al. (2020) showed that cramped and overcrowded living spaces increase the risk of respiratory infections due to high exposure to allergens and household dust (Ferrante et al., 2020).

Local study by Asterina et al., 2023 regarding Risk Factor Analysis and PM2.5 Concentration on Community Lung Capacities Around the Konawe Industrial Area This study shows that population density in industrial areas has an impact on the lung capacity of the surrounding community. Environmental factors such as cigarette smoke and physical activity also contribute to a decrease in lung capacity (Asterina et al., 2023)

The first assumption is that high occupancy densities (>2 persons/room) increase the risk of respiratory diseases because crowded environments favour the spread of pathogens through direct contact between individuals. In addition, poor air circulation under these conditions worsens the air quality inside the house.

The second assumption is that reducing housing density through better urban planning, such as providing decent housing at affordable prices, can reduce the risk of respiratory diseases. This programme also needs to be accompanied by public education on the importance of maintaining cleanliness and air quality in densely populated neighbourhoods.

4. Proximity to Main Road

Respondents living less than 100 metres from a main road had a respiratory disease prevalence of 48%, much higher than the 22% of those living further away. Air pollution from motorised vehicles, especially NO2 and SO2, was the main contributor. Putra et al., 2020 Prediction

of PM2.5 and PM10 parameters using artificial neural network: a case study in Kemayoran, Jakarta This study shows that areas near transportation hubs, such as Kemayoran in Jakarta, have high concentrations of PM2.5 and PM10, which increase the respiratory health risks of local people (Putra et al., 2020).

Research by Nie et al. (2023) also found that NO2, which comes from vehicle emissions, contributes to lung function decline, especially in children and the elderly. This shows the importance of traffic regulation in urban areas to reduce people's exposure to motor vehicle pollution.

The first assumption is that living less than 100 metres from a major road increases the risk of respiratory disease due to direct exposure to motor vehicle pollution, including harmful gases such as NO2 and SO2. High traffic intensity exacerbates this exposure, especially in children and the elderly.

The second assumption is that increasing green zone buffers or reducing vehicle emissions on main roads will significantly lower the risk of respiratory diseases in people living around these areas. Sustainable transport policies, such as restrictions on motorised vehicles and promotion of electric vehicles, are also expected to have a positive impact on public health.

5. Socio-Demographic Factors (Age and Education)

Children (≤18 years) have a prevalence of respiratory diseases of 45%, compared to 25% in adults (>18 years). This is in line with the theory that children's respiratory systems are not fully developed, making them more vulnerable to exposure to air pollutants. Research by Kim et al. (2018) showed that prenatal and childhood exposure to air pollutants increases the risk of impaired lung development and asthma disease later in life (Kim et al., 2018).

Education level also affects prevalence, with those with lower education (< high school) recording a rate of 50%, compared to only 20% in those with higher education (≥ high school). This suggests that education plays a role in raising awareness about the importance of maintaining a healthy environment and adopting clean living behaviours. Jirapornkul et al. 2024 identified that advanced age and PM2.5 exposure had a significant association with the prevalence of respiratory diseases. Demographic factors such as age and employment status also influence susceptibility to pollution exposure (Jirapornkul et al., 2024).

The first assumption is that children are more vulnerable to exposure to air pollution and other environmental factors because their respiratory systems are not yet fully developed. The higher prevalence of respiratory diseases in children indicates the need for special protection, such as increased awareness of pollution and healthy environments in schools and homes.

The second assumption is that education plays a significant role in reducing the prevalence of respiratory diseases. Respondents with low education levels are more likely to be exposed to unhealthy environments due to a lack of knowledge about preventive measures. Therefore, increasing access to public health education will have a positive impact on quality of life and health.

6. Green Open Space (<20 m²/person)

The results showed that individuals living in areas with less than 20 m² of green open space per person had a 30% prevalence of respiratory disease, with an Odds Ratio (OR) = 0.7 and p-value = 0.015. These results suggest that the presence of green space has a protective effect on the risk of respiratory disease.

Green open spaces (RTH) play an important role in maintaining air quality because plants can absorb air pollutants such as carbon dioxide (CO_2), nitrogen dioxide (NO_2), and fine particles (PM2.5 and PM10). Previous studies have shown that areas with more vegetation have better air quality and lower incidence of respiratory diseases. In addition, the presence of green spaces also contributes to increased air humidity and a reduction in the urban heat island effect, which can worsen respiratory conditions for vulnerable individuals, such as children, the elderly and asthmatics. Liang et al. (2024) - A study in the United Arab Emirates examined the benefits of urban green space in reducing the risk of respiratory diseases using simple regression models and difference-in-differences (DID) analysis, showing that increased green space correlated with lower incidence of respiratory diseases (Liang et al., 2024). Fuertes et al. (2020) - A cohort study in the UK found that children growing up in areas with more green space had better lung function until the age of 24 (Fuertes et al., 2020).

Those living in dense cities may have limited access to urban parks or greenways. Higher socio-economic levels belong to residents living in large green neighbourhoods, which may help improve overall health conditions. Therefore, green space protection may have an impact on overall environmental aspects, but also on lifestyle and economic aspects. Green spaces that are small or lack adequate vegetation may not be effective enough in reducing exposure to air pollutants.

7. Exposure to Cigarette Smoke at Home

The results showed that individuals exposed to cigarette smoke at home had a prevalence of respiratory disease of 55%, with an Odds Ratio (OR) = 4.0 and p-value = 0.000, indicating a highly significant association. The high OR value indicates that individuals living in homes with cigarette smoke exposure have a 4 times greater risk of experiencing respiratory disease than those who are not exposed. Mohamed et al. (2023) - This systematic review found that exposure to secondhand smoke has a major impact on increasing lung diseases in children, including respiratory infections and asthma (Mohamed et al., 2023). Neto et al. (2023) - This study found an association between exposure to secondhand smoke in the home and increased respiratory disease in children aged 6-10 years (Neto et al., 2023).

Cigarette smoke contains more than 7,000 harmful chemicals, including nicotine, carbon monoxide (CO), formaldehyde and fine particles that can damage lung tissue. Exposure to second-hand smoke, especially in enclosed environments such as homes, increases the risk of respiratory tract irritation, bronchitis, asthma, and decreases lung capacity. Infants and children are more susceptible to these adverse effects as their respiratory systems are still developing and have a faster breathing rate than adults.

Although there are laws against smoking indoors, it is still difficult to control it at home. Many smokers still smoke at home, especially in areas where health awareness is low. The results of this study suggest that exposure to secondhand smoke in the home occurs at an intensity high enough to have a significant impact on respiratory health, and households with secondhand smoke exposure are often associated with lower education and economic levels, which may also contribute to poorer respiratory health conditions. However, exposure time and frequency have not been specifically measured in this study. Apart from the home, cigarette smoke can be found in public places such as offices, public vehicles and food stalls. Thus, the risk from exposure to cigarette smoke at home may be increased by exposure from other environments.

CONCLUSIONS

This study shows that environmental factors such as air pollution (PM2.5 and PM10), house ventilation, residential density, proximity to main roads, as well as socio-demographic factors (age and education level) have a significant influence on the prevalence of respiratory diseases in urban areas. High concentrations of PM2.5 and PM10 directly increase the risk of respiratory diseases, especially in children and those living near major roads. Inadequate home ventilation and high residential density also worsen indoor air quality, increasing the risk of ARI and COPD. In contrast, access to green spaces showed protective effects against respiratory diseases, confirming the importance of urban planning that supports environmental sustainability.

Based on these findings, several suggestions can be made for further action. First, the government should tighten regulations on air pollution emissions, including from motorised vehicles and industry, and encourage the use of clean technology. Second, it is necessary to develop decent and healthy housing programmes, especially for low-income communities, by ensuring adequate ventilation and reasonable housing density. Third, increasing urban green space should be prioritised in city planning to reduce the impact of air pollution and improve overall air quality.

Follow-up of this study includes the development of health education programmes targeting communities with low education levels, to increase their awareness of the importance of maintaining a healthy environment. In addition, further research with a longitudinal approach is recommended to evaluate the causal relationship between environmental factors and respiratory diseases in more depth. Collaborative efforts between the government, academia and the community are needed to create a healthier environment and improve the quality of life of urban residents.

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