



## Environment-Based Public Health: The Impact of Air Pollution on the Risk of Respiratory Diseases in Children

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### ABSTRACT

Especially in vulnerable groups such as children. This study aims to analyze the relationship between exposure to air pollution and the risk of respiratory diseases in children from an environment-based public health perspective. The research method used is a literature review with a descriptive-analytic approach to scientific articles obtained from databases such as Google Scholar, PubMed, and ScienceDirect over the last 10 years. Inclusion criteria include articles that are relevant to the topic, available in full text, and have a clear methodology. The study results show that air pollutants such as particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), and carbon monoxide (CO) contribute significantly to the increase in respiratory diseases in children, including acute respiratory infections (ARI), asthma, and bronchitis. Air pollution is an important determinant of children's respiratory health, so a comprehensive environment-based public health approach is needed through emission control policies, environmental quality improvement, and increased community education. Collaborative cross-sector efforts are highly needed to reduce the impact of air pollution and protect children's health as the future generation

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## **INTRODUCTION**

Public health is one of the main indicators in assessing a country's level of welfare, as it reflects the overall quality of life of the population, including physical, social, and environmental aspects (Kilimova, 2019; Kim, 2023; Murawska, 2025). The high degree of public health is not only determined by the availability of adequate health service facilities, competent medical personnel, and equitable accessibility to services, but is also greatly influenced by the environmental conditions where the community lives and carries out daily activities. In recent decades, environmentally based public health approaches have increasingly gained widespread attention at both global and national levels, along with growing awareness of the importance of maintaining a balance between development and environmental sustainability. This is based on the understanding that environmental quality is closely related to human health status, where a clean and healthy environment can prevent various diseases, whereas a polluted environment becomes a major risk factor for the emergence of various health disorders (Shetty, 2023; Olorunsogo, 2024). One of the most significant forms of environmental pollution is air pollution, which has now become a crucial issue in various countries, including Indonesia (Li, 2022; Mir, 2024). An unhealthy environment due to air pollution has been proven to contribute to an increased burden of disease, both communicable and non-communicable, making this issue a serious challenge in efforts to sustainably improve public health quality (Sitorus, 2025).

Air pollution is one of the most complex forms of environmental pollution because it involves various types of pollutants with different chemical and physical characteristics, and has diverse sources from both natural activities and human activities (Ahmed, 2024). Nevertheless, the largest contribution to air pollution comes from anthropogenic activities, such as motor vehicle emissions that continue to increase with population growth and mobility, industrial activities that produce hazardous gas waste, burning of fossil fuels for energy needs, as well as open waste burning practices that are still widely carried out in various regions (Odubo, 2024). Along with the increasing urbanization and industrialization, especially in developing countries, air quality in many areas has experienced a significant decline. Poorly planned city growth often results in high traffic density and industrial activities in areas close to residential neighborhoods, thereby increasing public exposure to harmful substances in the air (Gupta, 2023). This situation is exacerbated by weak emissions monitoring and low public awareness of the importance of maintaining environmental quality, making air pollution an increasingly difficult problem to control.

The impact of air pollution on human health is very diverse and multidimensional, ranging from mild temporary health disturbances to chronic diseases that can be life-threatening and significantly reduce the quality of life. One of the most affected body systems is the respiratory system, because polluted air directly enters the body through inhalation and interacts with the respiratory tract tissues (Akbar, 2024; Krismanuel, 2024). Exposure to pollutants such as particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), and carbon monoxide (CO) has been scientifically proven to cause

irritation to the respiratory tract, trigger inflammation, and damage lung tissue in the long term (Meo, 2024; Esposito, 2025). In addition, fine particles such as PM<sub>2.5</sub> can even penetrate into the bloodstream, potentially causing disruptions to the cardiovascular system (Thangavel, 2022). These health impacts are not only experienced in the short term, such as coughing, shortness of breath, and throat irritation, but also in the long term in the form of increased risk of chronic diseases such as asthma, chronic obstructive pulmonary disease (COPD), and even lung cancer.

Children's groups are the population most vulnerable to the impacts of air pollution compared to other age groups, due to their physiological conditions that are still in the stages of growth and development (Urrutia, 2022). Vital organs, particularly the lungs, have not developed fully and are therefore more sensitive to exposure to harmful substances present in the air. In addition, children's immune systems are not as strong as adults', making them more susceptible to infections and other health disorders. Children also have a higher breathing frequency compared to adults, which means they inhale more air in the same amount of time, thereby indirectly increasing the amount of pollutants that enter the body. This vulnerability makes children the group most at risk of experiencing the negative effects of air pollution, both in the short and long term. In addition to biological factors, children's behavior also contributes to the high risk of exposure to air pollution (Yu, 2023). Children tend to be more physically active and spend more time outdoors playing, exercising, or interacting with peers. These activities, although important for their physical and social development, actually increase the likelihood of being exposed to air pollutants, especially if conducted in environments with poor air quality. A lack of awareness of the dangers of pollution and minimal use of protective equipment such as masks also increase this risk (Tran, 2023). This condition becomes increasingly concerning if children live in areas with high levels of air pollution, such as around highways crowded with vehicle traffic or industrial areas that produce harmful emissions. The combination of these environmental factors and behaviors makes children a very vulnerable group and requires special attention in health protection efforts.

Respiratory diseases in children, such as acute respiratory infections (ARI), asthma, and bronchitis, still remain a significant public health problem (Swain, 2025). The high incidence of these diseases indicates that many risk factors have not been optimally addressed, including environmental factors such as air pollution. Epidemiological data shows that respiratory diseases are one of the leading causes of morbidity and mortality in children, especially in the under-five age group, which has a higher level of vulnerability (Ali, 2024). Various studies indicate a strong relationship between exposure to air pollution and increased incidence of respiratory diseases in children (Pakpahan, 2025). Environments with poor air quality tend to have higher incidence rates of ARI and other respiratory diseases compared to environments with good air quality (Monoson, 2023). This underscores that the issue of air pollution cannot be separated from efforts to combat respiratory diseases in children.

In addition to the direct health impacts, air pollution also has serious long-term consequences on children's quality of life. Long-term exposure to pollutants can hinder lung growth and development, resulting in suboptimal lung capacity and increasing vulnerability to various diseases in the future (Dondi, 2023). Children who are exposed to air pollution from an early age are at a higher risk of developing chronic respiratory problems in adulthood and have a lower quality of life compared to those who grow up in a clean environment (Maharani, 2023). These long-term impacts indicate that air pollution is not only a temporary health issue but also a serious threat to future generations. Therefore, efforts to prevent and control air pollution become very important to ensure the sustainable continuity of public health.

Various studies have been conducted to examine the relationship between air pollution and respiratory diseases in children, through epidemiological, clinical, and experimental approaches. The results of these studies consistently show a significant relationship between increased air pollutant concentrations and an increased risk of respiratory disorders in children (Huang, 2022; Septiani, 2025). However, there are variations in the results influenced by various factors, such as geographic conditions, population density, socio-economic status, and environmental policies implemented in each region. These differences indicate that the impact of air pollution is not homogeneous, but rather influenced by a complex local context. Therefore, more contextual and specific research is needed to understand the dynamics of the relationship between air pollution and children's health in various regions.

In the context of environment-based public health, a comprehensive and integrated approach is required to effectively address air pollution issues. This approach not only focuses on treating diseases through healthcare services but also emphasizes the importance of preventive efforts through controlling pollution sources, improving environmental quality, and educating the public about the importance of maintaining environmental health. The role of the government is crucial in formulating policies that support environmental protection, such as regulating vehicle and industrial emissions, developing environmentally friendly transportation, and supervising activities that have the potential to pollute the air. In addition, the private sector and the community also have a responsibility in protecting the environment through more sustainable practices. Collaboration among these various parties becomes key in creating a healthy environment and supporting the improvement of public health.

## LITERATURE REVIEW

Based on this background, this study aims to analyze in depth the impact of air pollution on the risk of respiratory diseases in children from an environmentally based public health perspective. This research is expected to provide a more comprehensive overview of the relationship between air quality and child health, as well as to identify factors that influence the level of vulnerability to respiratory diseases. The results of this study are expected to make a significant scientific contribution to the development of more effective and targeted policies and intervention strategies, both at the local and national levels. In addition, this research is also expected to serve as a basis for increasing public awareness of the importance of maintaining environmental quality as a preventive effort in protecting the health of future generations as well as improving overall quality of life.

## METHODOLOGY

This study uses a qualitative approach with a descriptive-analytical literature review design to comprehensively examine the relationship between air pollution and the risk of respiratory diseases in children. Data sources were obtained from various scientific articles published in reputable national and international journals, accessed through databases such as Google Scholar, PubMed, and ScienceDirect. The literature search process was carried out using the keywords "air pollution," "environmental health," "respiratory diseases," and "children," both in Indonesian and English.

The inclusion criteria in this study include articles published within the last 10 years, relevant to the research topic, and using clear and scientifically accountable research methods. Meanwhile, the exclusion criteria include articles that are not available in full text, have not undergone a peer-review process, and have low methodological quality. After the identification and selection process, articles that meet the criteria are analyzed in depth through the stages of data reduction, data presentation, and drawing conclusions.

Data analysis was conducted by grouping research findings based on the types of pollutants, their impact on children's respiratory systems, and the risk factors that influence vulnerability levels. Next, a synthesis was carried out to integrate various research results in order to obtain a comprehensive understanding of the relationship between air pollution and respiratory diseases in children. To increase validity, the researchers performed source triangulation by comparing results from different studies with varying contexts and methods. With this approach, it is expected that the research findings can provide a comprehensive overview and serve as a basis for making environmentally based public health policies.

## **RESULTS AND DISCUSSION**

The results of the literature review in this study comprehensively show that air pollution is an environmental risk factor that significantly contributes to the increase in respiratory diseases in children, both in the form of acute and chronic disorders that have long-term impacts on quality of life (Shahriyari, 2022; Aithal, 2023; George, 2024). Various studies analyzed, both epidemiological and clinical in nature, consistently show a strong, linear, and significant relationship between increased concentrations of air pollutants and disruptions in respiratory system health, especially in vulnerable age groups such as children who are physiologically still in developmental stages. Children living in areas with poor air quality, such as densely populated urban areas and industrial zones, have been shown to have higher incidence rates of respiratory diseases compared to those living in environments with better air quality, thus confirming that air quality is an important determinant of child health (Holden, 2023).

The air pollutants most studied in various previous studies include particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), and carbon monoxide (CO), each of which has different characteristics and health impacts (Aljafen, 2025; Tamayo, 2026). Fine particles such as PM<sub>2.5</sub> are considered to have the greatest impact because their very small size allows them to penetrate down to the lung alveoli and even enter the bloodstream, thereby triggering various health disorders. Literature findings indicate that increased PM<sub>2.5</sub> levels are significantly correlated with increased visits to healthcare facilities due to respiratory disorders in children, including an increase in cases of ARI and asthma (Mebrahtu, 2023; Wulan, 2024).

Exposure to nitrogen dioxide (NO<sub>2</sub>), which mostly comes from motor vehicle emissions, has also been shown to have a close relationship with the increased prevalence of asthma in school-aged children (Sari, 2025). Epidemiological studies indicate that children living near highways with high traffic levels have a greater risk of experiencing chronic respiratory symptoms such as persistent coughing, wheezing, and shortness of breath (Nawawonganun, 2026). This condition suggests that transportation-based pollution sources contribute significantly to the decline in air quality in residential areas and directly impact children's health.

Sulfur dioxide (SO<sub>2</sub>) and carbon monoxide (CO) also contribute to respiratory health disorders, although the level of impact is relatively lower compared to PM<sub>2.5</sub> (Khalaf, 2024; Shaheed, 2026). Exposure to SO<sub>2</sub> can cause irritation in the respiratory tract, constrict the bronchi, and worsen pre-existing conditions such as bronchitis and asthma. Meanwhile, carbon monoxide has a high affinity for hemoglobin, which can reduce the blood's capacity to bind oxygen, ultimately worsening overall health conditions, especially in children with already vulnerable health conditions.

In terms of types of diseases, research results show that acute respiratory infections (ARI) are the diseases most commonly associated with air pollution exposure in children (Irma, 2025; Shafwan, 2025). ARI generally occurs due to short-term exposure to high concentrations of pollutants that trigger an inflammatory response in the respiratory tract. In addition, chronic diseases such

as asthma also show a significant increase in prevalence in children exposed to air pollution over the long term, indicating differences in impact patterns based on exposure duration (Malamardi, 2022; Gentile, 2022; Paciência, 2022). Several longitudinal studies indicate that long-term air pollution exposure can lead to impaired lung development in children, including decreased lung function and hindered optimal growth of lung capacity (Teng, 2022; Wallbanks, 2024). This condition can result in a permanent decrease in lung capacity until adulthood, thereby increasing the risk of chronic respiratory diseases in the future. This finding is very important because it shows that the effects of air pollution are not only temporary, but also have long-term consequences for individual health.

Fine particles that enter the respiratory system can trigger inflammatory reactions in lung tissues, which if sustained can cause structural damage (Albano, 2022). In addition, exposure to pollutants also increases the production of free radicals that damage body cells, disrupt the normal function of the respiratory system, and increase sensitivity to allergens. Exposure to air pollution is also known to weaken the immune system of children, thereby increasing vulnerability to various types of infections, particularly respiratory tract infections. Children who are frequently exposed to air pollution tend to be more prone to experiencing ARIs and other infectious diseases compared to children living in environments with clean air (Esposito, 2025). This indicates that the impact of air pollution is not only limited to the respiratory system but also affects the immune system as a whole.

The study results also show that there are various other factors that can strengthen the impact of air pollution on children's health, such as the family's socioeconomic conditions, parents' education level, and the condition of the living environment (Permana, 2025). Children from families with low socioeconomic status tend to be more vulnerable due to limited access to healthy environments, good nutrition, and adequate health services, thereby increasing the risk of respiratory diseases. In addition, domestic environmental factors such as exposure to cigarette smoke inside the house also play a role in worsening children's respiratory health (Murphy, 2023). The combination of outdoor air pollution and indoor pollution can increase cumulative exposure levels, thereby raising the risk of health disorders. Therefore, efforts to control air pollution must include a comprehensive approach, both for the outdoor environment and inside the home. The duration and intensity of exposure are also important factors in determining the severity of health impacts caused by air pollution. Short-term exposure is generally associated with an increase in cases of acute respiratory infections and respiratory disturbances, while long-term exposure is more often linked to chronic diseases such as asthma and reduced lung function. This indicates that air pollution control must be carried out continuously and consistently to prevent long-term impacts.

From the perspective of environmental-based public health, the results of this study emphasize the importance of a preventive approach in addressing the impact of air pollution on children's health. Preventive efforts can be carried out through controlling emission sources, such as limiting the use of motor vehicles, increasing energy efficiency, and using environmentally friendly energy. In

addition, providing green open spaces can also play a role in improving air quality in urban environments. From the community side, education about the importance of maintaining air quality and protecting children from pollution exposure is also an equally important aspect. Parents need to be given an understanding of simple steps that can be taken to reduce exposure, such as limiting outdoor activities when air quality is poor, wearing masks, and maintaining the cleanliness of the home environment. Thus, the results and discussion in this study overall indicate that air pollution is an important determinant of children's respiratory health, with wide-ranging and complex impacts. Therefore, a comprehensive, integrated, and sustainable approach involving the government, healthcare workers, and the community is needed in efforts to control air pollution to protect the health of future generations.

## **CONCLUSIONS AND RECOMMENDATIONS**

Based on the results of the literature review that has been conducted, it can be concluded that air pollution is an environmental factor that has a significant influence on increasing the risk of respiratory diseases in children. Exposure to various pollutants such as PM<sub>2.5</sub>, PM<sub>10</sub>, nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), and carbon monoxide (CO) has been proven to contribute to impaired lung function, both in the short term and long term. Children, as a vulnerable group, have a higher level of susceptibility due to their respiratory system that is not yet fully developed and the high frequency of exposure to the external environment. Research results also indicate that there is a consistent relationship between the level of air pollution exposure and the incidence of respiratory diseases such as acute respiratory infections (ARI), asthma, and bronchitis. Short-term exposure tends to increase cases of acute diseases, while long-term exposure has the potential to cause chronic disorders and permanent decline in lung function. In addition, socioeconomic factors, living environmental conditions, and exposure to indoor pollution also reinforce the negative impact of air pollution on children's health. Therefore, a public health approach based on the environment becomes very important in efforts to prevent and control respiratory diseases in children. Comprehensive interventions are needed through emission control policies, improvement of environmental quality, and public education to reduce exposure to air pollution. Cross-sectoral collaboration between the government, healthcare workers, and the community is key to creating a healthy and sustainable environment to protect children's health as the generation of the future.

## **FURTHER STUDY**

This research still has limitations so that further research is needed on the topic of Environment-Based Public Health: The Impact of Air Pollution on the Risk of Respiratory Diseases in Children to perfect this research and increase insight for readers and writers.

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