POLTEKITA
Jurnal Ilmu Kesehatan
Online ISSN: 2527-7170
Print ISSN: 1907-459X

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Vol. 18 No. 1 (2024)

PUBLISHED: 2024-05-23

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Poltekita: Jurnal Ilmu Kesehatan
http://ojs.polkespalupress.id/index.php/JIK

Vol.18 No.1 May 2024: Hal. 1-15
p-ISSN: 1907-459X e-ISSN: 2527-7170

Article Review

The Effects of Air Pollution on Respiratory Problems: A Literature Review

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ABSTRACT

As the global prevalence of air pollution continues to rise, understanding its intricate impact on human health, particularly respiratory well-being, becomes imperative. The research objectives of the article is to explore and establish clear connections between air pollution and respiratory health. Methods: A comprehensive search of peer-reviewed literature was conducted using databases such as PubMed, Web of Science, and Google Scholar. Articles published between 2015 and 2023 were included, with a focus on epidemiological studies, experimental research, and reviews that explored the impact of air pollution on respiratory problems. The result is this review synthesizes the established connections between these pollutants and a range of respiratory problems. Extensive evidence showcases how exposure to elevated pollutant levels escalates the risk of respiratory maladies, encompassing aggravated asthma, exacerbated chronic obstructive pulmonary disease (COPD) symptoms, compromised lung function, heightened susceptibility to respiratory infections, elevated lung cancer risk, and potentiated allergic responses. This review also underscores the heightened vulnerability of certain demographics, such as prenatal age, children, the elderly, individuals with preexisting respiratory conditions, low socioeconomic groups, occupational groups, outdoor workers, and athletes, immune-compromised individuals, and genetic susceptibility to these detrimental effects. The underlying mechanisms orchestrating the impact of air pollution on respiratory health involve intricate interplays of oxidative stress, inflammation, and tissue damage within the respiratory system. In conclusion: The study advocates for urgent and targeted strategies to mitigate the adverse impact of air pollution on respiratory health.

Keywords: *Air Pollution, Allergies, COPD, Lung Cancer, Respiratory Infections.*

https://doi.org/10.33860/jik.v18i1.3151

INTRODUCTION

The air we breathe, once a symbol of purity, now carries an insidious threat that transcends geographic boundaries and infiltrates the very essence of human well-being. Air pollution, a global health threat, contributes significantly to millions of annual human deaths, particularly through its association with delayed onset respiratory diseases in both children and adults. In an era marked by unprecedented industrialization and urbanization, the consequences of air pollution have manifested with alarming clarity, particularly in the realm of respiratory health[1,2,3,4,5].

Air pollution, a complex amalgamation of pollutants emanating from vehicular emissions, industrial processes, and urban activities, has woven a silent but potent

narrative of harm. Its impact on the respiratory system is both pervasive and profound, affecting individuals across age groups and demographics[1,2,3,4,5].

As we navigate this intricate landscape, it becomes evident that the consequences extend far beyond the visible haze that obscures skylines. Respiratory problems, once sporadic, have assumed the shape of a burgeoning public health crisis. Whether in the delicate stages of fetal development, the formative years of childhood, or amidst the challenges of chronic respiratory conditions, the effects of inhaling polluted air echo across the stages of human life [1,2,3,4,5].

This introduction sets the stage for a focused exploration into the intricate mechanisms through which air pollution insinuates itself into the respiratory system, leaving a trail of health implications. Beyond its visible manifestations, air pollution's role in exacerbating respiratory diseases and compromising overall lung health warrants a closer examination, pointing towards the urgent need for mitigation strategies and a collective commitment to breathe life back into the air we share [1,2,3,4,5].

The intersection of air quality and human health has long been a subject of scientific inquiry. Among the manifold health ramifications of air pollution, the intricate ties between air quality and respiratory problems stand as a paramount concern. Extensive research has underscored the multifaceted impacts of air pollutants on the respiratory system, ranging from minor irritations to severe and chronic conditions[1,2,3,4,5].

This review aims to distill the wealth of knowledge surrounding the effects of air pollution on respiratory health, focusing on the established links between various pollutants and a spectrum of respiratory maladies[1,2,3,4,5].

METHODS

A comprehensive search of peer-reviewed literature was conducted using databases such as PubMed, Web of Science, and Google Scholar. Articles published between 2015 and 2023 were included, with a focus on epidemiological studies, experimental research, and reviews that explored the impact of air pollution on respiratory problems.

RESULTS AND DISCUSSIONS

Air Pollutants

Due to soil, air, and water pollution, human activity has a negative impact on the ecosystem. The industrial revolution brought about the generation of massive amounts of airborne pollutants that are damaging to human health, even if it was also a major achievement in terms of technology, society, and the supply of numerous services. Without a doubt, environmental contamination on a worldwide scale is regarded as a multifaceted international public health concern[1].

Air pollution is contamination of the outdoor or indoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution[2,3]. Outdoor air pollutants are either derived from human activities, such as industrial emissions, road traffic, residential heating, shipping, air traffic, construction, agricultural activities, war and fire accidents, or from natural hazards, such as earthquake, tsunami, volcanic eruption, spontaneous forest fires, and extreme temperature. Indoor air pollutants are generally released from smoking, building materials, air conditioning, house cleaning or air refreshing products, heating, lighting, and wood, fuel, or coal usage in cooking[4].

Pollutants of major public health concern include particulate matter, ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide are prominent constituents of the complex mixture of air pollutants[2]. Each of these pollutants has distinct properties, sources, and mechanisms of impact on the respiratory system. Particulate matter, categorized by size, infiltrates deep into lung tissues, while ozone and nitrogen dioxide irritate airways and instigate inflammatory responses. Sulfur dioxide and carbon monoxide, originating from industrial processes and vehicle emissions, respectively, also exert significant effects on respiratory health. These pollutants collectively impose a substantial burden on public health by contributing to a range of respiratory problems[1,2,3,4,5].

Factors contributing to the severity or level of air pollution

The severity or level of air pollution has significant implications for respiratory health and overall human health. Higher levels of air pollution are associated with increased risks of respiratory problems and other health issues[6,7,8,9,10,11,12,13].

Here's a summarized overview of factors that play a role in increasing the severity or level of air pollution:

Outdoor Air Pollution

Many factors can increase outdoor air pollution, including Emissions from Combustion Sources (Industrial activities and transportation contribute to pollutants through the burning of fossil fuels), Agricultural Practices (The use of pesticides, fertilizers, and agricultural activities can release pollutants into the air), Waste Management (Landfills and open burning of waste materials release pollutants), Deforestation and Land Use Changes (Forest fires and changes in land use contribute to air pollution), Energy Production {Power plants burning fossil fuels release pollutants like sulfur dioxide and nitrogen oxides), Residential Heating and Cooking (Solid fuel combustion in households contributes to indoor and outdoor air pollution), Volatile Organic Compounds (VOCs) (VOC emissions from industrial processes, paints, and other sources contribute to pollution), Natural Sources (Volcanic activity, wildfires, and biogenic emissions release pollutants into the atmosphere), Climate Conditions (Temperature inversions and other meteorological factors can trap pollutants), Vehicle and Industrial Technologies (Outdated technology in vehicles and industries can contribute to higher emissions), Population Density and Urbanization (Urban areas with high population density and industrial activities often experience elevated pollution levels, Geographic Scope (Topography: Mountainous areas, valleys, and wind patterns influence the dispersion and accumulation of pollutants, Meteorological Conditions: Climate zones, wind patterns, and temperature inversions impact pollution levels Proximity to Pollution Sources: Geographic location relative to industrial zones, highways, and pollution sources affects exposure)[6,7,8,9,10].

Indoor Air Pollution

Factors that can increase outdoor air pollution, including: Ventilation Rates (Inadequate ventilation in buildings leads to the accumulation of indoor pollutants), Building Design and Construction (Sealing and insulation practices can trap pollutants indoors, Appliance and Fuel Use (Combustion appliances, solid fuel use, and improper venting contribute to indoor pollution), Household Products (VOCs from paints, cleaning agents, and other products contribute to indoor air pollution), Smoking (Tobacco smoke releases harmful chemicals indoors, degrading air quality), Moisture and Mold (Excess moisture and damp conditions can lead to mold growth and indoor air pollution), Pest Control Practices (Indoor pesticide use can release harmful chemicals without proper ventilation), Furniture and Building Materials (Off-gassing from furniture, carpets, and building materials contributes to indoor pollution), Occupant Behavior (Cooking practices, cleaning habits, and other activities can release pollutants indoors), Radon Gas (Radon, a naturally occurring radioactive gas, can enter homes and contribute to indoor air pollution)[11,12,13].

Air Pollution and Protective Mechanism of Respiratory System

Air pollution poses a significant global health threat, resulting in millions of annual human deaths. The delayed development of respiratory disorders in adults and children that can be linked to prenatal or perinatal exposure to air pollution is a growing concern in the field of human health. Particularly sensitive to environmental exposure are the stages of pregnancy and fetal development, which may have long-term effects on people in the future[3,4].

Air pollution diminishes both quality of life and life expectancy, exacerbating acute and chronic respiratory symptoms in individuals with preexisting airway conditions. Additionally, it raises morbidity rates and heightens the risk of hospitalization for those affected by respiratory diseases[3,4].

The air-blood barrier and mucosal cilia are two of the protective mechanisms found in the bronchopulmonary tract; however, the size and chemical makeup of air pollutants determine their capacity to either concentrate in or transit through lung tissues[4]. Because air pollutants are mostly hydrophilic and hydrophobic, they can

either dissolve in bodily fluids or be absorbed by human cells. PM10 (about 10 μm) particulate matter can enter the proximal airways and is primarily removed by mucociliary clearance. While ultrafine particles can travel via the bloodstream to distant organs and tissues, such as the liver for detoxification and placental tissues during pregnancy, PM2.5, a major health risk factor, can enter the lungs more deeply[4].

The detrimental health effects of air pollutants have been demonstrated in relation to various respiratory diseases, including respiratory infections, asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. Furthermore, these pollutants have been linked to an increased risk of stroke and heart disease when considered in combination, as reviewed[4].

Mucociliary epithelium lining the upper and lower respiratory tract constitutes the first line of defense of the airway and lungs against inhaled pollutants and pathogens. Mucosal cilia are hair-like structures that line the respiratory tract, including the bronchopulmonary tract, from the nasal passages down to the smaller airways in the lungs. These cilia are specialized projections that extend from the surface of epithelial cells, which are the cells that form the lining of the airways. The coordinated movement of these cilia serves several important functions, including acting as a protective mechanism against various particles and microorganisms, including air pollutants[5,14,15].

One crucial role of mucosal cilia is in the clearance of mucus. The respiratory tract is coated with a layer of mucus that functions as a trap for inhaled particles, dust, pathogens, and airborne contaminants, including air pollutants. This mucus contains substances that can immobilize these particles. The coordinated beating of mucosal cilia generates a sweeping motion, propelling the mucus layer upward from the deeper airways toward the throat, a process known as the mucociliary escalator. As the mucus moves along, it carries trapped particles and pollutants, effectively removing these foreign substances from the sensitive airway tissues and directing them toward the throat. The mucus, along with the trapped particles, can then be either swallowed and directed to the stomach (where stomach acid neutralizes pathogens) or expelled through coughing and clearing the throat[5,14,15].

Moreover, mucosal cilia also play a pivotal role in preventing the entry of particles and pollutants into the deeper and more sensitive areas of the respiratory system, such as the alveoli where gas exchange takes place. The continuous action of these cilia helps keep contaminants trapped in the mucus layer, continuously moving them upward, thus reducing the risk of these substances causing damage or inflammation deeper within the lungs[5,14,15].

Additionally, mucosal cilia contribute to defending against respiratory infections. When harmful microorganisms like bacteria and viruses enter the respiratory tract, the cilia work in concert with the mucus to move them toward the throat, where they can be expelled or swallowed. This action limits the opportunity for these pathogens to establish infections within the lungs[5,14,15].

However, prolonged exposure to high levels of air pollutants, especially fine particulate matter (PM2.5) and toxic gases, can lead to impairment of mucosal cilia function. The pollutants can interfere with the cilia's movement, disrupting their ability to effectively clear mucus and particles. This impairment can result in a buildup of pollutants and particles in the airways, making individuals more susceptible to respiratory infections, exacerbating pre-existing respiratory conditions, and increasing overall respiratory discomfort[16].

To support the function of mucosal cilia and their protective role against air pollutants, it's important to maintain good respiratory health. This includes avoiding prolonged exposure to polluted air, staying hydrated, practicing good hygiene, and adopting a healthy lifestyle that includes a balanced diet and regular physical activity[5,14,15,17,18].

The air-blood barrier, also known as the respiratory membrane or alveolar-capillary membrane, is a crucial anatomical structure within the bronchopulmonary tract that facilitates the exchange of gases (oxygen and carbon dioxide) between the air in the lungs and the bloodstream. This barrier is primarily located in the alveoli, which are the tiny air sacs within the lungs where gas exchange occurs[18,19].

This barrier facilitates the exchange of gases, such as oxygen and carbon dioxide, between the air in the lungs and the bloodstream. It consists of several layers, including Type I Alveolar Cells, which are thin,

flat cells forming the alveolar walls, allowing efficient gas diffusion between the air and the bloodstream. Similarly, Endothelial Cells, which line the walls of the capillaries surrounding the alveoli, are thin to facilitate gas exchange. Between these cell types lies the Basement Membrane, a thin layer of connective tissue providing structural support and cell anchoring[18,19].

The role of the air-blood barrier as a protective mechanism against air pollutants is related to its selective permeability. The barrier is designed to allow efficient diffusion of oxygen from the alveolar air into the bloodstream and the simultaneous removal of carbon dioxide from the bloodstream into the alveoli. However, this barrier is not equally permeable to all substances[18,19].

Air pollutants, such as fine particulate matter (PM2.5) and certain gases, can be harmful to human health because they can penetrate the air-blood barrier[8,9,10]. The air-blood barrier is a protective layer that separates the air in the lungs from the blood vessels. It is made up of a fine structure that prevents larger particles, like dust and most pathogens, from entering the bloodstream and causing systemic effects[3,16,19,20].

The respiratory system is equipped with immune cells that patrol the alveoli and lung tissues. These cells can engulf and neutralize particles that manage to breach the air-blood barrier, helping to minimize their impact [3,16,20,21]. If pollutants do manage to cause damage to the air-blood barrier, the body's immune response is triggered, leading to inflammation. This inflammation helps recruit immune cells to the site of damage, clear away debris, and initiate repair processes to restore the integrity of the barrier[3,16,20,21].

However, chronic exposure to high levels of pollutants can lead to persistent inflammation and damage to the air-blood barrier, compromising its function. This can result in the direct entry of pollutants into the bloodstream, potentially causing systemic health issues and affecting other organs[20,21].

To protect the air-blood barrier from the harmful effects of pollutants, it's essential to maintain good air quality, reduce exposure to pollutants, and support overall lung health through a healthy lifestyle and proper respiratory care[17,21].

Effects on Specific Respiratory Conditions

A cornerstone of the research in this domain is the exploration of how air pollution affects specific respiratory conditions.

Asthma

Air pollution can have significant negative effects on individuals with asthma. Asthma is a chronic respiratory condition characterized by inflammation and narrowing of the airways, which can lead to symptoms like wheezing, coughing, chest tightness, and difficulty breathing. Air pollutants that can irritate and inflame an asthmatic's airways include fine particulate matter (PM2.5), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2). This inflammation can make asthma symptoms more severe and harder to control[22,23,24,25,26,27,28].

Prolonged exposure to air pollution can lead to decreased lung function, which is particularly problematic for people with asthma, as they already have compromised airways. Reduced lung function can result in increased breathlessness and a decreased ability to expel mucus and other irritants from the airways [(22,23,24,25,26,27,28)].

Air pollution can trigger asthma attacks or make them more frequent and severe. These attacks can be life-threatening in some cases, especially if not promptly treated[22,23,24,25, 26,27,28].

Air pollution can reduce the effectiveness of asthma medications, making it more chal-lenging to control asthma symptoms. People may need higher doses of medications or more frequent use of rescue inhalers when exposed to polluted air[22,23,24,25,26,27,28].

Long-term exposure to air pollution has been linked to the development and progression of asthma in children and adults. It can also lead to the development of other respiratory conditions, such as chronic obstructive pulmonary disease (COPD)[22,23,24,25,26,27,28].

Poor air quality, especially during periods of high pollution levels, can lead to an increase in hospital admissions for asthma-related issues. This places a significant burden on healthcare systems and can be emotionally distressing for individuals and their families[22,23,24,25,26,27,28].

Chronic obstructive pulmonary disease (COPD)

Air pollution can have serious and detrimental effects on individuals with Chronic Obstructive Pulmonary Disease (COPD), a chronic lung condition that includes conditions like chronic bronchitis and emphysema. COPD is characterized by the obstruction of airflow in and out of the lungs, making it difficult to breathe. Air pollutants, especially fine particulate matter (PM2.5), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2), can irritate and inflame the airways and lung tissues. This can lead to increased coughing, mucus production, shortness of breath, and wheezing in individuals with COPD[29,30,31,32,33].

Exposure to air pollution can trigger exacerbations or acute worsening of COPD symptoms. These exacerbations often result in increased breathlessness and coughing, more severe mucus production, and a higher risk of respiratory infections, which can be life-threatening for COPD patients[29,30,31,32,33].

Long-term exposure to air pollution can further reduce lung function in individuals with COPD, making it even harder for them to breathe. This decreased lung function can contribute to a decline in overall health and quality of life[29,30,31,32,33].

Poor air quality can lead to an increase in hospital admissions for COPD-related issues, such as exacerbations and respiratory infections. This places a significant burden on healthcare systems and can be emotionally distressing for individuals and their families[29,30,31,32,33].

Air pollution can reduce the effectiveness of medications used to manage COPD symptoms. This may require COPD patients to use higher doses of medications or to rely more on rescue medications when exposed to polluted air[29,30,31,32,33].

Many individuals with COPD have other health conditions, such as cardiovascular diseases, diabetes, or hypertension. Air pollution can exacerbate these coexisting conditions, leading to a cascade of health problems and complications[29,30,31,32,33].

Hampers lung function development in children and perpetuates lung function decline in adults

Beyond these conditions, air pollution hampers lung function development in children and perpetuates lung function decline in adults, setting the stage for an array of respiratory ailments[28,34,35,36].

Air pollution can have significant and lasting effects on lung function in both children and adults. Here's how it can hamper lung function development in children and perpetuate lung function decline in adults[28,34,35,36].

Long-term exposure to air pollution, particularly fine particulate matter (PM2.5) and pollutants like nitrogen dioxide (NO2) and ozone (O3), can lead to stunted lung growth in children, which means that their lungs may not reach their full potential size and capacity, limiting their ability to breathe efficiently. Air pollutants can impair lung function in children by causing inflammation and damage to lung tissues, resulting in decreased lung function, making it harder for children to breathe and engage in physical activities. Air pollution can weaken the immune system and increase children's susceptibility to respiratory infections, which can further damage lung tissue and hinder lung development[28,34].

Long-term exposure to air pollution can accelerate the aging of the lungs in adults, leading to a natural decline in lung function occurring at a faster rate than in individuals with cleaner air exposure. Air pollution is a major risk factor for the development and exacerbation of chronic respiratory conditions in adults, including asthma and Chronic Obstructive Pulmonary Disease (COPD), which often result in a progressive decline in lung function. Prolonged exposure to high levels of air pollution has been linked to premature death, primarily due to respiratory and cardiovascular diseases. This further underscores the long-term consequences of air pollution on lung health. Individuals with compromised lung function due to air pollution may experience reduced quality of life, as they may be more limited in their physical activities and daily functioning. The healthcare costs associated with treating respiratory and cardiovascular diseases related to air pollution are substantial, placing an economic burden on both individuals and healthcare systems[35,36].

Respiratory infections

Encompassing bronchitis, pneumonia, and other upper respiratory tract infections, find

fertile ground in air-polluted environments due to compromised immune responses in the respiratory tract[37,38,39,40,41].

Air pollution can have a significant impact on respiratory infections, both in terms of increasing the risk of respiratory infections and exacerbating the severity of existing infections[37,38,39,40,41].

The immune system's capacity to fend off infections can be weakened by prolonged exposure to air pollutants such as sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), and fine particulate matter (PM2.5).This weakened immunity makes individuals more susceptible to respiratory infections caused by viruses and bacteria. Air pollutants can irritate and inflame the respiratory tract, making it easier for pathogens like viruses and bacteria to enter and infect the lungs. This can lead to a higher likelihood of developing respiratory infections. Some research suggests that air pollution can enhance the transmission of respiratory viruses, like the flu and the common cold, by promoting the survival and stability of viral particles in the air. This can increase the chances of infection in susceptible individuals[37,38,39,40,41].

Exacerbation of Respiratory diseases: People suffering from diseases such as the flu, pneumonia, or bronchitis may have increased coughing, mucus production, chest discomfort, and dyspnea as a result of exposure to air pollution. Respiratory infections can become more severe when individuals are exposed to high levels of air pollution, resulting in more frequent hospitalizations and complications, especially in vulnerable populations like children, the elderly, and individuals with preexisting respiratory conditions. Air pollution can slow down the recovery process from respiratory infections by hindering the body's ability to repair damaged lung tissues and clear mucus and pathogens from the airways. Studies have shown that individuals with respiratory infections who are exposed to high levels of air pollution may face a higher risk of mortality, particularly if they have underlying health conditions[37,38,39,40,41].

Lung cancer

Moreover, the link between air pollution and lung cancer underscores the gravity of long-term exposure to certain pollutants.

Air pollution is a significant environmental risk factor for the development and progression of lung cancer. Exposure to various air pollutants has been linked to an increased risk of lung cancer in both smokers and non-smokers. Air pollution contains fine particulate matter (PM2.5) and other airborne particles that can carry carcinogenic compounds, including heavy metals, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs). These substances can penetrate deep into the respiratory tract and potentially lead to genetic mutations in lung cells, contributing to the initiation of cancer. Air pollution also contains various chemical pollutants, such as benzene, formaldehyde, and acetaldehyde, which are known or suspected carcinogens. Prolonged exposure to these substances can increase the risk of developing lung cancer[42,43,44,45,46].

Air pollution, particularly fine particulate matter and ozone, can induce inflammation in the respiratory system. Chronic inflammation may promote cell damage and mutations, which can increase the risk of lung cancer. Air pollutants can also lead to oxidative stress, where there is an imbalance between free radicals and antioxidants in the body. This oxidative stress can damage DNA and cellular structures, potentially contributing to the development of cancerous cells[42,43,44,45,46].

Prolonged exposure to air pollutants, especially in heavily polluted areas, can suppress the immune system's ability to detect and eliminate cancerous cells. This weakened immune response may allow cancer cells to proliferate and evade destruction[42,43,44,45,46].

Air pollution can promote tumor growth and progression by creating a favorable environment for cancer cells to thrive. It has been linked to the promotion of angiogenesis, the formation of new blood vessels to supply tumors with nutrients and oxygen. This can facilitate the growth and spread of lung cancer. Some research suggests that air pollution may enhance the ability of cancer cells to metastasize or spread to other parts of the body, making lung cancer more aggressive [42,43,44,45,46].

Air pollution can have a carcinogenic effect on people, especially children and those with previous respiratory disorders. Pollution exposure throughout childhood can raise the chance of developing lung cancer later in life[42,43,44,45,46].

Smoking and exposure to air pollution

have a synergistic effect on lung cancer risk. Smokers who live in areas with high levels of air pollution face a significantly higher risk of developing lung cancer than those in cleaner air environments[42,43,44,45,46].

Allergies and sensitization to allergens

Additionally, allergies and sensitization to allergens are exacerbated by air pollution, fueling the prevalence of allergic respiratory diseases like allergic rhinitis [(47,48,49,50,51)].

Air pollution can significantly affect allergies and sensitization to allergens in several ways. Air pollution, especially in urban areas, can lead to higher levels of airborne allergens, such as pollen and mold spores. This can increase the exposure of individuals to allergens, which is particularly problematic for people with allergies[47,48,49,50,51].

Some studies suggest that air pollutants, such as diesel exhaust particles and ozone, can interact with allergens and make them more potent or allergenic. This means that even a small amount of allergen exposure can trigger a stronger allergic reaction in individuals who are sensitized to these allergens[47,48,49,50,51].

Prolonged exposure to air pollution can weaken the immune system, making individuals more susceptible to allergic reactions. Air pollutants can disrupt the balance of immune cells, reducing the body's ability to regulate immune responses effectively[47,48,49,50,51].

Air pollution may also contribute to the sensitization of individuals to allergens. Long-term exposure to pollutants can lead to chronic inflammation in the airways and respiratory system. This inflammation can make individuals more susceptible to developing allergies or becoming sensitized to allergens they were previously not allergic [47,48,49,50,51].

For people who are already allergic, air pollution can exacerbate their allergic symptoms. Pollutants can irritate the respiratory tract, leading to symptoms like coughing, sneezing, and wheezing, which can be especially problematic for individuals with asthma or allergic rhinitis[47,48,49,50,51].

Air pollution is a known trigger for asthma exacerbations. Individuals with asthma may experience more frequent and severe attacks when exposed to high levels of air pollutants. Additionally, pollutants can worsen the inflammation and bronchoconstriction associated with asthma [47,48,49,50,51].

Prolonged exposure to air pollution, especially in childhood, has been linked to the development of allergic diseases and conditions, such as allergic rhinitis, asthma, and eczema. It can also lead to a more severe course of these conditions over time [47,48,49,50,51].

Climate change, driven in part by air pollution, can affect the distribution and abundance of allergenic plants and species. This can expose individuals to new allergens and extend the duration of allergen seasons, leading to increased sensitization and allergy symptoms [47,48,49,50,51].

In summary, air pollution can have a profound impact on allergies and sensitization to allergens by increasing allergen exposure, enhancing allergen potency, weakening the immune response, and exacerbating existing allergic conditions. Efforts to reduce air pollution and improve air quality can help mitigate these adverse effects on allergic individuals and promote better respiratory health[47,48,49,50,51].

Vulnerable Populations

The disparate impact of air pollution on vulnerable populations amplifies the urgency of addressing this pervasive issue. Vulnerability to air pollution can affect various groups across different life stages. Here's a summarized overview of key vulnerable groups.

Prenatal Age (Unborn Babies and Pregnant Women). Risk of adverse outcomes such as preterm birth and developmental issues. Protective measures needed to ensure the well-being of both the mother and the developing fetus. Children, still undergoing lung development, are particularly susceptible to long-term lung damage caused by air pollution, respiratory problems, and asthma. Long-term impacts on health, necessitating measures like clean air initiatives and targeted healthcare. The elderly, often burdened with preexisting health conditions, confront exacerbated symptoms and heightened mortality risks when exposed to poor air quality. Individuals with preexisting respiratory conditions face escalated risks of exacerbations and disease progression, further eroding their quality of life [(52,53,54,55)]. Individuals with Pre-existing Health Conditions. This group is vulnerable against exacerbation of respiratory or cardiovascular diseases. It requires increased vulnerability, emphasizing the importance of managing existing health conditions and reducing

exposure to pollution. Low Socioeconomic Groups. Vulnerability: Higher exposure due to residence in areas with poor air quality, and limited resources for protective measures. Importance: Addressing environmental justice concerns, ensuring equitable access to clean air, and minimizing health disparities. Occupational Groups, Outdoor Workers, and Athletes. Vulnerability: Higher exposure due to the nature of their work or outdoor activities. Importance: Occupational health measures, awareness, and protective equipment may be necessary. Communities Near Pollution Sources. Vulnerability: Proximity to industrial zones, highways, or other sources leads to increased exposure. Importance: Addressing localized pollution sources, implementing regulations, and community engagement are crucial. Immune-compromised Individuals. Weakened immune systems may increase susceptibility to health impacts. Extra precautions and healthcare support are essential for individuals with compromised immunity. Genetic Susceptibility. Genetic factors contribute to individual variability in response to pollutants. Understanding gene-environment interactions for tailored interventions and personalized healthcare[56,57,58].

Addressing vulnerability across life stages requires a holistic approach, including policy interventions, community engagement, healthcare access, and awareness programs. Protecting vulnerable groups is essential for promoting environmental justice and ensuring the well-being of diverse populations [52,53,54,55,56,57,58].

Mechanisms of Impact

Elucidating the mechanisms through which air pollution wreaks havoc on respiratory health is pivotal for comprehensive understanding. Oxidative stress, arising from an imbalance between reactive oxygen species and antioxidant defenses, serves as a central player in initiating cellular damage and inflammation. Inflammation, a fundamental response to irritants and foreign invaders, becomes dysregulated in the presence of sustained exposure to pollutants, thereby contributing to respiratory symptoms and disease progression. Tissue damage, resulting from a cascade of oxidative stress and inflammation, impairs lung function and elevates susceptibility to infections and diseases[16, 53, 59].

Mitigation Strategies

Ameliorating the adverse impact of air pollution on respiratory health necessitates multifaceted strategies. Stringent air quality standards, enforced through regulatory mechanisms, serve as the foundation for cleaner air. Concurrently, reducing emissions from industrial sources and transportation systems curtails the influx of pollutants into the atmosphere. The promotion of cleaner energy sources, such as renewable energy, is pivotal in decreasing the generation of pollutants. Equally important is the role of public awareness campaigns, enlightening individuals about the risks of air pollution and fostering behaviors that minimize exposure[17, 60,61,62].

CONCLUSION

The extensive body of research outlined in this review unequivocally substantiates the profound influence of air pollution on respiratory health. The intricate interplay of pollutants like particulate matter, ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide with the respiratory system manifests in a range of maladies, from aggravated asthma to escalated lung cancer risk. Vulnerable populations bear the brunt of these detrimental effects, emphasizing the need for targeted interventions. The mechanisms underlying these effects—oxidative stress, inflammation, and tissue damage—illuminate the complexity of the interactions between pollutants and respiratory health. As societies grapple with the imperatives of cleaner air and improved public health, the adoption of stringent air quality standards, emission reduction strategies, and informed public engagement emerges as the path forward in mitigating the adverse consequences of air pollution on respiratory well-being. Given the continuous evolution of research in this field, staying abreast of new findings is imperative for refining our understanding and crafting effective interventions.

CONFLICT OF INTEREST

There is no conflict of interest associated with this publication. I want to clarify that for this literature review, there is no specific affiliation for research funding. The review was conducted independently without any external affiliations influencing the content. While I don't have

specific funding sources to disclose, I want to assure the readers that the review was carried out with the utmost impartiality and dedication to presenting an unbiased analysis of the available literature on the topic.

ACKNOWLEDGEMENT

Thank you to the Faculty of Medicine, Universitas Trisakti for the support.

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The Effects of Air Pollution on Respiratory Problems

by Hari Krismanuel

Poltekita: Jurnal Ilmu Kesehatan
http://jurnal.poltekkespalu.ac.id/index.php/JIK

Vol.15 No.1 Mei 2021: Hal. 1-11
p-ISSN: 1907-459X e-ISSN: 2527-7170

Article Review

The Effects of Air Pollution on Respiratory Problems

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ABSTRACT

As the global prevalence of air pollution continues to rise, understanding its intricate impact on human health, particularly respiratory well-being, becomes imperative. The research objectives of the article is to explore and establish clear connections between air pollution and respiratory health. Methods: A comprehensive search of peer-reviewed literature was conducted using databases such as PubMed, Web of Science, and Google Scholar. Articles published between 2015 and 2023 were included, with a focus on epidemiological studies, experimental research, and reviews that explored the impact of air pollution on respiratory problems. This review synthesizes the established connections between these pollutants and a range of respiratory problems. Extensive evidence showcases how exposure to elevated pollutant lev escalates the risk of respiratory maladies, encompassing aggravated asthma, exacerbated chronic obstructive pulmonary disease (COPD) symptoms, compromised lung function, heightened susceptibility to respiratory infections, elevated lung cancer risk, and potentiated allergic responses. This review also underscores the heightened vulnerability of certain demographics, such as prenatal age, children, the elderly, and individuals with preexisting respiratory conditions, low socioeconomic group, occupational groups, outdoor workers, and athletes, immune-compromised indi uals, and genetic susceptibility to these detrimental effects. The underlying mechanisms orchestrating the impact of air pollution on respiratory health involve intricate interplays of oxidative stress, inflammation, and tissue damage within the respiratory system. In conclusion, the study advocates for urgent and targeted strategies to mitigate the adverse impact of air pollution on respiratory health.

Keywords : Air pollution, allergies, COPD, lung cancer, respiratory infections.

https://doi.org/10.33860/jik.v15i1.430

INTRODUCTION

The air we breathe, once a symbol of purity, now carries an insidious threat that transcends geographic boundaries and infiltrates the very essence of human well-being. Air pollution, a global health threat, contributes significantly to millions of annual human deaths, particularly through its association with delayed onset respiratory diseases in both children and adults. In an era marked by unprecedented industrialization and urbanization, the consequences of air pollution have manifested with alarming clarity, particularly in the realm of respiratory health.

Air pollution, a complex amalgamation of pollutants emanating from vehicular emissions, industrial processes, and urban activities, has woven a silent but potent narrative of harm. Its impact on the respiratory system is both pervasive and profound, affecting individuals across age groups and demographics

As we navigate this intricate landscape, it becomes evident that the consequences extend far beyond the visible haze that obscures skylines. Respiratory problems, once sporadic, have assumed the shape of a burgeoning public health crisis. Whether in the delicate stages of fetal development, the formative years of childhood, or amidst the challenges of chronic respiratory conditions, the effects of inhaling polluted air echo across the stages of human life.

This introduction sets the stage for a focused exploration into the intricate mechanisms through which air pollution insinuates itself into the respiratory system, leaving a trail of health implications. Beyond its visible manifestations, air pollution's role in exacerbating respiratory diseases and compromising overall lung health warrants a closer examination, pointing towards the urgent need for mitigation strategies and a collective commitment to breathe life back into the air we share.

The intersection of air quality and human health has long been a subject of scientific inquiry. Among the manifold health ramifications of air pollution, the intricate ties between air quality and respiratory problems stand as a paramount concern. Extensive research has underscored the multifaceted impacts of air pollutants on the respiratory system, ranging from minor irritations to severe and chronic conditions [1, 2, 3, 4, 5].

This review aims to distill the wealth of knowledge surrounding the effects of air pollution on respiratory health, focusing on the established links between various pollutants and a spectrum of respiratory maladies [1, 2, 3, 4, 5].

METHODS

A comprehensive search of peer-reviewed literature was conducted using databases such as PubMed, Web of Science, and Google Scholar. Articles published between 2015 and 2023 were included, with a focus on epidemiological studies, experimental research, and reviews that explored the impact of air pollution on respiratory problems.

REVIEW

Air Pollutants

Due to soil, air, and water pollution, human activity has a negative impact on the ecosystem. The industrial revolution brought about the generation of massive amounts of airborne pollutants that are damaging to human health, even if it was also a major achievement in terms of technology, society, and the supply of numerous services. Without a doubt, environmental contamination on a worldwide scale is regarded as a multifaceted international public health concern [1].

Air pollution is contamination of the outdoor or indoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution [2,3]. Outdoor air pollutants are either derived from human activities, such as industrial emissions, road traffic, residential heating, shipping, air traffic, construction, agricultural activities, war and fire accidents, or from natural hazards, such as earthquake, tsunami, volcanic eruption, spontaneous forest fires, and extreme temperature. Indoor air pollutants are generally released from smoking, building materials, air conditioning, house cleaning or air refreshing

products, heating, lighting, and wood, fuel, or coal usage in cooking [4].

Pollutants of major public health concern include particulate matter, ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide are prominent constituents of the complex mixture of air pollutants [2]. Each of these pollutants has distinct properties, sources, and mechanisms of impact on the respiratory system. Particulate matter, categorized by size, infiltrates deep into lung tissues, while ozone and nitrogen dioxide irritate airways and instigate inflammatory responses. Sulfur dioxide and carbon monoxide, originating from industrial processes and vehicle emissions, respectively, also exert significant effects on respiratory health. These pollutants collectively impose a substantial burden on public health by contributing to a range of respiratory problems [1,2,3,4,5].

Factors contributing to the severity or level of air pollution

The severity or level of air pollution has significant implications for respiratory health and overall human health. Higher levels of air pollution are associated with increased risks of respiratory problems and other health issues.

Here's a summarized overview of factors that play a role in increasing the severity or level of air pollution:

Outdoor Air Pollution

There are many factors that can increase outdoor air pollution, including: **Emissions from Combustion Sources** (Industrial activities and transportation contribute to pollutants through the burning of fossil fuels), **Agricultural Practices** (The use of pesticides, fertilizers, and agricultural activities can release pollutants into the air), **Waste Management** (Landfills and open burning of waste materials release pollutants), **Deforestation and Land Use Changes** (Forest fires and changes in land use contribute to air pollution), Energy Production {Power plants burning fossil fuels release pollutants like sulfur dioxide and nitrogen oxides), **Residential Heating and Cooking** (Solid fuel combustion in households contributes to indoor and outdoor air pollution), **Volatile Organic Compounds (VOCs)** (VOC emissions from industrial processes, paints, and other sources contribute to pollution), **Natural Sources** (Volcanic activity, wildfires, and biogenic emissions release pollutants into the atmosphere), **Climate Conditions** (Temperature inversions and other meteorological factors can trap pollutants), **Vehicle and Industrial Technologies** (Outdated technology in vehicles and industries can contribute to higher emissions), **Population Density and Urbanization** (Urban areas with high population density and industrial activities often experience elevated pollution levels, **Geographic Scope** (Topography: Mountainous areas, valleys, and wind patterns influence the dispersion and accumulation of pollutants, Meteorological Conditions: Climate zones, wind patterns, and temperature inversions impact pollution levels Proximity to Pollution Sources: Geographic location relative to industrial zones, highways, and pollution sources affects exposure).

Indoor Air Pollution

Factors that can increase outdoor air pollution, including: **Ventilation Rates** (Inadequate ventilation in buildings leads to the accumulation of indoor pollutants), **Building Design and Construction** (Sealing and insulation practices can trap pollutants indoors, **Appliance and Fuel Use** (Combustion appliances, solid fuel use, and improper venting contribute to indoor pollution), **Household Products** (VOCs from paints, cleaning agents, and other products contribute to indoor air pollution), **Smoking** (Tobacco smoke releases harmful chemicals indoors, degrading air quality), **Moisture and Mold** (Excess moisture and damp conditions can lead to mold growth and indoor air pollution), **Pest Control Practices** (Indoor pesticide use can release harmful chemicals without proper ventilation), **Furniture and Building Materials** (Off-gassing from furniture, carpets, and building materials contributes to indoor pollution), **Occupant Behavior** (Cooking practices, cleaning habits, and other activities can release pollutants indoors), **Radon Gas** (Radon, a naturally occurring radioactive gas, can enter homes and contribute to indoor air pollution).

Air Pollution and Protective Mechanism of Respiratory System

Air pollution poses a significant global health threat, resulting in millions of annual human deaths. The delayed development of

respiratory disorders in adults and children that can be linked to prenatal or perinatal exposure to air pollution is a growing concern in the field of human health. Particularly sensitive to environmental exposure are the stages of pregnancy and fetal development, which may have long-term effects on people in the future [3,4].

Air pollution diminishes both quality of life and life expectancy, exacerbating acute and chronic respiratory symptoms in individuals with preexisting airway conditions. Additionally, it raises the morbidity rates and heightens the risk of hospitalization for those affected by respiratory diseases [3,4].

The air-blood barrier and mucosal cilia are two of the protective mechanisms found in the bronchopulmonary tract; however, the size and chemical makeup of air pollutants determine their capacity to either concentrate in or transit through lung tissues (4). Because air pollutants are mostly hydrophilic and hydrophobic, they can either dissolve in bodily fluids or be absorbed by human cells. PM10 (about 10 μm) particulate matter can enter the proximal airways and is primarily removed by mucociliary clearance. While ultrafine particles can travel via the bloodstream to distant organs and tissues, such as the liver for detoxification and placental tissues during pregnancy, PM2.5, a major health risk factor, can enter the lungs more deeply [4].

The detrimental health effects of air pollutants have been demonstrated in relation to various respiratory diseases, including respiratory infections, asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. Furthermore, these pollutants have been linked to an increased risk of stroke and heart diseases when considered in combination, as reviewed [4].

Mucociliary epithelium lining the upper and lower respiratory tract constitutes the first line of defense of the airway and lungs against inhaled pollutants and pathogens. Mucosal cilia are hair-like structures that line the respiratory tract, including the bronchopulmonary tract, from the nasal passages down to the smaller airways in the lungs. These cilia are specialized projections that extend from the surface of epithelial cells, which are the cells that form the lining of the airways. The coordinated movement of these cilia serves several important functions, including acting as a protective mechanism against various particles and microorganisms, including air pollutants [5,6,7].

One crucial role of mucosal cilia is in the clearance of mucus. The respiratory tract is coated with a layer of mucus that functions as a trap for inhaled particles, dust, pathogens, and airborne contaminants, including air pollutants. This mucus contains substances that can immobilize these particles. The coordinated beating of mucosal cilia generates a sweeping motion, propelling the mucus layer upward from the deeper airways toward the throat, a process known as the mucociliary escalator. As the mucus moves along, it carries trapped particles and pollutants, effectively removing these foreign substances from the sensitive airway tissues and directing them toward the throat. The mucus, along with the trapped particles, can then be either swallowed and directed to the stomach (where stomach acid neutralizes pathogens) or expelled through coughing and clearing the throat [5,6,7].

Moreover, mucosal cilia also play a pivotal role in preventing the entry of particles and pollutants into the deeper and more sensitive areas of the respiratory system, such as the alveoli where gas exchange takes place. The continuous action of these cilia helps keep contaminants trapped in the mucus layer, continuously moving them upward, thus reducing the risk of these substances causing damage or inflammation deeper within the lungs [5,6,7].

Additionally, mucosal cilia contribute to defending against respiratory infections. When harmful microorganisms like bacteria and viruses enter the respiratory tract, the cilia work in concert with the mucus to move them toward the throat, where they can be expelled or swallowed. This action limits the opportunity for these pathogens to establish infections within the lungs [5,6,7].

However, prolonged exposure to high levels of air pollutants, especially fine particulate matter (PM2.5) and toxic gases, can

lead to impairment of mucosal cilia function. The pollutants can interfere with the cilia's movement, disrupting their ability to effectively clear mucus and particles. This impairment can result in a buildup of pollutants and particles in the airways, making individuals more susceptible to respiratory infections, exacerbating pre-existing respiratory conditions, and increasing overall respiratory discomfort [8].

To support the function of mucosal cilia and their protective role against air pollutants, it's important to maintain good respiratory health. This includes avoiding prolonged exposure to polluted air, staying hydrated, practicing good hygiene, and adopting a healthy lifestyle that includes a balanced diet and regular physical activity [5,6,7,9,13].

The air-blood barrier, also known as the respiratory membrane or alveolar-capillary membrane, is a crucial anatomical structure within the bronchopulmonary tract that facilitates the exchange of gases (oxygen and carbon dioxide) between the air in the lungs and the bloodstream. This barrier is primarily located in the alveoli, which are the tiny air sacs within the lungs where gas exchange occurs [10,11].

This barrier facilitates the exchange of gases, such as oxygen and carbon dioxide, between the air in the lungs and the bloodstream. It consists of several layers, including Type I Alveolar Cells, which are thin, flat cells forming the alveolar walls, allowing efficient gas diffusion between the air and the bloodstream. Similarly, Endothelial Cells, which line the walls of the capillaries surrounding the alveoli, are thin to facilitate gas exchange. Between these cell types lies the Basement Membrane, a thin layer of connective tissue providing structural support and cell anchoring [10,11].

The role of the air-blood barrier as a protective mechanism against air pollutants is related to its selective permeability. The barrier is designed to allow efficient diffusion of oxygen from the alveolar air into the bloodstream and the simultaneous removal of carbon dioxide from the bloodstream into the alveoli. However, this barrier is not equally permeable to all substances [10,11].

Air pollutants, such as fine particulate matter (PM2.5) and certain gases, can be harmful to human health because they can penetrate the air-blood barrier [8,9,10]. The air-blood barrier is a protective layer that separates the air in the lungs from the blood vessels. It is made up of a fine structure that prevents larger particles, like dust and most pathogens, from entering the bloodstream and causing systemic effects [3,8,11,12].

The respiratory system is equipped with immune cells that patrol the alveoli and lung tissues. These cells can engulf and neutralize particles that manage to breach the air-blood barrier, helping to minimize their impact [3,8,12,13]. If pollutants do manage to cause damage to the air-blood barrier, the body's immune response is triggered, leading to inflammation. This inflammation helps recruit immune cells to the site of damage, clear away debris, and initiate repair processes to restore the integrity of the barrier [3,8,12,13].

However, chronic exposure to high levels of pollutants can lead to persistent inflammation and damage to the air-blood barrier, compromising its function. This can result in the direct entry of pollutants into the bloodstream, potentially causing systemic health issues and affecting other organs [12,13].

To protect the air-blood barrier from the harmful effects of pollutants, it's essential to maintain good air quality, reduce exposure to pollutants, and support overall lung health through a healthy lifestyle and proper respiratory care [9,13].

Effects on Specific Respiratory Conditions

A cornerstone of the research in this domain is the exploration of how air pollution affects specific respiratory conditions.

Asthma

Air pollution can have significant negative effects on individuals with asthma. Asthma is a chronic respiratory condition characterized by inflammation and narrowing of the airways, which can lead to symptoms like wheezing, coughing, chest tightness, and difficulty breathing. Air pollutants that can irritate and

inflame an asthmatic's airways include fine particulate matter (PM2.5), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2). This inflammation can make asthma symptoms more severe and harder to control [14,15,16,17,18,19,20].

Prolonged exposure to air pollution can lead to decreased lung function, which is particularly problematic for people with asthma, as they already have compromised airways. Reduced lung function can result in increased breathlessness and a decreased ability to expel mucus and other irritants from the airways [14, 15, 16, 17, 18, 19, 20].

Air pollution can trigger asthma attacks or make them more frequent and severe. These attacks can be life-threatening in some cases, especially if not promptly treated [14, 15, 16, 17, 18, 19, 20].

Air pollution can reduce the effectiveness of asthma medications, making it more challenging to control asthma symptoms. People may need higher doses of medications or more frequent use of rescue inhalers when exposed to polluted air [14, 15, 16, 17, 18, 19, 20].

Long-term exposure to air pollution has been linked to the development and progression of asthma in children and adults. It can also lead to the development of other respiratory conditions, such as chronic obstructive pulmonary disease (COPD) [14,15,16,17,18,19,20].

Poor air quality, especially during periods of high pollution levels, can lead to an increase in hospital admissions for asthma-related issues. This places a significant burden on healthcare systems and can be emotionally distressing for individuals and their families [14,15,16,17,18,19,20].

Chronic obstructive pulmonary disease (COPD)

Air pollution can have serious and detrimental effects on individuals with Chronic Obstructive Pulmonary Disease (COPD), a chronic lung condition that includes conditions like chronic bronchitis and emphysema. COPD is characterized by the obstruction of airflow in and out of the lungs, making it difficult to breathe. Air pollutants, especially fine particulate matter (PM2.5), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2), can irritate and inflame the airways and lung tissues. This can lead to increased coughing, mucus production, shortness of breath, and wheezing in individuals with COPD [21,22,23,24,25].

Exposure to air pollution can trigger exacerbations or acute worsening of COPD symptoms. These exacerbations often result in increased breathlessness and coughing, more severe mucus production, and a higher risk of respiratory infections, which can be life-threatening for COPD patients [21,22,23,24,25].

Long-term exposure to air pollution can further reduce lung function in individuals with COPD, making it even harder for them to breathe. This decreased lung function can contribute to a decline in overall health and quality of life [21,22,23,24,25].

Poor air quality can lead to an increase in hospital admissions for COPD-related issues, such as exacerbations and respiratory infections. This places a significant burden on healthcare systems and can be emotionally distressing for individuals and their families [21,22,23,24,25].

Air pollution can reduce the effectiveness of medications used to manage COPD symptoms. This may require COPD patients to use higher doses of medications or to rely more on rescue medications when exposed to polluted air [21,22,23,24,25].

Many individuals with COPD have other health conditions, such as cardiovascular diseases, diabetes, or hypertension. Air pollution can exacerbate these coexisting conditions, leading to a cascade of health problems and complications [21,22,23,24,25].

Hampers lung function development in children and perpetuates lung function decline in adults

Beyond these conditions, air pollution hampers lung function development in children and perpetuates lung function decline in adults, setting the stage for an array of respiratory ailments [20,26,27,28].

Air pollution can have significant and lasting effects on lung function in both children and adults. Here's how it can hamper lung function development in children and perpetuate lung function decline in adults [20,26,27,28].

Long-term exposure to air pollution, particularly fine particulate matter (PM2.5) and pollutants like nitrogen dioxide (NO2) and ozone (O3), can lead to stunted lung growth in children, which means that their lungs may not reach their full potential size and capacity, limiting their ability to breathe efficiently. Air pollutants can impair lung function in children by causing inflammation and damage to lung tissues, resulting in decreased lung function, making it harder for children to breathe and engage in physical activities. Air pollution can weaken the immune system and increase children's susceptibility to respiratory infections, which can further damage lung tissue and hinder lung development [20,26].

Long-term exposure to air pollution can accelerate the aging of the lungs in adults, leading to a natural decline in lung function occurring at a faster rate than in individuals with cleaner air exposure. Air pollution is a major risk factor for the development and exacerbation of chronic respiratory conditions in adults, including asthma and Chronic Obstructive Pulmonary Disease (COPD), which often result in a progressive decline in lung function. Prolonged exposure to high levels of air pollution has been linked to premature death, primarily due to respiratory and cardiovascular diseases. This further underscores the long-term consequences of air pollution on lung health. Individuals with compromised lung function due to air pollution may experience reduced quality of life, as they may be more limited in their physical activities and daily functioning. The healthcare costs associated with treating respiratory and cardiovascular diseases related to air pollution are substantial, placing an economic burden on both individuals and healthcare systems [27,28].

Respiratory infections

Encompassing bronchitis, pneumonia, and other upper respiratory tract infections, find fertile ground in air-polluted environments due to compromised immune responses in the respiratory tract [29,30,31,32,33].

Air pollution can have a significant impact on respiratory infections, both in terms of increasing the risk of respiratory infections and exacerbating the severity of existing infections [29,30,31,32,33].

The immune system's capacity to fend off infections can be weakened by prolonged exposure to air pollutants such as sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), and fine particulate matter (PM2.5).This weakened immunity makes individuals more susceptible to respiratory infections caused by viruses and bacteria. Air pollutants can irritate and inflame the respiratory tract, making it easier for pathogens like viruses and bacteria to enter and infect the lungs. This can lead to a higher likelihood of developing respiratory infections. Some research suggests that air pollution can enhance the transmission of respiratory viruses, like the flu and the common cold, by promoting the survival and stability of viral particles in the air. This can increase the chances of infection in susceptible individuals [29,30,31,32,33].

Exacerbation of Respiratory diseases: People suffering from diseases such as the flu, pneumonia, or bronchitis may have increased coughing, mucus production, chest discomfort, and dyspnea as a result of exposure to air pollution. Respiratory infections can become more severe when individuals are exposed to high levels of air pollution, resulting in more frequent hospitalizations and complications, especially in vulnerable populations like children, the elderly, and individuals with preexisting respiratory conditions. Air pollution can slow down the recovery process from respiratory infections by hindering the body's

ability to repair damaged lung tissues and clear mucus and pathogens from the airways. Studies have shown that individuals with respiratory infections who are exposed to high levels of air pollution may face a higher risk of mortality, particularly if they have underlying health conditions [29, 30, 31, 32, 33].

Lung cancer

Moreover, the link between air pollution and lung cancer underscores the gravity of long-term exposure to certain pollutants.

Air pollution is a significant environmental risk factor for the development and progression of lung cancer. Exposure to various air pollutants has been linked to an increased risk of lung cancer in both smokers and non-smokers. Air pollution contains fine particulate matter (PM2.5) and other airborne particles that can carry carcinogenic compounds, including heavy metals, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs). These substances can penetrate deep into the respiratory tract and potentially lead to genetic mutations in lung cells, contributing to the initiation of cancer. Air pollution also contains various chemical pollutants, such as benzene, formaldehyde, and acetaldehyde, which are known or suspected carcinogens. Prolonged exposure to these substances can increase the risk of developing lung cancer [34,35,36,37,38].

Air pollution, particularly fine particulate matter and ozone, can induce inflammation in the respiratory system. Chronic inflammation may promote cell damage and mutations, which can increase the risk of lung cancer. Air pollutants can also lead to oxidative stress, where there is an imbalance between free radicals and antioxidants in the body. This oxidative stress can damage DNA and cellular structures, potentially contributing to the development of cancerous cells [34,35,36,37,38].

Prolonged exposure to air pollution, especially in heavily polluted areas, can suppress the immune system's ability to detect and eliminate cancerous cells. This weakened immune response may allow cancer cells to proliferate and evade destruction [34,35,36,37,38].

Air pollution can promote tumor growth and progression by creating a favorable environment for cancer cells to thrive. It has been linked to the promotion of angiogenesis, the formation of new blood vessels to supply tumors with nutrients and oxygen. This can facilitate the growth and spread of lung cancer. Some research suggests that air pollution may enhance the ability of cancer cells to metastasize or spread to other parts of the body, making lung cancer more aggressive [34,35,36,37,38].

Air pollution can have a carcinogenic effect on people, especially children and those with previous respiratory disorders. Pollution exposure throughout childhood can raise the chance of developing lung cancer later in life [34,35,36,37,38].

Smoking and exposure to air pollution have a synergistic effect on lung cancer risk. Smokers who live in areas with high levels of air pollution face a significantly higher risk of developing lung cancer than those in cleaner air environments [34,35,36,37,38].

Allergies and sensitization to allergens

Additionally, allergies and sensitization to allergens are exacerbated by air pollution, fueling the prevalence of allergic respiratory diseases like allergic rhinitis [39, 40, 41, 42, 43].

Air pollution can significantly affect allergies and the sensitization to allergens in several ways. Air pollution, especially in urban areas, can lead to higher levels of airborne allergens, such as pollen and mold spores. This can increase the exposure of individuals to allergens, which is particularly problematic for people with allergies [39, 40, 41, 42, 43].

Some studies suggest that air pollutants, such as diesel exhaust particles and ozone, can interact with allergens and make them more potent or allergenic. This means that even a small amount of allergen exposure can trigger a stronger allergic reaction in individuals who are sensitized to these allergens [39, 40, 41, 42, 43].

Prolonged exposure to air pollution can weaken the immune system, making individuals more susceptible to allergic reactions. Air pollutants can disrupt the balance of immune

cells, reducing the body's ability to regulate immune responses effectively [39, 40, 41, 42, 43].

Air pollution may also contribute to the sensitization of individuals to allergens. Long-term exposure to pollutants can lead to chronic inflammation in the airways and respiratory system. This inflammation can make individuals more susceptible to developing allergies or becoming sensitized to allergens they were previously not allergic to [39, 40, 41, 42, 43].

For people who are already allergic, air pollution can exacerbate their allergic symptoms. Pollutants can irritate the respiratory tract, leading to symptoms like coughing, sneezing, and wheezing, which can be especially problematic for individuals with asthma or allergic rhinitis [39, 40, 41, 42, 43].

Air pollution is a known trigger for asthma exacerbations. Individuals with asthma may experience more frequent and severe attacks when exposed to high levels of air pollutants. Additionally, pollutants can worsen the inflammation and bronchoconstriction associated with asthma [39, 40, 41, 42, 43].

Prolonged exposure to air pollution, especially in childhood, has been linked to the development of allergic diseases and conditions, such as allergic rhinitis, asthma, and eczema. It can also lead to a more severe course of these conditions over time [39, 40, 41, 42, 43].

Climate change, driven in part by air pollution, can affect the distribution and abundance of allergenic plants and species. This can expose individuals to new allergens and extend the duration of allergen seasons, leading to increased sensitization and allergy symptoms [39, 40, 41, 42, 43].

In summary, air pollution can have a profound impact on allergies and the sensitization to allergens by increasing allergen exposure, enhancing allergen potency, weakening the immune response, and exacerbating existing allergic conditions. Efforts to reduce air pollution and improve air quality can help mitigate these adverse effects on allergic individuals and promote better respiratory health [39, 40, 41, 42, 43].

Vulnerable Populations

The disparate impact of air pollution on vulnerable populations amplifies the urgency of addressing this pervasive issue. Vulnerability to air pollution can affect various groups across different life stages. Here's a summarized overview of key vulnerable groups.

Prenatal Age (Unborn Babies and Pregnant Women). Risk of adverse outcomes such as preterm birth and developmental issues. Protective measures needed to ensure the well-being of both the mother and the developing fetus. **Children**, still undergoing lung development, are particularly susceptible to long-term lung damage caused by air pollution, respiratory problems, and asthma. Long-term impacts on health, necessitating measures like clean air initiatives and targeted healthcare. **The elderly**, often burdened with preexisting health conditions, confront exacerbated symptoms and heightened mortality risks when exposed to poor air quality. Individuals with preexisting respiratory conditions face escalated risks of exacerbations and disease progression, further eroding their quality of life [44, 45, 46, 47, 48, 49, 50, 51]. **Individuals with Pre-existing Health Conditions**. This group is vulnerable against exacerbation of respiratory or cardiovascular diseases. It requires increased vulnerability, emphasizing the importance of managing existing health conditions and reducing exposure to pollution. **Low Socioeconomic Groups**. Vulnerability: Higher exposure due to residence in areas with poor air quality, limited resources for protective measures. Importance: Addressing environmental justice concerns, ensuring equitable access to clean air, and minimizing health disparities. **Occupational Groups, Outdoor Workers, and Athletes**. Vulnerability: Higher exposure due to the nature of their work or outdoor activities. Importance: Occupational health measures, awareness, and protective equipment may be necessary. **Communities Near Pollution Sources**. Vulnerability: Proximity to industrial zones, highways, or other sources leads to increased exposure. Importance: Addressing localized pollution sources, implementing regulations, and community engagement are crucial. **Immune-compromised Individuals**. Weakened immune systems may increase susceptibility to health impacts. Extra precautions and healthcare support are essential

for individuals with compromised immunity. **Genetic Susceptibility**. Genetic factors contribute to individual variability in response to pollutants. Understanding gene-environment interactions for tailored interventions and personalized healthcare.

Addressing vulnerability across life stages requires a holistic approach, including policy interventions, community engagement, healthcare access, and awareness programs. Protecting vulnerable groups is essential for promoting environmental justice and ensuring the well-being of diverse populations.

Mechanisms of Impact

Elucidating the mechanisms through which air pollution wreaks havoc on respiratory health is pivotal for comprehensive understanding. Oxidative stress, arising from an imbalance between reactive oxygen species and antioxidant defenses, serves as a central player in initiating cellular damage and inflammation. Inflammation, a fundamental response to irritants and foreign invaders, becomes dysregulated in the presence of sustained exposure to pollutants, thereby contributing to respiratory symptoms and disease progression. Tissue damage, resulting from a cascade of oxidative stress and inflammation, impairs lung function and elevates susceptibility to infections and diseases [8,52,53].

Mitigation Strategies

Ameliorating the adverse impact of air pollution on respiratory health necessitates multifaceted strategies. Stringent air quality standards, enforced through regulatory mechanisms, serve as the foundation for cleaner air. Concurrently, reducing emissions from industrial sources and transportation systems curtails the influx of pollutants into the atmosphere. The promotion of cleaner energy sources, such as renewable energy, is pivotal in decreasing the generation of pollutants. Equally important is the role of public awareness campaigns, enlightening individuals about the risks of air pollution and fostering behaviors that minimize exposure [9,54,55,56].

CONCLUSION

The extensive body of research outlined in this review unequivocally substantiates the profound influence of air pollution on respiratory health. The intricate interplay of pollutants like particulate matter, ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide with the respiratory system manifests in a range of maladies, from aggravated asthma to escalated lung cancer risk. Vulnerable populations bear the brunt of these detrimental effects, emphasizing the need for targeted interventions. The mechanisms underlying these effects—oxidative stress, inflammation, and tissue damage—illuminate the complexity of the interactions between pollutants and respiratory health. As societies grapple with the imperatives of cleaner air and improved public health, the adoption of stringent air quality standards, emission reduction strategies, and informed public engagement emerges as the path forward in mitigating the adverse consequences of air pollution on respiratory well-being. Given the continuous evolution of research in this field, staying abreast of new findings is imperative for refining our understanding and crafting effective interventions.

CONFLICT OF INTEREST

There is no conflict of interest associated with this publication. I want to clarify that for this literature review, there is no specific affiliation for research funding. The review was conducted independently without any external affiliations influencing the content. While I don't have specific funding sources to disclose, I want to assure the readers that the review was carried out with the utmost impartiality and dedication to presenting an unbiased analysis of the available literature on the topic.

ACKNOWLEDGEMENT

Thank you to Faculty of Medicine, Universitas Trisakti for the support.

The Effects of Air Pollution on Respiratory Problems

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Poltekita : Jurnal Ilmu Kesehatan (e-ISSN: 2527-7170, p-ISSN: 1907-459X)

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The Effects Of Air Pollution On Respiratory Problems

ABSTRACT

This literature review delves into the extensive body of research investigating the intricate relationship between air pollution and its profound effects on respiratory health. Focusing on pollutants including particulate matter (PM), ozone (O3), nitrogen dioxide (NO2), sulfur dioxide (SO2), and carbon monoxide (CO), this review synthesizes the established connections between these pollutants and a range of respiratory problems. **Extensive evidence showcases how exposure to elevated pollutant levels escalates the risk of respiratory maladies, encompassing aggravated asthma, exacerbated chronic obstructive pulmonary disease (COPD) symptoms, compromised lung function, heightened susceptibility to respiratory infections, elevated lung cancer risk, and potentiated allergic responses.** This review also underscores the heightened vulnerability of certain demographics, such as children, the elderly, and individuals with preexisting respiratory conditions, to these detrimental effects. The underlying mechanisms orchestrating the impact of air pollution on respiratory health involve intricate interplays of oxidative stress, inflammation, and tissue damage within the respiratory system.

Notably, the implementation of stringent air quality standards, the reduction of emissions from industrial and transportation sources, and strategic public awareness campaigns stand out as pivotal strategies for mitigating the adverse impact of air pollution on respiratory health. While this review encapsulates findings available up **until September 2021**, the dynamic nature of ongoing research serves as a reminder of the continuous evolution of knowledge in this domain.

Keywords: Air pollution, allergies, COPD, lung cancer, respiratory infections.

INTRODUCTION

The intersection of air quality and human health has long been a subject of scientific inquiry. Among the manifold health ramifications of air pollution, the intricate ties between air quality and respiratory problems stand as a paramount concern. Extensive research has underscored the multifaceted impacts of air pollutants on the respiratory system, ranging from minor irritations to severe and chronic conditions. This review aims to distill the wealth of knowledge surrounding the effects of air pollution on respiratory health, focusing on the established links between various pollutants and a spectrum of respiratory maladies [1, 2, 3, 4, 5].

Numerous studies have established a clear link between air pollution and various respiratory problems. The pollutants of concern include particulate matter (PM), ozone (O3), nitrogen dioxide (NO2), sulfur dioxide (SO2), and carbon monoxide (CO). These pollutants originate from sources such as vehicle emissions, industrial processes, and natural sources [1, 2, 3, 4, 5].

METHODS

A comprehensive search of peer-reviewed literature was conducted using databases such as PubMed, Web of Science, and Google Scholar. Articles published between 2015 and 2023 were included, with a focus on epidemiological studies, experimental research, and reviews that explored the impact of air pollution on respiratory problems.

REVIEW

Air Pollutants

Human activities have an adverse effect on the environment by polluting water, air, and soil in which plants grow. Although the industrial revolution was a great success in terms of technology, society, and the provision of multiple services, it also introduced the production of huge quantities of pollutants emitted into the air that are harmful to human health. Without any doubt, the global environmental pollution is considered an international public health issue with multiple facets [(1)].

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution [(2,3)].

Outdoor air pollutants are either derived from human activities, such as industrial emissions, road traffic, residential heating, shipping, air traffic, construction, agricultural activities, war and fire accidents, or from natural hazards, such as earthquake, tsunami, volcanic eruption, spontaneous forest fires, and extreme temperature. **Indoor air pollutants** are generally released from smoking, building materials, air conditioning, house cleaning or air refreshing products, heating, lighting, and wood, fuel, or coal usage in cooking [(4)].

Pollutants of major public health concern include particulate matter, ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide are prominent constituents of the complex mixture of air pollutants [(2)]. Each of these pollutants has distinct properties, sources, and mechanisms of impact on the respiratory system. Particulate matter, categorized by size, infiltrates deep into lung tissues, while ozone and nitrogen dioxide irritate airways and instigate inflammatory responses. Sulfur dioxide and carbon monoxide, originating from industrial processes and vehicle emissions, respectively, also exert significant effects on respiratory health. These pollutants collectively impose a substantial burden on public health by contributing to a range of respiratory problems [(1,2,3,4,5)].

Air Pollution and Protective Mechanism of Respiratory System

Air pollution poses a significant global health threat, resulting in millions of annual human deaths. An increasingly critical concern in human health is the delayed onset of respiratory diseases in both children and adults, which can be attributed to prenatal or perinatal exposure to air pollutants. Pregnancy and fetal development stages are particularly vulnerable to environmental exposure, with potential long-term consequences for individuals in later life [(3,4)].

Air pollution diminishes both quality of life and life expectancy, exacerbating acute and chronic respiratory symptoms in individuals with preexisting airway conditions. Additionally, it raises the morbidity rates and heightens the risk of hospitalization for those affected by respiratory diseases [3,4].

While the bronchopulmonary tract possesses various protective mechanisms, such as mucosal cilia and the air-blood barrier, the ability of air pollutants to accumulate in or pass through lung tissues depends on their size and chemical composition (4). Vapor from air pollutants can be absorbed by human tissues or dissolved in body fluids, primarily influenced by their hydrophilicity and hydrophobicity. Particulate matter with a size of PM10 (~10 μm) can reach the proximal airways and is largely eliminated through mucociliary clearance. PM2.5, a significant health risk factor, can penetrate deeper into the lungs, while ultrafine particles can translocate through the bloodstream to distant organs and tissues, such as the liver for detoxification and placental tissues during pregnancy. The detrimental health effects of air pollutants have been demonstrated in relation to various respiratory diseases, including respiratory infections, asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. Furthermore, these pollutants have been linked to an increased risk of stroke and heart diseases when considered in combination, as reviewed [4].

Mucociliary epithelium lining the upper and lower respiratory tract constitutes the first line of defense of the airway and lungs against inhaled pollutants and pathogens. Mucosal cilia are hair-like structures that line the respiratory tract, including the bronchopulmonary tract, from the nasal passages down to the smaller airways in the lungs. These cilia are specialized projections that extend from the surface of epithelial cells, which are the cells that form the lining of the airways. The coordinated movement of these cilia serves several important functions, including acting as a protective mechanism against various particles and microorganisms, including air pollutants [5,6,7].

One crucial role of mucosal cilia is in the clearance of mucus. The respiratory tract is coated with a layer of mucus that functions as a trap for inhaled particles, dust, pathogens, and airborne contaminants, including air pollutants. This mucus contains substances that can immobilize these particles. The coordinated beating of mucosal cilia generates a sweeping motion, propelling the mucus layer upward from the deeper airways toward the throat, a process known as the mucociliary escalator. As the mucus moves along, it carries trapped particles and pollutants, effectively removing these foreign substances from the sensitive airway tissues and directing them toward the throat. The mucus, along with the trapped particles, can then be either swallowed and directed to the stomach (where stomach acid neutralizes pathogens) or expelled through coughing and clearing the throat [5,6,7].

Moreover, mucosal cilia also play a pivotal role in preventing the entry of particles and pollutants into the deeper and more sensitive areas of the respiratory system, such as the alveoli where gas exchange takes place. The continuous action of these cilia helps keep contaminants trapped in the mucus layer, continuously moving them upward, thus reducing the risk of these substances causing damage or inflammation deeper within the lungs [5,6,7].

Additionally, mucosal cilia contribute to defending against respiratory infections. When harmful microorganisms like bacteria and viruses enter the respiratory tract, the cilia work in concert with

the mucus to move them toward the throat, where they can be expelled or swallowed. This action limits the opportunity for these pathogens to establish infections within the lungs [5,6,7].

However, prolonged exposure to high levels of air pollutants, especially fine particulate matter (PM2.5) and toxic gases, can lead to impairment of mucosal cilia function. The pollutants can interfere with the cilia's movement, disrupting their ability to effectively clear mucus and particles. This impairment can result in a buildup of pollutants and particles in the airways, making individuals more susceptible to respiratory infections, exacerbating pre-existing respiratory conditions, and increasing overall respiratory discomfort [8].

To support the function of mucosal cilia and their protective role against air pollutants, it's important to maintain good respiratory health. This includes avoiding prolonged exposure to polluted air, staying hydrated, practicing good hygiene, and adopting a healthy lifestyle that includes a balanced diet and regular physical activity [5,6,7,9,13].

The air-blood barrier, also known as the respiratory membrane or alveolar-capillary membrane, is a crucial anatomical structure within the bronchopulmonary tract that facilitates the exchange of gases (oxygen and carbon dioxide) between the air in the lungs and the bloodstream. This barrier is primarily located in the alveoli, which are the tiny air sacs within the lungs where gas exchange occurs [10,11].

This barrier facilitates the exchange of gases, such as oxygen and carbon dioxide, between the air in the lungs and the bloodstream. It consists of several layers, including Type I Alveolar Cells, which are thin, flat cells forming the alveolar walls, allowing efficient gas diffusion between the air and the bloodstream. Similarly, Endothelial Cells, which line the walls of the capillaries surrounding the alveoli, are thin to facilitate gas exchange. Between these cell types lies the Basement Membrane, a thin layer of connective tissue providing structural support and cell anchoring [10,11].

The role of the air-blood barrier as a protective mechanism against air pollutants is related to its selective permeability. The barrier is designed to allow efficient diffusion of oxygen from the alveolar air into the bloodstream and the simultaneous removal of carbon dioxide from the bloodstream into the alveoli. However, this barrier is not equally permeable to all substances [10,11].

Air pollutants, such as fine particulate matter (PM2.5) and certain gases, can be harmful to human health because they can penetrate the air-blood barrier [8,9,10]. The air-blood barrier is a protective layer that separates the air in the lungs from the blood vessels. It is made up of a fine structure that prevents larger particles, like dust and most pathogens, from entering the bloodstream and causing systemic effects [3,8,11,12].
The respiratory system is equipped with immune cells that patrol the alveoli and lung tissues. These cells can engulf and neutralize particles that manage to breach the air-blood barrier, helping to minimize their impact [3,8,12,13]. If pollutants do manage to cause damage to the air-blood barrier, the body’s immune response is triggered, leading to inflammation. This inflammation helps recruit immune cells to the site of damage, clear away debris, and initiate repair processes to restore the integrity of the barrier [3,8,12,13].

However, chronic exposure to high levels of pollutants can lead to persistent inflammation and damage to the air-blood barrier, compromising its function. This can result in the direct entry of pollutants into the bloodstream, potentially causing systemic health issues and affecting other organs [12,13].

To protect the air-blood barrier from the harmful effects of pollutants, it's essential to maintain good air quality, reduce exposure to pollutants, and support overall lung health through a healthy lifestyle and proper respiratory care [9,13].

Effects on Specific Respiratory Conditions

A cornerstone of the research in this domain is the exploration of how air pollution affects specific respiratory conditions.

Asthma

Air pollution can have significant negative effects on individuals with asthma. Asthma is a chronic respiratory condition characterized by inflammation and narrowing of the airways, which can lead to symptoms like wheezing, coughing, chest tightness, and difficulty breathing. Air pollutants, such as fine particulate matter (PM2.5), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2), can irritate and inflame the airways of individuals with asthma. This inflammation can make asthma symptoms more severe and harder to control [14,15,16,17,18,19,20].

Prolonged exposure to air pollution can lead to decreased lung function, which is particularly problematic for people with asthma, as they already have compromised airways. Reduced lung function can result in increased breathlessness and a decreased ability to expel mucus and other irritants from the airways [14, 15, 16, 17, 18, 19, 20].

Air pollution can trigger asthma attacks or make them more frequent and severe. These attacks can be life-threatening in some cases, especially if not promptly treated [14, 15, 16, 17, 18, 19, 20].

Air pollution can reduce the effectiveness of asthma medications, making it more challenging to control asthma symptoms. People may need higher doses of medications or more frequent use of rescue inhalers when exposed to polluted air [14, 15, 16, 17, 18, 19, 20].

Long-term exposure to air pollution has been linked to the development and progression of asthma in children and adults. It can also lead to the development of other respiratory conditions, such as chronic obstructive pulmonary disease (COPD) [14,15,16,17,18,19,20].

Poor air quality, especially during periods of high pollution levels, can lead to an increase in hospital admissions for asthma-related issues. This places a significant burden on healthcare systems and can be emotionally distressing for individuals and their families [14,15,16,17,18,19,20].

Chronic obstructive pulmonary disease (COPD)

Air pollution can have serious and detrimental effects on individuals with Chronic Obstructive Pulmonary Disease (COPD), a chronic lung condition that includes conditions like chronic bronchitis and emphysema. COPD is characterized by the obstruction of airflow in and out of the lungs, making it difficult to breathe. Air pollutants, especially fine particulate matter (PM2.5), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2), can irritate and inflame the airways and lung tissues. This can lead to increased coughing, mucus production, shortness of breath, and wheezing in individuals with COPD [21,22,23,24,25].

Exposure to air pollution can trigger exacerbations or acute worsening of COPD symptoms. These exacerbations often result in increased breathlessness and coughing, more severe mucus production, and a higher risk of respiratory infections, which can be life-threatening for COPD patients [21,22,23,24,25].

Long-term exposure to air pollution can further reduce lung function in individuals with COPD, making it even harder for them to breathe. This decreased lung function can contribute to a decline in overall health and quality of life [21,22,23,24,25].

Poor air quality can lead to an increase in hospital admissions for COPD-related issues, such as exacerbations and respiratory infections. This places a significant burden on healthcare systems and can be emotionally distressing for individuals and their families [21,22,23,24,25].

Air pollution can reduce the effectiveness of medications used to manage COPD symptoms. This may require COPD patients to use higher doses of medications or to rely more on rescue medications when exposed to polluted air [21,22,23,24,25].

Many individuals with COPD have other health conditions, such as cardiovascular diseases, diabetes, or hypertension. Air pollution can exacerbate these coexisting conditions, leading to a cascade of health problems and complications **[21,22,23,24,25]**.

Hampers lung function development in children and perpetuates lung function decline in adults

Beyond these conditions, air pollution hampers lung function development in children and perpetuates lung function decline in adults, setting the stage for an array of respiratory ailments [20,26,27,28].

Air pollution can have significant and lasting effects on lung function in both children and adults. Here's how it can hamper lung function development in children and perpetuate lung function decline in adults [20,26,27,28].

Long-term exposure to air pollution, particularly fine particulate matter (PM2.5) and pollutants like nitrogen dioxide (NO2) and ozone (O3), can lead to stunted lung growth in children, which means that their lungs may not reach their full potential size and capacity, limiting their ability to breathe efficiently. Air pollutants can impair lung function in children by causing inflammation and damage to lung tissues, resulting in decreased lung function, making it harder for children to breathe and engage in physical activities. Air pollution can weaken the immune system and increase children's susceptibility to respiratory infections, which can further damage lung tissue and hinder lung development [20,26].

Long-term exposure to air pollution can accelerate the aging of the lungs in adults, leading to a natural decline in lung function occurring at a faster rate than in individuals with cleaner air exposure. Air pollution is a major risk factor for the development and exacerbation of chronic respiratory conditions in adults, including asthma and Chronic Obstructive Pulmonary Disease (COPD), which often result in a progressive decline in lung function. Prolonged exposure to high levels of air pollution has been linked to premature death, primarily due to respiratory and cardiovascular diseases. This further underscores the long-term consequences of air pollution on lung health. Individuals with compromised lung function due to air pollution may experience reduced quality of life, as they may be more limited in their physical activities and daily functioning. The healthcare costs associated with treating respiratory and cardiovascular diseases related to air pollution are substantial, placing an economic burden on both individuals and healthcare systems [27,28].

Respiratory infections

Encompassing bronchitis, pneumonia, and other upper respiratory tract infections, find fertile ground in air-polluted environments due to compromised immune responses in the respiratory tract [29, 30, 31, 32, 33].

Air pollution can have a significant impact on respiratory infections, both in terms of increasing the risk of respiratory infections and exacerbating the severity of existing infections [29, 30, 31, 32, 33].

Prolonged exposure to air pollutants, such as fine particulate matter (PM2.5), ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2), can weaken the immune system's ability to fight off infections. This weakened immunity makes individuals more susceptible to respiratory infections caused by viruses and bacteria. Air pollutants can irritate and inflame the respiratory tract, making it easier for pathogens like viruses and bacteria to enter and infect the lungs. This can lead to a higher likelihood of developing respiratory infections. Some research suggests that air pollution can enhance the transmission of respiratory viruses, like the flu and the common cold, by promoting the survival and stability of viral particles in the air. This can increase the chances of infection in susceptible individuals [29, 30, 31, 32, 33].

Exacerbation of Respiratory Infections: Exposure to air pollution can worsen the symptoms of respiratory infections, leading to increased coughing, mucus production, chest discomfort, and breathlessness in individuals with infections like the flu, pneumonia, or bronchitis. Respiratory

infections can become more severe when individuals are exposed to high levels of air pollution, resulting in more frequent hospitalizations and complications, especially in vulnerable populations like children, the elderly, and individuals with preexisting respiratory conditions. Air pollution can slow down the recovery process from respiratory infections by hindering the body's ability to repair damaged lung tissues and clear mucus and pathogens from the airways. Studies have shown that individuals with respiratory infections who are exposed to high levels of air pollution may face a higher risk of mortality, particularly if they have underlying health conditions [29, 30, 31, 32, 33].

Lung cancer

Moreover, the link between air pollution and lung cancer underscores the gravity of long-term exposure to certain pollutants.

Air pollution is a significant environmental risk factor for the development and progression of lung cancer. Exposure to various air pollutants has been linked to an increased risk of lung cancer in both smokers and non-smokers. Air pollution contains fine particulate matter (PM2.5) and other airborne particles that can carry carcinogenic compounds, including heavy metals, polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs). These substances can penetrate deep into the respiratory tract and potentially lead to genetic mutations in lung cells, contributing to the initiation of cancer. Air pollution also contains various chemical pollutants, such as benzene, formaldehyde, and acetaldehyde, which are known or suspected carcinogens. Prolonged exposure to these substances can increase the risk of developing lung cancer [34,35,36,37,38].

Air pollution, particularly fine particulate matter and ozone, can induce inflammation in the respiratory system. Chronic inflammation may promote cell damage and mutations, which can increase the risk of lung cancer. Air pollutants can also lead to oxidative stress, where there is an imbalance between free radicals and antioxidants in the body. This oxidative stress can damage DNA and cellular structures, potentially contributing to the development of cancerous cells [34,35,36,37,38].

Prolonged exposure to air pollutants, especially in heavily polluted areas, can suppress the immune system's ability to detect and eliminate cancerous cells. This weakened immune response may allow cancer cells to proliferate and evade destruction [34,35,36,37,38].

Air pollution can promote tumor growth and progression by creating a favorable environment for cancer cells to thrive. It has been linked to the promotion of angiogenesis, the formation of new blood vessels to supply tumors with nutrients and oxygen. This can facilitate the growth and spread of lung cancer. Some research suggests that air pollution may enhance the ability of cancer cells to metastasize or spread to other parts of the body, making lung cancer more aggressive [34,35,36,37,38].

Children and individuals with preexisting respiratory conditions may be especially vulnerable to the carcinogenic effects of air pollution. Childhood exposure to pollutants can increase the risk of lung cancer later in life [34,35,36,37,38].

Smoking and exposure to air pollution have a synergistic effect on lung cancer risk. Smokers who live in areas with high levels of air pollution face a significantly higher risk of developing lung cancer than those in cleaner air environments [34,35,36,37,38].

Allergies and sensitization to allergens

Additionally, allergies and sensitization to allergens are exacerbated by air pollution, fueling the prevalence of allergic respiratory diseases like allergic rhinitis [39, 40, 41, 42, 43].

Air pollution can significantly affect allergies and the sensitization to allergens in several ways. Air pollution, especially in urban areas, can lead to higher levels of airborne allergens, such as pollen and mold spores. This can increase the exposure of individuals to allergens, which is particularly problematic for people with allergies [39, 40, 41, 42, 43].

Some studies suggest that air pollutants, such as diesel exhaust particles and ozone, can interact with allergens and make them more potent or allergenic. This means that even a small amount of allergen exposure can trigger a stronger allergic reaction in individuals who are sensitized to these allergens [39, 40, 41, 42, 43].

Prolonged exposure to air pollution can weaken the immune system, making individuals more susceptible to allergic reactions. Air pollutants can disrupt the balance of immune cells, reducing the body's ability to regulate immune responses effectively [39, 40, 41, 42, 43].

Air pollution may also contribute to the sensitization of individuals to allergens. Long-term exposure to pollutants can lead to chronic inflammation in the airways and respiratory system. This inflammation can make individuals more susceptible to developing allergies or becoming sensitized to allergens they were previously not allergic to [39, 40, 41, 42, 43].

For people who are already allergic, air pollution can exacerbate their allergic symptoms. Pollutants can irritate the respiratory tract, leading to symptoms like coughing, sneezing, and wheezing, which can be especially problematic for individuals with asthma or allergic rhinitis [39, 40, 41, 42, 43].

Air pollution is a known trigger for asthma exacerbations. Individuals with asthma may experience more frequent and severe attacks when exposed to high levels of air pollutants. Additionally, pollutants can worsen the inflammation and bronchoconstriction associated with asthma [39, 40, 41, 42, 43].

Prolonged exposure to air pollution, especially in childhood, has been linked to the development of allergic diseases and conditions, such as allergic rhinitis, asthma, and eczema. It can also lead to a more severe course of these conditions over time [39, 40, 41, 42, 43].

Climate change, driven in part by air pollution, can affect the distribution and abundance of allergenic plants and species. This can expose individuals to new allergens and extend the duration of allergen seasons, leading to increased sensitization and allergy symptoms [39, 40, 41, 42, 43].

In summary, air pollution can have a profound impact on allergies and the sensitization to allergens by increasing allergen exposure, enhancing allergen potency, weakening the immune response, and exacerbating existing allergic conditions. Efforts to reduce air pollution and improve air quality can help mitigate these adverse effects on allergic individuals and promote better respiratory health [39, 40, 41, 42, 43].

Vulnerable Populations

The disparate impact of air pollution on vulnerable populations amplifies the urgency of addressing this pervasive issue. Children, still undergoing lung development, are particularly susceptible to long-term lung damage caused by air pollution. The elderly, often burdened with preexisting health conditions, confront exacerbated symptoms and heightened mortality risks when exposed to poor air quality. Individuals with preexisting respiratory conditions face escalated risks of exacerbations and disease progression, further eroding their quality of life [44, 45, 46, 47, 48, 49, 50, 51].

Mechanisms of Impact

Elucidating the mechanisms through which air pollution wreaks havoc on respiratory health is pivotal for comprehensive understanding. Oxidative stress, arising from an imbalance between reactive oxygen species and antioxidant defenses, serves as a central player in initiating cellular damage and inflammation. Inflammation, a fundamental response to irritants and foreign invaders, becomes dysregulated in the presence of sustained exposure to pollutants, thereby contributing to respiratory symptoms and disease progression. Tissue damage, resulting from a cascade of oxidative stress and inflammation, impairs lung function and elevates susceptibility to infections and diseases [8, 52, 53]..

Mitigation Strategies

Ameliorating the adverse impact of air pollution on respiratory health necessitates multifaceted strategies. Stringent air quality standards, enforced through regulatory mechanisms, serve as the foundation for cleaner air. Concurrently, reducing emissions from industrial sources and transportation systems curtails the influx of pollutants into the atmosphere. The promotion of cleaner energy sources, such as renewable energy, is pivotal in decreasing the generation of pollutants. Equally important is the role of public awareness campaigns, enlightening individuals about the risks of air pollution and fostering behaviors that minimize exposure [9, 54, 55, 56].

CONCLUSION

The extensive body of research outlined in this review unequivocally substantiates the profound influence of air pollution on respiratory health. The intricate interplay of pollutants like particulate matter, ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide with the respiratory system manifests in a range of maladies, from aggravated asthma to escalated lung cancer risk. Vulnerable populations bear the brunt of these detrimental effects, emphasizing the need for targeted interventions. The mechanisms underlying these effects—oxidative stress, inflammation, and tissue damage—illuminate the complexity of the interactions between pollutants and respiratory health. As societies grapple with the imperatives of cleaner air and improved public health, the

adoption of stringent air quality standards, emission reduction strategies, and informed public engagement emerges as the path forward in mitigating the adverse consequences of air pollution on respiratory well-being. Given the continuous evolution of research in this field, staying abreast of new findings is imperative for refining our understanding and crafting effective interventions.

CONFLICT OF INTEREST

There is no conflict of interest associated with this publication.

ACKNOWLEDGEMENT

Thank you to Faculty of Medicine, Universitas Trisakti for the support.

CONTRIBUTORS

HK: majorly participated in drafting the article, critical revision and final approval of the manuscript to be published.

NA: majorly participated in article review. All authors have read and approved the final manuscript.

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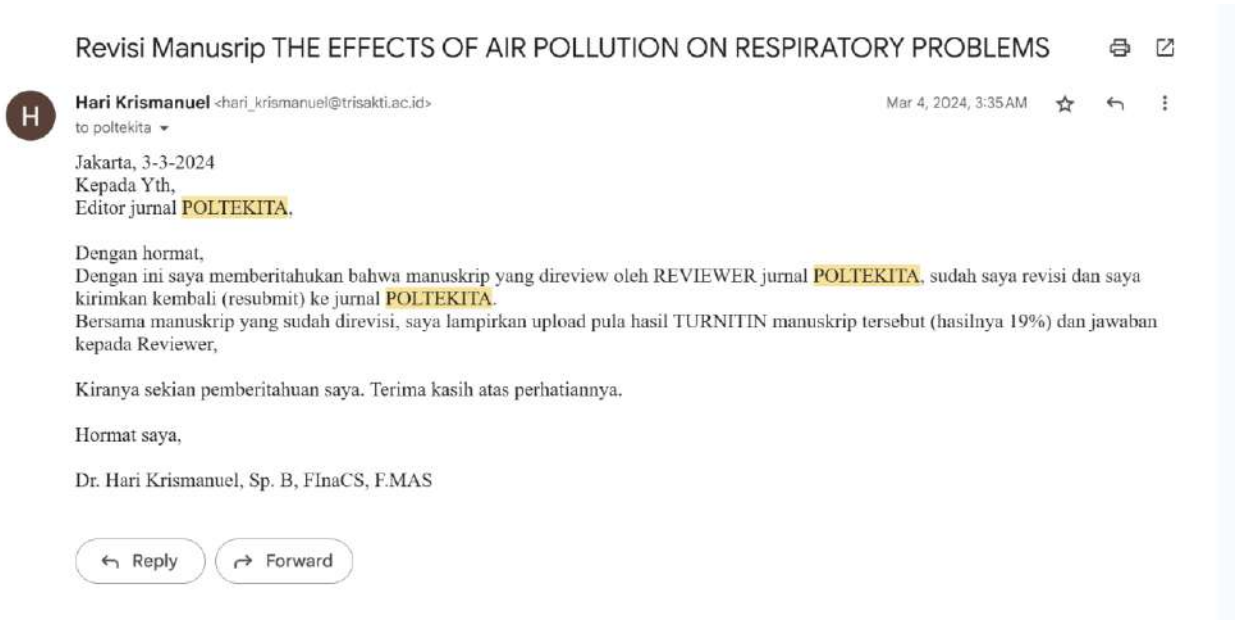

Revisi Manusrip THE EFFECTS OF AIR POLLUTION ON RESPIRATORY PROBLEMS

Hari Krismanuel <hari_krismanuel@trisakti.ac.id> Mar 4, 2024, 3:35 AM
to poltekita

Jakarta, 3-3-2024
Kepada Yth,
Editor jurnal POLTEKITA.

Dengan hormat,
Dengan ini saya memberitahukan bahwa manuskrip yang direview oleh REVIEWER jurnal POLTEKITA, sudah saya revisi dan saya kirimkan kembali (resubmit) ke jurnal POLTEKITA.
Bersama manuskrip yang sudah direvisi, saya lampirkan upload pula hasil TURNITIN manuskrip tersebut (hasilnya 19%) dan jawaban kepada Reviewer,

Kiranya sekian pemberitahuan saya. Terima kasih atas perhatiannya.

Hormat saya,

Dr. Hari Krismanuel, Sp. B, FInaCS, F.MAS

Reply Forward

THE ANSWERS OF REVIEWER COMMENTS

Dear Reviewer,

I made the answer to the reviewer's review separately because it is quite long and to make the delivery clearer.

1. Reviewer: Limited Temporal Scope: The article acknowledges that the review encapsulates findings up until September 2021. However, given the dynamic nature of

research, it would be beneficial to provide information on any significant developments or studies that may have been published after that date.

Dear Reviewer,

"Thank you for your review, sir. I appreciate your observation regarding the dynamic nature of research in this field. While the article notes that the review encompasses findings up until September 2021, I would like to highlight that some of the references used, including papers published in 2023, contribute to the ongoing research landscape. It's important to note that there is often a time delay between research being conducted and the subsequent publication of the findings. Consequently, this review does not intend to limit the data findings only to September 2021. I will conduct a thorough review of the literature published after that date to identify any significant developments or studies and integrate this additional information to ensure a more comprehensive and up-to-date analysis."

2. Reviewer: Lack of Critical Evaluation of Studies: The article mentions an extensive literature review but does not critically evaluate the individual studies. A more critical analysis of the quality, methodology, and potential biases in the selected studies would strengthen the article's credibility.

Dear Reviewer,

Thank you for your insightful comments and thorough review of our manuscript. We appreciate your constructive feedback.

We would like to address your observation regarding the need for a more critical evaluation of individual studies in our literature review. While we understand the importance of a detailed analysis of the quality, methodology, and potential biases in systematic reviews, we want to clarify that our study was not designed as a systematic review.

Our intention was to conduct a comprehensive literature review to provide a broad understanding of the current state of research in our field. However, we recognize the value of a more nuanced discussion of individual study characteristics.

Thank you once again for your time and valuable feedback.

3. Reviewer: Insufficient Attention to Indoor Air Pollution: The article primarily focuses on outdoor air pollution, neglecting the impact of indoor air pollution. Considering that people spend a significant amount of time indoors, particularly in urban areas, addressing indoor air quality is crucial for a comprehensive understanding of the issue

Dear Reviewer,

Thank you for your thoughtful comments and valuable insights into the importance of considering indoor air pollution in our literature review.

Your observation regarding the importance of indoor air pollution is insightful and valid. It's crucial to acknowledge the impact of indoor air quality, given the significant amount of time people spend indoors, particularly in urban areas. However, I would like to clarify that the article does not necessarily primarily focus on outdoor air pollution.

While the effects on respiratory disorders are similar for both indoor and outdoor air pollution, the article aims to address the broader issue of air pollution and its impact on respiratory health without specifically emphasizing one over the other. The initial discussion in our review focuses on air pollutants that cause both outdoor and indoor air pollution, highlighting their shared characteristics. Subsequently, we delve into the specifics of outdoor and indoor pollutants, providing a comprehensive analysis of their origins and effects.

We appreciate your feedback, and we believe that this clarification will enhance the understanding of our review's scope and structure. Thank you again for your valuable insights.

4. Reviewer: **Geographical Scope**: The article does not specify the geographical regions covered in the literature review. Air pollution levels and sources can vary significantly across different regions, and including this information would provide a more nuanced understanding of the issue.

Dear Reviewer,

Thank you for your valuable feedback and constructive comments on our manuscript. We appreciate the time and effort you have dedicated to reviewing our work.

We have carefully considered your suggestion regarding the discussion of factors influencing the severity or level of air pollution. We would like to clarify that the primary focus of our study is to investigate the direct impact of air pollution on respiratory problems.

While we acknowledge the importance of understanding the determinants of air pollution severity, we believe that our research question and objectives are more aligned with exploring the health implications of air pollution. Our study aims to contribute valuable insights into the specific respiratory challenges faced by individuals in relation to air quality in the designated area.

We are more than willing to incorporate additional information or context that you deem necessary to enhance the manuscript. If there are specific aspects related to the effects of air pollution on respiratory health that you believe should be expanded upon or clarified, please do not hesitate to provide further guidance.

Once again, we sincerely appreciate your thoughtful feedback, and we are committed to ensuring that our manuscript meets the standards and expectations of the journal.

5. Reviewer: Overemphasis on Certain Pollutants: While the article discusses various pollutants, there seems to be an overemphasis on PM, O3, NO2, SO2, and CO. Other pollutants or emerging pollutants could be considered, and their potential impact on respiratory health should be explored

   Dear Reviewer,

   "I respectfully disagree with the suggestion of an overemphasis on specific pollutants in the article. The focus on PM, O3, NO2, SO2, and CO stems from their status as major pollutants with substantial concentrations in the air. Discussing these pollutants in detail provides a comprehensive understanding of the primary contributors to air pollution and their impact on respiratory health. Including the effects of all pollutants, especially those with minimal concentrations, could potentially dilute the significance of the major contributors. Therefore, the emphasis on these key pollutants allows for a more targeted and practical exploration of their effects on respiratory disorders."

6. Reviewer: Mechanisms Section Needs Clarification: The section on the mechanisms of impact could benefit from more clarity and specific references to studies supporting the stated mechanisms. Additionally, discussing **the interplay between genetic susceptibility and air pollution effects on respiratory health** would enhance the article's depth.

   We appreciate the reviewer's valuable feedback on the mechanisms section of our manuscript. We acknowledge the need for greater clarity and more specific references to support the stated mechanisms.

   Thank you once again for your time and constructive comments.

7. Reviewer: Lack of Visual Aids: Incorporating visual aids such as tables, figures, or graphs could help in presenting complex information more effectively and engagingly.

   Dear Reviewer,

   Thank you for your insightful feedback on our manuscript. We appreciate your suggestion regarding the incorporation of visual aids such as tables, figures, or graphs to enhance the presentation of complex information.

   We acknowledge the value of visual aids in improving the clarity and engagement of the manuscript. However, as our study is a literature review, primary sources in the form of figures and tables may not be readily available. We emphasize the importance of including

visual aids only when they are derived from primary sources and deemed necessary for a comprehensive understanding of the reviewed literature.

Thank you once again for your time and constructive comments.

8. Reviewer: Repetitive Language: The article tends to use repetitive language, especially in listing the pollutants and their effects on various respiratory conditions. Streamlining the language and avoiding unnecessary repetition would enhance the readability of the article.

   Dear Reviewer,

   Thank you for your valuable feedback on our manuscript. We appreciate your keen observations regarding the repetitive language, particularly in the listing of pollutants and their effects on various respiratory conditions.

   In our revision, we will make a concerted effort to streamline the language and reduce unnecessary repetition. This will involve consolidating information where possible, using concise terminology, and presenting the content in a more reader-friendly manner. Our aim is to maintain clarity while enhancing the overall flow and readability of the article.

   We will pay special attention to sections where redundancy may be present, such as the enumeration of pollutants and their associated respiratory effects. By doing so, we hope to create a more engaging and efficient narrative for our readers.

   We sincerely appreciate your thoughtful critique, and we are committed to delivering a revised manuscript that addresses this concern.

   If you have any specific recommendations or areas of the manuscript where you believe the repetition is more pronounced, your guidance would be immensely helpful.

   Thank you once again for your time and valuable insights.

9. Reviewer: Limited Discussion on **Socioeconomic Factors**: The article briefly mentions vulnerable populations but does not delve deeply into the role of socioeconomic factors in exacerbating the impact of air pollution on respiratory health. Exploring these factors would provide a more holistic view of the issue.

   Dear Reviewer,

   We appreciate the reviewer's insightful comment regarding the need for a more in-depth exploration of socioeconomic factors in our discussion. While our current discussion primarily focuses on factors that make individuals more susceptible to the impact of air pollution on respiratory health, we recognize the importance of distinguishing this from factors that directly contribute to exacerbating air pollution levels.

Socioeconomic factors play a pivotal role in exacerbating the impact of air pollution on respiratory health, and a more comprehensive analysis is indeed warranted.

Thank you once again for your time and constructive comments.

10. Reviewer: Conflict of Interest Statement: While the article states that there is no conflict of interest, providing information about the funding sources for the research or any potential affiliations with organizations related to air pollution could increase transparency.

Dear Reviewer,
"I appreciate the reviewer's suggestion regarding transparency. I want to clarify that for this literature review, there is no specific affiliation for research funding. The review was conducted independently without any external affiliations influencing the content. While I don't have specific funding sources to disclose, I want to assure the readers that the review was carried out with the utmost impartiality and dedication to presenting an unbiased analysis of the available literature on the topic. If there are any further questions or concerns, I am open to addressing them to ensure transparency and maintain the integrity of the research."
It's not uncommon for researchers, especially those conducting literature reviews or academic work independently, to not have specific affiliations for funding.

Jakarta, March 3, 2024

Best regards,

Dr. Hari Krismanuel, Sp. B, FInaCS, F.MAS

Kepada : poltekita@gmail.com

Manusrip THE EFFECTS OF AIR POLLUTION ON RESPIRATORY PROBLEMS

Jakarta, 21-3-2024
Kepada Yth,
Editor jurnal POLTEKITA,

Dengan hormat,

Dengan ini saya ingin menanyakan perihal manuskrip berjudul THE EFFECTS OF AIR POLLUTION ON RESPIRATORY PROBLEMS No. 3151 yang sudah saya revisi, bersama hasil Turnitin dan jawaban kepada Reviewer. Manuskrip tersebut sudah saya resubmit ke POLTEKITA tanggal 3-3-2024 lalu. Apakah manuskrip tersebut sudah diterima dan dapat segera dipublikasi?

Kiranya sekian email saya. Terima kasih atas perhatiannya.

Hormat saya,

Dr. Hari Krismanuel, Sp. B, FInaCS, F.MAS

POLTEKITA: JURNAL ILMU KESEHATAN

POLTEKKES KEMENKES PALU

Jln.Thalua Konchi No.19 Mamboro Palu Utara, Kota Palu Sulawesi Tengah Indonesia

LETTER OF ACCEPTANCE

Nomor:
3151/Poltekita/V/2024

Thank you for submitting the manuscript, " **The Effects of Air Pollution on Respiratory Problems: A Systematic Review**" for Polytechnic: Journal of Health Sciences. With our online journal management system, you will be able to track the progress of your manuscript in the editorial process by logging into the journal's website at the Manuscript URL:
https://jurnal.poltekkespalu.ac.id/index.php/JIK/authorDashboard/submission/3151

Name : Hari Krismanuel[1*], Nany Hairunisa[2]
Institution : Department of Surgery, Faculty of Medicine, Universitas Trisakti,Jakarta, Indonesia
Email : hari_krismanuel@trisakti.ac.id

If you have any questions, please contact me. Your article will be published in Volume 18 No 1 May 2024. If you have any questions, please contact me at 081314119647. Thank you for considering this journal as a venue for your work.

Palu, May 05, 2024

Editor in Chief

POLTEKITA
JURNAL ILMU KESEHATAN

Nasrul, SKM., M. Kes

Acceptance of Article Submission for Poltekita: Jurnal Ilmu Kesehatan

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Jurnal Poltekita 3:20 PM (1 hour ago)

to me

Dear Hari Krismanuel,

We are pleased to inform you that your article titled "**The Effects of Air Pollution on Respiratory Problems: A Systematic Review"** has been accepted for publication in Poltekita: Jurnal Ilmu Kesehatan. We appreciate your valuable contribution and look forward to sharing your work with our readers.

To proceed with the publication process, please refer to the attached invoice for the payment details. Kindly ensure that the payment is made promptly to avoid any delays in the publication process.

Once the payment is completed, please send us the proof of payment for our records.

Thank you for your cooperation and for choosing Poltekita: Jurnal Ilmu Kesehatan for your publication.

14-5-2024

Best regards,

Editor.

One attachment • Scanned by Gmail

Letter of Accepted

×Close Panel

Participants

- Kadar Ramadhan (editorpjpm)
- Kadar Ramadhan (editorkadarramadhan)
- Hari Krismanuel (hari_krismanuel)

Messages

Note

Fro
edit
20

Dear Authors,

Thank you for submitting the manuscript, " **The Effects of Air Pollution on Respiratory Problems: A Systematic Review**" for Polytechnic: Journal of Health Sciences. With our online journal management system, you will be able to track the progress of your manuscript in the editorial process by logging into the journal's website at the Manuscript URL:

https://jurnal.poltekkespalu.ac.id/index.php/JIK/authorDashboard/submission/3151

If you have any questions, please contact me. **Your article will be published in Volume 18 No 1 May 2024.**

If you have any questions, please contact me at 081314119647. Thank you for considering this journal

as a venue for your work.

1. Hari.pdf