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Analysis of the Influence of Parental Knowledge and Attitudes on Children's Environmental Health Mitigation Behavior During the Dry Season in the City of Jakarta: A Case Study of Air Pollution

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Abstract: Air quality in major cities like Jakarta harms health and the economy, particularly affecting children. Areas frequented by children, such as roads around schools and playgrounds, have especially concerning pollution levels. This study aims to investigate how parents' knowledge and attitudes towards reducing the effects of air pollution on children's health are related. A quantitative correlational survey was conducted among 75 parents of children aged 5-17 in Jakarta, particularly those residing near roads or high-pollution areas. The data was analyzed using SPSS. Key findings include (1) a significant correlation between parents' knowledge of air pollution and their efforts to lessen its impact on children's health (.000 < 0.05), (2) a connection between parents' attitudes and their efforts to mitigate health issues (.000 < 0.05), (3) a link between the desire to address air pollution and actual mitigation behavior (.000 < 0.05), and (4) the combined impact of knowledge, attitudes, and the desire to address air pollution on children's health protection parental's behavior (.000 < 0.05), contributing to 54.8% of the variance. Moreover, 90% of participants concurred that improving air quality is a shared responsibility, underscoring the necessity for public education on reducing air pollution to safeguard children's health.

Keyword: Knowledge, Air Pollution, Attitudes, Behavior, Parents, Mitigation, Sdgs, Environment, Children's Health

INTRODUCTION

In recent times, there has been a rise in scientific and industrial development in countries like Indonesia, accompanied by challenges, including urban air pollution. As the capital, Jakarta faces a severe air pollution problem with significant public health impacts, especially on children.[1] According to the Ministry of Environment and Forestry, transportation and industrial activities are Jakarta's main sources of air pollution. Studies indicate that in 2019, air pollution led to 5,054 deaths and 168,000 years of healthy life lost due to non-communicable diseases in Jakarta.[2] Nearly all respondents (90%) agree that every citizen is responsible for improving air quality. [3] Effective cooperation between the government and citizens is crucial to addressing Jakarta's serious air pollution problem. Resources should be allocated to educate citizens about

air pollution and provide them with practices to minimize its adverse impacts, especially on children.[4]

Air pollution has emerged as a critical environmental issue in major cities like Jakarta, where high pollution levels stem from vehicle emissions, industrial activities, and waste burning. According to the 2023 Air Quality Index (AQI) report, Jakarta is often ranked as the city with the poorest air quality globally, particularly during the dry season. Data from IQAir projects that in August 2023, PM2.5 concentrations in Jakarta will average 160-200 µg/m³, well above the safe threshold the World Health Organization (WHO) set at 25 µg/m³.[15] The impact of air pollution is particularly concerning for children, who are more susceptible to respiratory diseases and other health issues.[6] A report from the Ministry of Health of the Republic of Indonesia in 2022 reveals a significant increase in asthma and acute respiratory infections (ARI) in children in urban areas with high air pollution levels like Jakarta.[7] This situation requires urgent attention, especially from parents who play a vital role in safeguarding their children's health through environmental health measures.

While regional governments have tried to mitigate the negative impacts of air pollution, behavioral changes, and active community participation are still needed to address this issue. Parents play a crucial role in minimizing the impact of air pollution on their children's health in urban settings.[6] This study seeks to explore the knowledge and attitudes of parents in Jakarta regarding mitigating the impact of air pollution on their children's health.

The primary issue in this context is the insufficient understanding among the public, particularly parents, regarding the hazards of air pollution on children's health. A small survey conducted by the DKI Jakarta Environmental Control Agency in 2021 revealed that only 45% of parents knew that air pollution could lead to chronic respiratory diseases in children.[8] Furthermore, many parents are not proactive in implementing mitigation measures, such as providing personal protective equipment for children outdoors or limiting outdoor activities when air quality is poor. This lack of knowledge has the potential to exacerbate the health impacts on children who are increasingly exposed to air pollution.

While research on air pollution and its health effects has been extensive, there is still relatively limited focus on parents' knowledge and attitudes in mitigating children's health, especially in urban areas like Jakarta. Most previous studies have concentrated on the scientific aspects of air pollution's impact on children's health,[9] such as the prevalence of respiratory diseases, without delving deeply into how parents comprehend and address this issue. This study introduces a novel approach by integrating social and environmental health perspectives, especially in the context of child health mitigation,[10] which is a highly pertinent but not comprehensively researched topic. Research on the overall effects of air pollution on public health is extensive, but few studies specifically examine the knowledge and attitudes of parents in highly urbanized cities like Jakarta regarding environmental health mitigation for their children. Existing literature often discusses the impact of air pollution on children's health in a broader context, but there is limited focus on how parental understanding and attitudes influence health mitigation efforts. Additionally, there is a scarcity of localized studies that investigate the role of parents as primary decision-makers in safeguarding children from air pollution, especially in rapidly expanding urban areas grappling with significant air quality issues.

Prior studies have demonstrated the adverse effects of air pollution on health, particularly in children with more sensitive respiratory systems. A study published in The Lancet in 2021 revealed that long-term exposure to air pollution increased children's risk of developing asthma by up to 30% compared to children living in areas with better air quality.[11] Another study conducted by the Indonesian Institute of Sciences in 2022 indicated that air pollution also contributes to a decline in cognitive function in children due to long-term exposure to fine particles (PM2.5). However, there is still limited research linking parental knowledge and attitudes with efforts to mitigate children's environmental health.[12] This research offers a fresh viewpoint by centering on Jakarta's specific urban environment, a city facing significant air

pollution issues, and the crucial role of parents in protecting their children's well-being. It delves into the connection between parents' understanding of environmental health, their attitudes, and their direct efforts to reduce the negative impacts of air pollution on children. The study provides new perspectives on how parents in a highly polluted urban area perceive environmental risks and take action to address them[13]. Furthermore, it fills a gap in localized public health strategies by integrating community-level knowledge and attitudes into broader initiatives aimed at improving air quality and mitigating health risks. By focusing on parental perspectives in an urban Southeast Asian context, this research introduces an innovative aspect to the global conversation on air pollution and children's health.

The research holds great significance given Jakarta's ongoing struggle with air quality, which directly impacts public health, particularly that of children. Despite government efforts to implement exhaust gas emission regulations and control sources of air pollution, there remains a lack of public awareness, especially among parents, regarding the protection of children's health from air pollution.[14] This research aims to generate empirical data that can aid relevant stakeholders, including local governments, health institutions, and educational organizations, in developing more effective community educational programs for safeguarding children's health from air pollution.

This research seeks to:

1. Assess parents' level of understanding in Jakarta about the effects of air pollution on children's health.
2. Examine parents' attitudes towards safeguarding children's health in the face of air pollution.
3. Identify the measures parents take to mitigate the adverse effects of air pollution on children's health.
4. Offer recommendations to the government and related entities for enhancing parental awareness and preventive measures in addressing air pollution in urban areas, particularly concerning children's health.

It is anticipated that this research will contribute to the formulation of air pollution mitigation strategies that prioritize the protection of children's health and elevate the role of parents in fostering a healthier living environment for forthcoming generations.

METHOD

This study employs a survey research design to gather information on parents' awareness, attitudes, and readiness to address children's environmental health impacted by air pollution in urban areas. Survey research was selected due to its effectiveness in gathering quantitative data from a large population and enabling the analysis of relationships between variables using statistical methods.[2] The study will be conducted in five areas of the Municipality of Jakarta City, namely Central Jakarta, North Jakarta, West Jakarta, South Jakarta, and East Jakarta. Jakarta was chosen as the research area due to its significant air pollution issues affecting children's health, particularly in densely populated urban regions

Figure 1: Map of Jakarta, Indonesia, as a research study area

The study's population consists of parents with children aged 5 to 20 years residing in the five areas of Jakarta. Children in this age group were chosen because they are in a vulnerable developmental phase susceptible to the adverse effects of air pollution, both physically and mentally.[15] From this population, 75 parents will be selected as research participants using purposive sampling, which involves selecting respondents based on specific criteria, specifically parents living in Jakarta with children within the specified age range.

Table 1 The Proposed indicators for the research variables

Variables	Indicators
. Parents' Knowledge of the Dangers of Air Pollution (Measuring the extent to which parents understand the risks and impacts of air pollution.)	Awareness of the causes of air pollution in urban areas. Knowledge of the health effects of air pollution, particularly on children. Understanding of the sources and types of air pollutants. Awareness of air quality standards and monitoring systems. Familiarity with preventive measures to minimize exposure to air pollution.
Attitudes Toward Air Pollution Mitigation (Evaluating parents' perceptions, beliefs, and readiness to engage in air pollution mitigation efforts.)	Belief in the importance of reducing air pollution for public health. Attitude toward adopting eco-friendly practices (e.g., reducing vehicle use, planting trees). Willingness to support policies and programs aimed at air quality improvement. Concern for the long-term environmental and health consequences of air pollution. Readiness to advocate for collective actions to combat air pollution.
Parents' Behavior in Mitigating Children's Environmental Health Impacts of Air Pollution (Assessing actions taken by parents to protect their children's health from air pollution.)	Implementation of household measures to reduce exposure to air pollution (e.g., using air purifiers, sealing windows). Ensuring children's use of protective gear (e.g., masks) during high pollution periods. Encouraging indoor activities during poor air quality days. Participation in community or local initiatives to improve air quality. Educating children about air pollution and preventive practices.

Data for this study will be collected through a questionnaire designed to assess parents' knowledge, attitudes, willingness to act, and health mitigation behavior concerning air pollution's impact on children. The questionnaire will utilize a Likert scale format with five response options to gauge the level of agreement or intensity of each respondent. The questionnaire was developed based on the four primary variables in the study: parental knowledge, attitudes toward mitigation, willingness to act, and mitigation behavior. The following is the questionnaire grid that will be utilized for the research: SPSS 25 Data Analysis Techniques.

RESULTS AND DISCUSSION

The table containing respondent profiles provides comprehensive data on key demographic variables, such as age, type of occupation, monthly income, length of residence, and education level. These factors are crucial for assessing their knowledge of air pollution, attitudes towards environmental health, and practices related to child health mitigation.

The level of education significantly impacts parents' awareness of air pollution and its health effects. Those with higher education levels are more likely to have access to scientific knowledge about air quality and its impact on health, especially for vulnerable groups like children.7 Conversely, individuals with lower levels of education may rely on informal or limited sources of information, potentially leading to gaps in understanding the full extent of air pollution's dangers. Age plays a role in how parents gather and process information.

Younger parents may be more connected to digital platforms, where current research and health advisories about pollution are easily accessible. On the other hand, older parents, while experienced, might hold more traditional views on environmental health, potentially lacking the latest data unless actively sought.

The duration of residence in Jakarta affects parents' awareness of changes in air quality over time and their practical, experiential knowledge about pollution levels.16 Newer residents may not be as familiar with the specific air pollution challenges in Jakarta or the associated health risks, leading to potential knowledge gaps. Certain occupations, particularly in healthcare, education, or environmental sciences, may directly expose parents to information about air pollution and its effects, significantly enhancing their understanding. Conversely, those in unrelated fields may lack similar access to relevant information.

Influence on Attitudes Toward Protection from Air Pollution: The level of education influences parents' attitudes toward taking preventive measures against air pollution. Those with higher education are more likely to have positive attitudes toward proactive protection, such as reducing outdoor activities during high pollution periods or investing in air purifiers. Conversely, parents with lower education may not perceive air pollution as an immediate threat, leading to more passive attitudes toward prevention. Age also affects parents' concerns regarding future consequences, with younger parents often displaying greater concern driven by contemporary environmental movements and access to real-time pollution data. Conversely, older parents, while sometimes more conservative, may still take precautionary steps, especially if they have observed the adverse health effects of pollution over time. The length of residence in Jakarta impacts parents' sensitivity to air pollution, with long-term residents often displaying deeper concern and a stronger commitment to protective behaviors. Conversely, newcomers might underestimate the seriousness of the pollution problem and show a less urgent attitude toward protection. Parents working in health-related or environmentally conscious industries are likely to adopt stronger protective attitudes, driven by their professional understanding. Occupations that expose individuals to pollution, such as outdoor labor, may lead to either increased concern due to personal exposure or complacency if the exposure becomes normalized.

Table 2. Profile Respondents of The Research

		Frequency	Percent	Valid Percent	Cumulative Percent
Occupation	Housewife	38	52.5	52.5	52.5
	Fisherman	2	2.5	2.5	55.0
	Fish Farmer	2	2.5	2.5	57.5
	Trader	8	10.0	10.0	67.5
	Government Employees	8	10.0	10.0	77.5
	Private Employee	6	7.5	7.5	85.0
	others	11	15.0	15.0	100.0
	Total	75	100.0	100.0	.000
Long Stay	Less than 4 years	10	15.0	15.0	15.0
	4 years	6	7.5	7.5	22.5
	5 years	50	67.5	67.5	90.0
	More than 5 Years	9	10.0	10.0	100.0
	Total	75	100.0	100.0	.000
Income per Month	Don’t know	4	5.0	5.0	5.0
	Less than 500.000	15	20.0	20.0	25.0
	500.000-1.000.000	15	20.0	20.0	45.0
	1.000.001-1.500.000	17	22.5	22.5	67.5
	1.500.001-2.000.000	6	7.5	7.5	75.0

	> 2.000.000	18	25.0	25.0	100.0
	Total	75	100.0	100.0	.000
Age	14 - 20 years	3	5.0	5.0	5.0
	21 - 30 years	3	5.0	5.0	10.0
	31 - 40 years	55	72.5	72.5	82.5
	41 - 50 years	14	17.5	17.5	100.0
	Total	75	100.0	100.0	.000

The level of education, professional status, and income can impact people's understanding of air pollution and its risks, with those who have more education and resources being more aware of the potential health effects on children. Attitudes towards environmental health can be influenced by factors such as age, occupation, and length of residence, as older and long-term residents may prioritize health risks due to personal experiences, while younger residents may be more focused on proactive environmental behavior. The ability to implement health mitigation practices is closely linked to income and education, as higher-income individuals are more likely to adopt practical solutions like air filtration systems, while those with less income but higher awareness may still engage in cost-effective measures such as limiting outdoor exposure or using masks during high-pollution days. Understanding how demographic factors influence parents' willingness to protect their children from urban air pollution in Jakarta is crucial for developing targeted interventions that can improve awareness and action across different demographic groups, in line with Sustainable Development Goal (SDG) 3 on health and well-being.

Table 3 Correlation of Knowledge, Attitude, Behaviour, and Mitigation Children's Environmental Health in The face of Air Pollution

Correlation

		Mitigating children's environmental health in the face of air pollution	level of knowledge of parents in Jakarta regarding the impacts of air pollution	Environmental Health Attitude	Air Pollution Protection Behaviour
Pearson Correlation	mitigating children's environmental health in the face of air pollution	1.000	.644	.754	.724
	level of knowledge of parents in Jakarta regarding the impacts of air pollution	.644	1.000	.646	.539
	parental attitude	.754	.646	1.000	.732
	Air Pollution Protection Behaviour	.724	.539	.732	1.000
Sig. (1-tailed)	mitigating children's environmental health in the face of air pollution	.000	.000	.000	.000
	level of knowledge of parents in Jakarta regarding the impacts of air pollution	.000	.000	.000	.000
	Environmental Health Attitude	.000	.000	.000	.000
	Clean Water Environmental Sanitation Behaviour	.000	.000	.000	.000
N	Community Health Resilience	75	75	75	75

Clean Water Sanitation Knowledge	75	75	75	75
Environmental Health Attitude	75	75	75	75
Clean Water Environmental Sanitation Behaviour	75	75	75	75

Based on the research findings, we can draw several important conclusions about the correlation between parents' knowledge, attitudes, and willingness to address children's environmental health about air pollution. Here is a comprehensive breakdown of the findings:

1. Connection between Parental Understanding of Air Pollution and Mitigation of Children's Environmental Health (0.00 < 0.05)

The substantial link between parental understanding of air pollution and the mitigation of children's environmental health indicates that parents' awareness of the risks associated with air pollution plays a critical role in determining how they safeguard their children from its harmful effects. The significant value ($p < 0.05$) confirms that the better parents comprehend the sources, types, and impacts of air pollution, the more likely they are to take effective steps to mitigate its effects.

2. Connection between Parental Awareness of Air Pollution and Mitigation of Children's Environmental Health (0.00 < 0.05)

The substantial relationship between parental awareness of air pollution and the mitigation of children's environmental health highlights the crucial role of parents' understanding of the dangers of air pollution in determining how they protect their children from its adverse effects. The significant value (p-value < 0.05) confirms that the better parents understand the sources, types, and impacts of air pollution, the higher the probability they will take effective mitigation measures.

The health behavior model suggests that having good knowledge is crucial for parents to recognize potential dangers and take necessary precautions to protect their children from air pollution, such as limiting their exposure to polluted air and utilizing technology to enhance air quality at home.

The correlation between parents' attitudes towards children's environmental health mitigation and positive attitudes towards air pollution indicates that the latter plays a significant role in determining parents' behavior to mitigate environmental health risks for their children. This strong attitude signifies parents' belief in the urgency of mitigating air pollution to safeguard their children's health.

The significant relationship between the desire to take action and children's environmental health mitigation demonstrates the importance of the desire to act, in addition to good knowledge and positive attitudes. It indicates the motivation or encouragement from within oneself to take concrete steps to mitigate air pollution. These findings underscore the significance of motivational factors in driving behavior change. Parents may possess the knowledge and a positive attitude, but without the desire to act, they may not take the necessary steps to mitigate air pollution. The desire to act can be prompted by awareness of the direct impact of air pollution on their children, as well as the influence of the social environment or supportive policies for mitigation actions.

Table 4 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.740[a]	.548	.312	3.748	.365	6.887	3	71	.000	2.047

a. Predictors: (Constant), parents' knowledge about air pollution, attitudes, parents' desire to act
b. Dependent Variable: Mitigation of Children's Environmental Health

The relationship between knowledge, attitude, and the desire to act collectively on parental mitigation behavior (0.00 < 0.05) has an influential contribution of 54.8%. These findings suggest that knowledge, attitudes, and the desire to act together significantly impact parents' behavior in mitigating children's environmental health. The 54.8% contribution implies that these three factors can account for more than half of the variation in mitigation behavior.

The examination of the impact of knowledge about air pollution effects and attitudes toward air pollution protection on safeguarding children's health from air pollution in Jakarta can be dissected as below:

1. Influence of Knowledge on Mitigation:

Parents with a deep understanding of air pollution and its detrimental effects on children's health are more inclined to take preventive and protective measures. Understanding enables parents to acknowledge the seriousness of exposure to pollutants and the potential long-term consequences, such as respiratory illnesses, impaired lung development, and other health issues. This awareness drives them to seek out and implement effective mitigation strategies, like reducing outdoor exposure during high pollution periods, installing air purifiers, and closely monitoring air quality. The extent of access to reliable information sources—like government health advisories, environmental reports, and academic research affects parents' knowledge level. In Jakarta, where air quality can vary due to traffic, industrial activities, and seasonal variations, parents with greater knowledge can better anticipate pollution occurrences and take timely steps to protect their children. Knowledge empowers parents to take proactive rather than reactive measures. For instance, informed parents may not wait for visible signs of pollution (e.g., smog or haze) but instead utilize real-time air quality tracking apps to make informed decisions on when to limit outdoor activities or take other precautions.[17]

2. Influence of Attitudes on Mitigation:

Parental attitudes toward safeguarding children from air pollution significantly influence the extent of mitigation efforts. Parents with a strong protective attitude are more likely to prioritize their children's health and take decisive actions. They may perceive air pollution as an immediate threat and invest in long-term solutions, such as improving home ventilation systems or relocating to areas with better air quality. Parents who view air pollution as a high-risk factor for their children's health are more inclined to engage in active preventive measures. [6] For example, they might limit their children's exposure to outdoor environments during high pollution periods, ensure regular medical check-ups, or use masks for their children during severe air quality episodes. Conversely, parents with a more indifferent or dismissive attitude toward air pollution may adopt fewer protective measures, potentially underestimating the risks.

The knowledge, attitudes, and environmental behaviors of parents play a pivotal role in mitigating the health effects of air pollution on children in Jakarta. Studies have indicated that parental education and awareness significantly influence their capacity to shield their children from health risks associated with air pollution. Research suggests that parents with higher levels of education tend to possess greater knowledge about air pollution sources and risks, which translates into more positive attitudes and behaviors toward mitigation efforts.[18] In Jakarta,

where air pollution levels rank among the highest in developing countries, parental awareness and action are particularly crucial for protecting children's health). This inconsistency suggests that knowledge alone may not be enough to drive effective mitigation behaviors. Additionally, integrating IoT technology for real-time air quality monitoring could provide valuable data to inform parents and policymakers about pollution levels and associated health risks.[19]

Jakarta parents have several options to lessen the impact of air pollution on their children's health. Encouraging the use of face masks is an effective way to protect against traffic-related air pollution (TRAP).[20] Children and caregivers may have different viewpoints on mask-wearing. [21] Both groups recognize discomfort and forgetfulness as barriers, but children are more worried about their appearance when wearing masks.[22] Parents should address these worries and inform their children about the health benefits of wearing masks.[23] Promoting the use of public transportation or active modes of transport like walking or cycling can help lower exposure to air and noise.

Research has indicated that using private transportation is linked to higher pollution exposure. For children who walk, bike, or ride motorcycles to commute, wearing masks is even more important. It's interesting to note that parental education level influences the promotion of mask-wearing.[24] Caregivers with higher education levels are more likely to encourage their children to wear masks.[25] This emphasizes the significance of parental awareness and education regarding air pollution risks.[22] Parents should concentrate on educating their children about the health hazards of air pollution, promoting protective measures such as masks, and advocating for cleaner transportation options. Furthermore, staying updated on air quality levels through IoT-based monitoring systems can help parents make well-informed decisions about their children's outdoor activities.

Parental behavior in protecting children's health is significantly influenced by their knowledge of the dangers of air pollution and their attitudes toward pollution mitigation in Jakarta. Children are particularly vulnerable to the health impacts of air pollution, which increases the risk of respiratory diseases and other health issues. Data from the Ministry of Health of the Republic of Indonesia in 2022 indicates a significant rise in cases of asthma and acute respiratory infections (ARI) among children in urban areas with high pollution levels, such as Jakarta. To address the impact of air pollution on children's health, it is necessary for parents to take individual actions and for the government to implement systemic solutions.[26] Parents have a vital role in minimizing direct exposure to air pollution by monitoring, establishing safe environments, and advocating for improved local conditions.[27] Conversely, the government needs to enforce policies to reduce pollution at its sources, increase public awareness, and invest in long-term infrastructure changes to enhance overall air quality.[2818] Both parties need to collaborate to safeguard the health of future generations from the hazards of air pollution.

This indicates that while other factors like social norms, government policies, or economic factors may influence parental mitigation behavior, knowledge, attitudes, and the desire to act play the most dominant role. An all-encompassing approach that integrates education, attitude change, and motivation to act will be more effective in motivating parents to take tangible steps to safeguard their children from air pollution. Among the respondents, there is a high level of awareness about the collective responsibility for air pollution, with 90% agreeing that improving air quality is the responsibility of all citizens. This high awareness underscores the crucial role of individuals in addressing air pollution issues. Such awareness is crucial as collective action is necessary to bring about improvements in air quality, especially in densely populated urban areas like Jakarta.

The sources of air pollution can be further divided into stationary and mobile sources. Stationary sources encompass power plants, factories, and residential areas where pollution emanates from fixed locations, typically from the combustion of fuels for energy or industrial processes.[29] These sources can be somewhat controlled through policies and technologies like

filters and scrubbers, which aid in reducing emissions. Conversely, mobile sources include motorized vehicles such as cars, trucks, buses, and ships, which continuously move and emit pollutants during operation. Air pollution levels are significantly exacerbated in urban areas due to traffic congestion, resulting in high emissions from gasoline- and diesel-powered vehicles.

Air pollution occurs when harmful substances are introduced into the atmosphere, leading to environmental degradation and reduced air quality. This poses significant risks to human health and ecosystems. Pollutants in the air can cause respiratory diseases, cardiovascular problems, and long-term damage to both human populations and the natural world. Experts indicate that air pollution can stem from two primary sources: natural and anthropogenic (human-induced) sources.

Natural sources, the first category, encompass events like volcanic eruptions, forest fires, and dust storms, all of which release particulate matter and gases like sulfur dioxide into the atmosphere. These occurrences, although natural, can significantly impact air quality on a local or global scale. However, the more prevalent and concerning source of air pollution is human activities, often referred to as anthropogenic sources.[11] These include emissions from transportation, industrial processes, energy production, and agriculture, which continuously release large quantities of pollutants such as carbon monoxide (CO), nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulate matter (PM).[10] Air pollution can arise in various environments, including both indoor and outdoor settings. Indoor air pollution, often overlooked but critical, especially in enclosed spaces like homes, schools, and offices, can be caused by factors such as poor ventilation, the use of biomass fuels for cooking, and the release of chemicals from household products and building materials. Indoor pollutants like carbon monoxide, volatile organic compounds (VOCs), and particulate matter can accumulate and pose severe health risks over time.[21] On the other hand, outdoor air pollution primarily results from vehicle emissions, industrial discharges, shipping activities, and the burning of fossil fuels for energy. These activities release large amounts of pollutants into the atmosphere, contributing to smog formation, acid rain, and global challenges like climate change. Motor vehicles, particularly in urban areas, stand as one of the largest contributors to air pollution, emitting a mixture of greenhouse gases (GHGs) and harmful pollutants such as nitrogen dioxide (NO_2) and particulate matter.[9]

It is essential to address both indoor and outdoor air pollution to achieve Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-Being), which aims to reduce the health impacts of pollution and hazardous chemicals. Furthermore, SDG 13 (Climate Action) is directly linked to reducing air pollution, as many pollutants contribute to global warming.[30] By improving air quality, implementing clean energy solutions, and promoting sustainable transportation and industrial practices, we can mitigate the negative impacts of air pollution and enhance both environmental health and public health outcomes. The health of children is significantly impacted by air pollution due to their developing respiratory and immune systems, making them more vulnerable to environmental toxins. Children inhale more air per unit of body weight than adults, increasing their exposure to air pollutants. Air pollution can have both short-term and long-term effects on children, affecting their respiratory, cardiovascular, neurological, and immune systems. Presented below is an examination of the primary health consequences of air pollution on children and the specific chemical pollutants involved.

Childhood asthma and bronchitis are largely caused by air pollution. Pollutants like particulate matter (PM), ground-level ozone (O_3), and nitrogen dioxide (NO_2) inflame the airways, leading to frequent coughing, wheezing, and shortness of breath. High pollution levels often trigger asthma exacerbations, resulting in hospitalizations and long-term lung damage. Children exposed to high levels of pollutants such as particulate matter (PM_{10}, $PM_{2.5}$) and sulfur dioxide (SO_2) may experience impaired lung development. Long-term exposure to these

pollutants can cause reduced lung function, which may not fully recover as the child grows, leading to chronic respiratory problems later in life.[22]

While cardiovascular impacts are more evident in adults, research indicates that long-term exposure to air pollution can also affect children's heart health. Exposure to fine particulate matter ($PM_{2.5}$) can lead to inflammation and oxidative stress, contributing to early signs of cardiovascular disease, including high blood pressure. Recent studies suggest that air pollutants, particularly fine particles ($PM_{2.5}$) and neurotoxic chemicals such as lead and polycyclic aromatic hydrocarbons (PAHs), can affect children's brain development. Prolonged exposure has been linked to reduced cognitive abilities, attention deficits, and learning disabilities. Pollutants can cross the blood-brain barrier, causing neuroinflammation, which may lead to developmental delays or lower IQ levels.

Table 5 Summarizing key air pollutants in Jakarta, their sources, and the health impacts they can cause in children or adults

Nu.	Pollutant	Source	Health Impact	Diseases in Children/Adults
1.	**Particulate Matter (PM2.5)**	Vehicle emissions, industrial processes, construction activities, burning of waste	Penetrates deep into the lungs, causing respiratory and cardiovascular problems	Asthma, bronchitis, pneumonia, reduced lung function, heart disease
2.	**Nitrogen Dioxide (NO_2)**	Vehicle emissions, power plants, industrial processes	Irritates the respiratory system, increases susceptibility to infections	Asthma, chronic bronchitis, respiratory infections
3.	**Sulfur Dioxide (SO_2)**	Coal combustion in power plants, industrial emissions	Causes respiratory problems, eye irritation, and lung tissue inflammation	Asthma attacks, bronchitis, lung inflammation
4.	**Carbon Monoxide (CO)**	Vehicle emissions, incomplete combustion of fossil fuels	Reduces oxygen supply in the body, particularly dangerous for young children and those with heart conditions	Headaches, dizziness, and impaired vision, in severe cases, can lead to death
5.	**Ozone (O_3)**	Reaction between sunlight and pollutants (NOx and VOCs)	Irritates the respiratory system, and worsens lung diseases	Asthma exacerbation, reduced lung function, respiratory infections
6.	**Lead (Pb)**	Vehicle emissions (from leaded gasoline), industrial sources	Affects nervous system development, particularly in children	Cognitive development issues, reduced IQ, behavioral problems
7.	**Volatile Organic Compounds (VOCs)**	Vehicle emissions, industrial solvents, paints, household products	Can cause eye, nose, and throat irritation; long-term exposure can lead to organ damage	Asthma, respiratory issues, liver and kidney damage, cancer
8.	**Ammonia (NH_3)**	Agricultural activities, fertilizers, waste treatment plants	Respiratory irritation, potential damage to lung tissue	Respiratory issues, lung inflammation
9.	**Benzene**	Vehicle emissions, industrial emissions, tobacco smoke	Long-term exposure linked to blood disorders and increased risk of cancer	Leukemia, anemia, immune system damage

Exposure to air pollution, especially during pregnancy and early childhood, has been associated with an increased risk of behavioral disorders such as attention-deficit/hyperactivity disorder (ADHD) and autism spectrum disorder (ASD).[31] Air pollution can compromise the immune system in children, making them more susceptible to infections. Pollutants such as ozone (O_3) and volatile organic compounds (VOCs) can weaken the body's defense

mechanisms, resulting in more frequent respiratory infections like pneumonia and influenza. Pregnant women exposed to high levels of air pollution are at greater risk of giving birth to premature or low birth-weight infants. Pollutants such as carbon monoxide (CO) and fine particulate matter ($PM_{2.5}$) can interfere with fetal oxygen supply, impacting growth and development in utero.

PM_{10} and $PM_{2.5}$ are particles smaller than 10 and 2.5 micrometers in diameter, respectively, capable of entering the lungs and bloodstream. These particles can lead to respiratory issues, reduced lung function, cardiovascular disease, cognitive impairment, and premature death. NO_2 is a gas produced mainly by vehicle emissions and industrial activity, contributing to ground-level ozone and particulate matter formation. It can cause respiratory system irritation, increased asthma risk, reduced lung growth, and heightened susceptibility to infections. Ground-level ozone forms when nitrogen oxides (NOx) and volatile organic compounds (VOCs) react in sunlight, being a major component of smog. Ozone can irritate the airways, leading to asthma attacks, shortness of breath, coughing, and long-term lung damage in children. SO_2 is released through burning fossil fuels and industrial processes, forming fine particles contributing to smog and acid rain.

The relationship between parents' understanding of the impacts of air pollution, their attitudes, and their inclination to take action to safeguard their children's environmental health is intricate and multi-dimensional.[32] Research has demonstrated that the level of education among parents has a substantial impact on their knowledge and attitudes toward air pollution.[28] Parents with higher levels of education tend to have better perceptions of the risks associated with air pollution and exhibit higher overall behavior scores in mitigating its effects.[33] This suggests that enhancing parents' knowledge about air pollution can lead to more positive attitudes and actions aimed at protecting children's health. Interestingly, while attitudes toward air pollution are generally positive,[34] tend to diminish as students progress to higher grade levels. This paradox underscores the necessity of continuous education and reinforcement of environmental awareness throughout a child's schooling.

CONCLUSION

This study indicates a correlation between parental knowledge and attitudes and mitigating children's environmental health. Parents' knowledge and attitudes refer to their understanding of air pollution, its impact on children's health, and the importance they place on mitigation efforts. Positive parental attitudes toward addressing air pollution influence their actions in protecting their children. Mitigating children's environmental health involves various preventive measures taken by parents to reduce health risks from exposure to polluted air, Research findings reveal that parental knowledge about the hazards of air pollution has a significant effect on their behavior in protecting their children's health ($p < .05$), as does their attitude toward pollution mitigation ($p < .05$). The combined contribution of knowledge and attitudes toward pollution mitigation accounts for 54.8% of the variance in this protective behavior. Therefore, educating parents in Jakarta on the health risks of air pollution is critically urgent. The government is also implementing measures to reduce pollution by limiting vehicle emissions and industrial pollutants, which is expected to contribute to a healthier and safer environment for children.

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