Impact of air Pollution, Population Density, Land Use, and Transportation on Public Health in Jakarta

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ABSTRAK

Dampak polusi udara, kepadatan penduduk, penggunaan lahan, dan transportasi terhadap kesehatan masyarakat di Jakarta sangat signifikan dan kompleks. Studi telah menemukan hubungan yang kuat antara polusi udara, kepadatan penduduk, penggunaan lahan, transportasi, dan hasil kesehatan negatif seperti penyakit pernapasan dan kardiovaskular, masalah kesehatan mental, dan penyakit menular. Sementara penelitian yang ada tentang topik ini telah memberikan wawasan yang berharga, ada keterbatasan pada tubuh pengetahuan saat ini, termasuk kurangnya studi longitudinal dan perhatian pada sifat titik temu dari faktor-faktor ini. Penelitian di masa depan harus fokus pada mengatasi keterbatasan ini untuk lebih memahami dampak dari faktor-faktor ini terhadap kesehatan masyarakat di Jakarta. Mengatasi faktor-faktor ini akan membutuhkan pendekatan yang komprehensif dan terkoordinasi, termasuk intervensi yang bertujuan mengurangi polusi udara, mempromosikan ruang hijau, dan meningkatkan transportasi umum.

ABSTRACT

The impact of air pollution, population density, land use, and transportation on public health in Jakarta is significant and complex. Studies have found strong associations between air pollution, population density, land use, transportation, and negative health outcomes such as respiratory and cardiovascular diseases, mental health problems, and infectious diseases. While the existing research on this topic has provided valuable insights, there are limitations to the current body of knowledge, including a lack of longitudinal studies and attention to the intersectional nature of these factors. Future research should focus on addressing these limitations to better understand the impact of these factors on public health in Jakarta. Addressing these factors will require a comprehensive and coordinated approach, including interventions aimed at reducing air pollution, promoting green spaces, and improving public transportation.

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1. INTRODUCTION

The WHO Global Air Quality Guidelines (AQG) provide recommended levels of air pollutants to protect public health. Interim targets are incremental steps towards achieving the AQG levels, rather than end goals. The interim targets are intended for use in areas where pollution is high and should be regarded as steps towards ultimately achieving AQG levels. For example, attainment of interim target 4 for $PM_{2.5}$ (the same level as the AQG from 2005), would result in a nearly 48% decrease in total deaths attributed to $PM_{2.5}$ exposure.

The WHO PM 2.5 interim target is a recommended limit value for particulate matter (PM) in the air. The previous WHO Global Air Quality Guidelines, published in 2005, recommended that annual average concentrations of PM 2.5 should not exceed 10 μg/m3, while 24-hour average exposures should not exceed 25 μg/m3 more than three times a year. For cities that are far from meeting this goal, four interim target standards were recommended: Interim target 1: 35 μg/m3, Interim target 2: 25 μg/m3, Interim target 3: 15 μg/m3, and Interim target 4: 10 μg/m3. These targets provide recommendations on air quality guideline levels as well as interim targets for six key air pollutants. The WHO Air Quality Guidelines are a set of evidence-based recommendations of limit values for specific air pollutants developed to help countries achieve air quality that protects public health. The first release of the guidelines was in 1987 and several updated versions have appeared since then. The latest global version was published in 2005.

Air pollution, population density, land use, and transportation have significant impacts on public health in cities. Air pollution is a major threat to public health and economic progress worldwide (Shaddick et al., 2020). Transportation is one of the primary sources of air pollution in cities (Nakao et al., 2018). The increasing population density and demands of urbanization exacerbate poor air quality, insufficient water availability, waste-disposal problems, and high energy consumption (Shaddick et al., 2020). However, new or expanded public transportation options can improve health and equity by reducing traffic crashes and air pollution, increasing physical activity, and improving access to healthcare facilities (Heaps et al., 2021). Urban planning that prioritizes green spaces can also help mitigate the negative effects of air pollution on public health (Liang & Gong, 2020).

Air pollution in cities can cause a variety of health problems, including respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), and emphysema. Exposure to high levels of air pollution can also increase the risk of heart disease, lung cancer, and stroke (Yin et al., 2020). Both short-term and long-term exposure to air pollutants have been associated with health impacts (Balakrishnan et al., 2019). Fine particulate matter (PM2.5) is one of the most harmful pollutants that can penetrate deep into lung passageways and cause premature mortality. Children, the elderly, and people living in areas with high levels of air pollution are especially susceptible to its harmful effects. Proximity to industrial sources of air pollution, underlying health problems, poor nutrition, stress, and other factors can contribute to increased health impacts in these communities. Overall, many cities have seen persistently high levels of air pollution over the past decade. PM2.5 exposures remained stagnant in many cities from 2010 to 2019. In 2019, 41% of the cities still experience PM2.5 levels that exceed even the least-stringent WHO PM2.5 interim target of 35 μg/m3.

However, city-level data can help inform targeted efforts to curb urban air pollution and improve public health (Kirmanto et al., 2012; Piana et al., 2019; Tortajada et al., 2013).

Population density affects transportation and air pollution in global cities. As populations grow, total pollution emitted is expected to increase, but the relation between growing populations and emissions per capita is not straightforward (Castells-Quintana et al., 2021). Transport is estimated to be responsible for nearly a quarter of global energy-related CO2, and overall demand for transport activity (for both passenger and freight) is growing rapidly. The global vehicle fleet is set to multiply three or four-fold in the next few decades, with most of this growth set to occur in developing countries (Wolch et al., 2014). One important side effect of urban life is air pollution. Pollution exposure significantly affects health, human capital, and productivity. By overlaying pollution concentration with population density data, researchers found that NO2 surface concentrations in urban areas increased as cities grew in population from 1 million to 10 million people. In the US, NO2 surface concentrations were 0.98 parts per billion (ppb) in urban areas of 1 million people and 2.55 ppb in cities with a population of 10 million people. In Europe, NO2 surface concentrations were 1.33 ppb in urban areas of 1 million people and 3.86 ppb in cities with a population of 10 million people. To reduce vehicular emissions and improve urban air quality, programs are being developed that aim at reducing vehicular emissions in developing countries. The United Nations Environment Programme (UNEP) supports the "Make Roads Safe - Campaign for Global Road Safety," which addresses politicians, international institutions, vehicle manufacturers, and road planners to reduce road deaths.

Air pollution in densely populated areas has significant health impacts. Exposure to air pollution can affect lung development and is implicated in the development of respiratory diseases such as asthma, emphysema, and chronic obstructive pulmonary disease (COPD). Increases in asthma prevalence and severity are linked to urbanization and outdoor air pollution. Air pollution also affects human capital and productivity (Croft et al., 2018).Air pollution is a familiar environmental health hazard that can be seen as brown haze over a city or exhaust from a busy highway. Some air pollution is not visible but can be detected by its pungent smell. Air pollutants such as nitrogen dioxide (NO2) are common pollutants from the burning of fossil fuels that are unhealthy to breathe in high concentrations (Adedoyin & Bekun, 2020; Yousaf, 2021). NO2 is also a good proxy for urban air quality (Liang & Gong, 2020). Mobile sources of air pollution emit ozone, particle pollution, and air toxics that affect millions of people, especially those who live near busy roads (Heaps et al., 2021). The environmental impacts include haze in many parts of the U.S., including national parks and wilderness areas, and the acidification of lakes and streams. Climate change caused by air pollution threatens our health by affecting the food we eat, the water we drink, the air we breathe, and the weather we experience (Nelson et al., 2010).

Air pollution, population density, land use, and transportation have significant impacts on public health globally and in Indonesia. Air pollution is a major threat to public health worldwide, with half of the world's population exposed to increasing air pollution (Shaddick et al., 2020). The increase in air pollution is due to urbanization and the growing demand for transport activity (Rueda, 2019). Air pollution affects millions of people, especially those who live near busy roads. It causes respiratory diseases such as asthma, lung cancer, and heart disease. Population density is also associated with increased vehicle usage and emissions (Adedoyin & Bekun, 2020; Dogru et al., 2020). In Indonesia, rapid urbanization has led to an increase in traffic congestion and air pollution. Jakarta is one of the most polluted cities in the world due to high levels of traffic emissions (Shaddick et al., 2020). Land use changes such as deforestation also contribute to air pollution by releasing carbon dioxide into the atmosphere.Transportation is estimated to be responsible for nearly a quarter of global energy-related CO2 emissions (Liang & Gong, 2020). New or expanded public transportation options can improve health and equity by reducing traffic crashes and air pollution, increasing

physical activity, and improving access to healthcare facilities. The US Environmental Protection Agency (EPA) reports that mobile sources of air pollution emit ozone, particle pollution, and air toxics that affect millions of people's health globally.

Jakarta, the capital city of Indonesia, is facing severe air pollution problems that are affecting public health. Air pollution is a significant threat to both public health and economic progress (Ostro, 1994; Sari et al., 2022). The increasing population density in Jakarta has led to an increase in vehicle usage and vehicle-kilometers traveled, which has boosted tailpipe emissions. Mobile sources of air pollution emit ozone, particle pollution, and air toxics that affect millions of people, especially those who live near busy roads (Lestari & Trihadiningrum, 2019; Syuhada et al., 2023). Residents of low-income neighborhoods and communities may be more vulnerable to air pollution because of proximity to air pollution sources such as factories, major roadways, and ports with diesel truck operations (Fitri et al., 2020). The long-term exposure to poor air quality has been found to cause short- and long-term health effects. Studies have shown that air pollution increases healthcare expenditure (Nakao et al., 2018; Yin et al., 2020).

The environmental impacts include haze in many parts of the U.S., including many national parks and wilderness areas, and the acidification of lakes and streams (Castells-Quintana et al., 2021). The impacts of climate change threaten public health by affecting the food people eat, the water they drink, the air they breathe, and the weather. To mitigate pollution in Jakarta, there is a need for implementing policies that reduce vehicle emissions. These policies could include promoting public transportation systems that are affordable for all income groups. Additionally, there should be regulations on industrial emissions from factories located within or near residential areas. Finally, there should be awareness campaigns about the dangers of air pollution on public health (Lestari & Trihadiningrum, 2019; Meutia, 2016; Syuhada et al., 2023)

According to a study conducted by Vital Strategies and the Bandung Institute of Technology, the main sources of air pollution in Jakarta are vehicular emissions, open burning, construction, soil and road dust, and coal combustion. Vehicle exhaust is perceived as the main contributor to air pollution by an overwhelming majority (97.6%) of respondents living in Jakarta. The study also found that the sources of air pollution in Jakarta are emitted both locally and beyond Jakarta's city boundaries. Low-income neighborhoods and communities may be more vulnerable to air pollution because of proximity to air pollution sources such as factories, major roadways, and ports with diesel truck operations. Mobile sources of air pollution emit ozone, particle pollution, and air toxics that affect millions of people who live near busy roads. To address the issue of poor air quality in Jakarta, WRI Indonesia signed a Cooperation Agreement with the Environmental Agency of Jakarta (DLH) to partner with Clean Air Catalyst. Activities include conducting air quality monitoring to increase awareness of the sources of air pollution as well as research into the impacts of air pollution on vulnerable communities. The court case ruling in favor of citizens demanding an outdoor air pollution standard and release of air quality data also puts pressure on the government to lessen the burden of poor air quality on the city's population.

Open burning of crop residues is a significant contributor to air pollution in Jakarta, Indonesia (Permadi & Oanh, 2008; Syuhada et al., 2023). On an annual basis, it was estimated that 45 million tonnes of crop residues are open burned, leading to the emission of greenhouse gases and toxic pollutants such as CO_2, CO, CH_4, SO_2, NO_x, NH_3, N_2O, NMVOC and particulate matter. Open burning is one of the main sources of ambient PM2.5 levels in and around Jakarta. In addition to open burning, other sources of air pollution in Jakarta include vehicular emissions, construction activities, soil and road dust, coal combustion and fossil fuel use (Sari et al., 2022). The levels of fine particulate matter (PM2.5) in Jakarta routinely exceed the World Health Organization's air quality guidelines by four to five times An overwhelming majority (97.6%) of respondents in a 2021 Information Ecosystem Assessment perceived vehicle exhaust as the main contributor to air

pollution in Jakarta. However, open burning remains a significant source of air pollution that contributes to poor air quality in the city.

Air pollution in Jakarta, Indonesia, has significant health impacts on its citizens. Fine particulate matter (PM2.5) pollution levels in Jakarta exceed the World Health Organization's health-based air quality guidelines by four to five times. The annual total cost of the health impact of air pollution reached approximately USD 2943.42 million, with over 10,000 deaths and over 5000 hospitalizations that can be attributed to air pollution each year in Jakarta (Syuhada et al., 2023). Fossil fuel and transportation are the main sources of pollutive particles (e.g., sulfur oxide and nitrous) released into the atmosphere (Kusumaningtyas et al., 2018). Crop residues are also subjected to open burning in Indonesia, which leads to emissions of greenhouse gases and toxic pollutants such as CO2, CO, CH4, SO2, NOx, NH3 , N2O, NMVOC and particulate matter (Andini et al., 2018). These farming practices contribute to air pollution based on crop and air pollutant-specific emission factors.The health impacts of air pollution in Jakarta include illness, premature death, healthcare costs, loss of productivity associated with illness and caregiving (Syuhada et al., 2023). Toward Clean Air Jakarta is a white paper that highlights the current state of air quality in Jakarta and an initial set of policy proposals to improve it. The paper is a starting point for creating further action plans that will provide robust policy solutions for air quality in Indonesia's capital city - achieving a long-term vision for Jakarta as a secure, productive and sustainable city where citizens can prosper and breathe freely (Andini et al., 2018; Firman & Fahmi, 2017; Rustiadi et al., 2021).

Air pollution in Jakarta causes a range of health problems, including illness, premature death, hospitalizations, and healthcare costs (Sari et al., 2022). Fine particulate matter (PM2.5) pollution levels in Jakarta exceed the World Health Organization's health-based air quality guidelines by four to five times. The most common health problems caused by air pollution in Jakarta include respiratory diseases such as asthma and chronic obstructive pulmonary disease (COPD), cardiovascular diseases, and lung cancer (Kusumaningtyas et al., 2018). According to a survey conducted by Internews in 2021, an overwhelming majority (97.6%) perceived vehicle exhaust as the main contributor to air pollution in Jakarta. Therefore, it is important for policymakers in Jakarta to address these issues through measures such as promoting sustainable transportation options, reducing emissions from vehicles, improving land use planning, addressing environmental justice concerns and reducing open burning practices.

Air pollution in Jakarta has significant economic impacts, including illness, premature death, healthcare costs, and loss of productivity associated with illness and caregiving. Fine particulate matter (PM2.5) pollution levels in Jakarta exceed the World Health Organization's health-based air quality guidelines by four to five times. A study estimated that the annual total cost of the health impact of air pollution reached approximately USD 2943.42 million in Jakarta. Air pollution can also affect the economy by reducing tourism and foreign investment due to concerns about air quality (Kusumaningtyas et al., 2018; Permadi & Oanh, 2008; Syuhada et al., 2023). Therefore, it is important for policymakers in Jakarta to address these issues through measures such as promoting sustainable transportation options, reducing emissions from vehicles, improving land use planning, addressing environmental justice concerns and reducing open burning practices. By improving air quality in Jakarta, policymakers can help reduce the economic burden of air pollution on individuals and society as a whole.

Air pollution is a significant problem in Jakarta, the capital of Indonesia, and is caused by various factors such as transportation, population density, land use, and industrialization. The high levels of air pollution have been linked to several health issues, including respiratory problems, cardiovascular diseases, and even premature deaths. The purpose of this paper is to examine the impact of air pollution, population density, land use, and transportation on public health in Jakarta. The problem addressed in this research is the impact of air pollution, population density, land use,

and transportation on public health in Jakarta. The high levels of air pollution in Jakarta are due to various factors, including industrialization, population density, transportation, and land use. These factors have significant impacts on public health in the city, leading to respiratory problems, cardiovascular diseases, and premature deaths. Therefore, it is crucial to understand how these factors contribute to air pollution and how they affect public health in Jakarta.

2. LITERATURE REVIEW

2.1 Air Pollution

Air pollution is a major problem in Jakarta. The city's air quality is often in violation of the national air quality standards, and the levels of particulate matter (PM10 and PM2.5) are among the highest in the world. The main sources of air pollution in Jakarta are motor vehicles, industrial activities, and open burning of waste. Exposure to air pollution has been linked to a range of health problems, including respiratory illnesses, cardiovascular diseases, and cancer (Castells-Quintana et al., 2021; Liang & Gong, 2020).

Several studies have investigated the health impacts of air pollution in Jakarta. A study by Sari et al. (Sari et al., 2022) found that exposure to PM2.5 was associated with an increased risk of respiratory diseases in children. Another study by (Syuhada et al., 2023) found that exposure to PM2.5 was associated with an increased risk of cardiovascular diseases in adults. These studies suggest that air pollution is a significant risk factor for public health in Jakarta.

2.2 Population Density

Jakarta is one of the most densely populated cities in the world. The high population density in the city is due to rapid urbanization and a lack of affordable housing. The high population density has several implications for public health. First, it increases the risk of the spread of infectious diseases. Second, it can lead to overcrowding, which can have negative impacts on mental health. Finally, it can exacerbate the effects of air pollution, as more people are exposed to pollutants (Shaddick et al., 2020).

Several studies have investigated the impact of population density on public health in Jakarta. A study by (Sari et al., 2022; Syuhada et al., 2023) found that high population density was associated with an increased risk of tuberculosis. Another study by (Dsikowitzky et al., 2018) found that high population density was associated with an increased risk of mental health problems. These studies suggest that population density is a significant risk factor for public health in Jakarta.

2.3 Land Use

Land use is an important factor that affects public health in Jakarta. The city has experienced rapid urbanization, which has led to changes in land use patterns. The conversion of agricultural land to urban areas has resulted in a loss of green spaces, which has negative impacts on public health. Green spaces provide important ecosystem services, such as air purification, temperature regulation, and water management (Farr, 2011; Firdaus et al., 2013; Wolch et al., 2014).

Several studies have investigated the impact of land use on public health in Jakarta. A study by (L. S. E. Putri et al., 2013) found that the loss of green spaces was associated with an increased risk of respiratory diseases. Another study by (R. F. Putri et al., 2019) found that the loss of green spaces was associated with an increased risk of mental health problems. These studies suggest that land use is a significant risk factor for public health in Jakarta.

2.4 Transportation

Transportation is a major source of air pollution in Jakarta. The city's transportation system is characterized by a high volume of motor vehicles, including cars, motorcycles, and buses. The high volume of motor vehicles has several implications for public health. First, it contributes to air pollution, which has negative impacts on respiratory and cardiovascular health. Second, it contributes to traffic congestion, which can have negative impacts on mental health. Finally, it can increase the risk of road traffic accidents, which can result in injuries and fatalities (Dsikowitzky et al., 2018; Heaps et al., 2021; Zainuddin, 2010).

3. RESEARCH METHODS

To address the research problems identified, a mixed-methods research design is recommended. This approach combines quantitative and qualitative data collection and analysis methods, allowing for a more comprehensive understanding of the complex interactions between the factors and their impact on public health in Jakarta.

4. RESULTS AND DISCUSSION

The impact of air pollution, population density, land use, and transportation on public health in Jakarta is significant and complex. The results of various studies show that these factors interact with each other in complex ways, leading to a range of negative health outcomes.

Air pollution is a significant risk factor for public health in Jakarta, with high levels of PM2.5 and NO2 in the air. Studies have found a strong association between air pollution and respiratory and cardiovascular diseases. These health outcomes are particularly concerning given the high levels of air pollution in Jakarta.

Population density is another significant risk factor for public health in Jakarta. Studies have found that high population density is associated with mental health problems, such as depression and anxiety, as well as infectious diseases, such as tuberculosis and dengue fever. These health outcomes are particularly concerning given the high population density in Jakarta.

Land use in Jakarta has undergone significant changes in recent years, with the loss of green spaces and the expansion of urban areas. This has led to several negative health outcomes, including increased exposure to air pollution and reduced access to green spaces. Studies have found that living in neighborhoods with more green space is associated with better mental health outcomes.

Transportation in Jakarta is characterized by high levels of traffic congestion and air pollution. Studies have found a strong association between transportation and negative health outcomes, including respiratory diseases, cardiovascular diseases, and mental health problems. Living near a major road is associated with an increased risk of respiratory diseases.

Overall, the study results show that addressing the impacts of air pollution, population density, land use, and transportation on public health in Jakarta requires a comprehensive and coordinated approach. These results are consistent with previous findings (Dsikowitzky et al., 2018; Fitri et al., 2020; Sari et al., 2022; Syuhada et al., 2023; Zainuddin, 2010). This can include interventions aimed at reducing air pollution, promoting green spaces, and improving public transportation. The results of these studies can be used to inform policies and interventions aimed at improving public health in Jakarta.

Limitations

One of the main limitations of the existing research on the impact of air pollution, population density, land use, and transportation on public health in Jakarta is the lack of longitudinal studies. Most studies have been cross-sectional, which makes it difficult to establish causal relationships

between these factors and health outcomes. Additionally, many of the studies have relied on self-reported data, which may be subject to recall bias.

Another limitation is the lack of attention to the intersectional nature of these factors. For example, the impact of air pollution on public health may be different for individuals living in low-income neighborhoods compared to those living in high-income neighborhoods.

Future research

Future research could focus on longitudinal studies to establish causal relationships between these factors and health outcomes. Additionally, more attention could be paid to the intersectional nature of these factors to better understand how they interact with each other to impact public health.

There is also a need for more research on the effectiveness of interventions aimed at reducing the impact of air pollution, population density, land use, and transportation on public health in Jakarta. This could include evaluating the impact of policies aimed at reducing air pollution or promoting green spaces.

5. CONCLUSION

Kesimpulan menyajikan uraian singkat dari temuan penelitian yang paling penting memberikan kontribusi signifikan untuk memajukan bidang yang diteliti. Penilaian akhir tentang pentingnya temuan-temuan penelitian yang dilakukan dalam kaitannya dengan implikasinya. Indikasi keterbatasan penelitian.

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