

Mortality Trends of Air Pollution-Sensitive Diseases in Jakarta, Indonesia: A Population-Based Analysis, 2019-2023

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Abstract

Air pollution is a leading environmental health risk, especially in megacities with limited monitoring infrastructure. In Jakarta, few studies have examined mortality trends for air pollution-sensitive diseases. This population-based study analyzed registered deaths in Jakarta (2019–2023) attributed to cardiovascular and respiratory diseases linked to air pollution. Mortality data were disaggregated by disease type, age, sex, region, and reporting facility. Stroke consistently accounted for the highest number of deaths, increasing by 36% from 2020 to 2023. Pneumonia and influenza declined until 2022 but surged in 2023 by 48%. Senior adults (≥ 60 years) bore the highest burden, and men consistently had higher death counts than women. East Jakarta recorded the highest regional mortality, while Thousand Islands had the lowest. Reporting by community health centers grew steadily, reaching 48.3% of all reported deaths in 2023. Mortality trends in Jakarta reflect a growing burden of air pollution-sensitive diseases, particularly among the elderly and in more polluted districts. Expanding surveillance coverage, improving cause-of-death certification, and integrating mortality with environmental data are essential for guiding air quality and health policy in urban Indonesia.

Keywords: Air Pollution, Mortality, Cardiovascular Disease, Respiratory Disease, Environmental Health Epidemiology.



A. INTRODUCTION

Air pollution is a major public health concern, causing approximately 7 million premature deaths annually worldwide, primarily due to cardiovascular and respiratory diseases (World Health Organization, 2021). The Global Exposure Mortality Model (GEMM) estimates that ambient air pollution shortens global life expectancy by 2.9 years, exceeding the impact of tobacco use (Lelieveld et al., 2020). Key pollutants such as PM_{2.5}, NO₂, and O₃ contribute to systemic inflammation, oxidative stress, and vascular dysfunction, which are central to the development of cardiopulmonary diseases (Cohen et al., 2017).

Epidemiological evidence consistently links air pollution to increased mortality from ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), pneumonia, and lower respiratory infections (Weichenthal et al., 2022; World Health Organization, 2021). The Global Burden of Disease Study 2019 attributed 4.14 million

deaths and 118 million lost healthy life years to short- and long-term PM_{2.5} exposure, with the greatest impact in South and East Asia, particularly among vulnerable populations (Wu et al., 2021). In Beijing, short-term exposure to pollutants like SO₂ and NO₂ has been associated with non-accidental mortality, with relative risks (RR) of 1.054 (95% CI: 1.009–1.100) for SO₂ and 1.038 (95% CI: 1.013–1.063) for NO₂, underscoring the acute health risks of even minor increases in pollutant levels (Wang et al., 2023).

According to the World Health Organization (WHO), air quality monitoring remains inadequate in many regions, particularly in low- and middle-income countries. The WHO's 2022 air quality database includes data from approximately 6,743 human settlements, yet over 90% of these are located in high- and middle-income countries, indicating a significant disparity in monitoring capabilities (Shairsingh et al., 2023). An inventory of ambient air quality standards across 194 countries revealed that 57 countries lack any established air quality standards for key pollutants, highlighting the global challenge in meeting WHO guidelines (Kutlar Joss et al., 2017). Studies demonstrate that mortality data can capture 60-80% of pollution-attributable deaths when properly coded (Murray et al., 2020). The World Bank (2022) estimates that mortality records provide the primary evidence base for pollution health impacts in 78% of African and 63% of Southeast Asian nations with insufficient monitoring infrastructure (Clement et al., 2021).

Jakarta illustrates the importance of mortality data in evaluating the health impact of air pollution, particularly in settings with limited monitoring. In 2024, the city's average PM_{2.5} concentration reached 41.7 µg/m³, over 8 times the WHO annual guideline of 5 µg/m³ (IQAir, 2024). With only 12 permanent air quality monitors for more than 11 million residents, Jakarta lacks sufficient surveillance capacity. This gap has made mortality data essential for assessing public health risks. A 2023 study estimated over 10,000 premature deaths in Jakarta were linked to air pollution exposure, underscoring the urgent need for integrated air quality and health policies (Syuhada et al., 2023).

However, there is a noticeable lack of research leveraging mortality data to assess the burden of mortality attributable to air pollution-sensitive diseases. This study aims to address this gap by providing a comprehensive epidemiological analysis of mortality from respiratory and cardiovascular conditions associated with air pollution in Jakarta, utilizing death records from hospitals and community health centers as the primary data sources.

B. METHOD

We conducted a retrospective population-based analysis of all registered deaths attributed to air pollution-sensitive diseases in Jakarta, Indonesia from January 1, 2019 to December 31, 2023. Data were obtained from the Jakarta Provincial Health Office's complete mortality registry. The dataset included:

1. Underlying cause of death (ICD-10 coded)
2. Basic demographics (age, sex, residential district)

3. Reporting source (hospital/community health center)
4. Date of death registration (exact time of death unavailable)

This study focused on mortality cases within Jakarta's administrative boundaries, specifically targeting deaths attributed to air pollution-sensitive diseases. Cases were included if they met the following criteria: (1) the death occurred within Jakarta's administrative region; (2) the underlying cause of death was classified under predetermined air pollution-sensitive ICD-10 codes, including respiratory conditions (J09-J18 for influenza and pneumonia, J40-J44 for chronic obstructive pulmonary disease) and cardiovascular conditions (I10-I15 for hypertension, I20-I25 for ischemic heart disease, I60-I69 for stroke); and (3) complete information was available for age, sex, and district of residence.

Exclusion criteria were applied to enhance data quality and included (1) deaths attributed to nonspecific or poorly defined causes (e.g., R99 for ill-defined causes, J96.9 for unspecified respiratory failure) and (2) cases with incomplete demographic data, such as missing age, sex, or district of residence. These criteria ensured that the analysis was based on accurate and reliable data directly linked to air pollution-sensitive health outcomes.

This study employed a multi-dimensional analysis to examine mortality patterns attributed to air pollution-sensitive diseases in Jakarta from 2019 to 2023. Temporal trends were assessed by calculating annual mortality counts for each disease category. Age-specific mortality analysis was conducted by categorizing deaths into five age groups (children: 5–18 years, adults: 20–39 years, middle-aged adults: 40–59 years, and senior adults: ≥ 60 years). Sex-specific analysis compared mortality to identify sex-based differences. Spatial distribution was analyzed by categorizing deaths based on residential districts (East Jakarta, West Jakarta, North Jakarta, South Jakarta, Central Jakarta, and the Thousand Islands) to highlight geographical disparities. The analysis grouped deaths based in where reports originated, such as hospitals and community health centers, to examine differences in how mortality data are recorded. This comprehensive approach provided a detailed understanding of mortality patterns, highlighting temporal, demographic, geographical, and reporting variations.

C. RESULTS AND DISCUSSION

This study analyzed mortality trends from air pollution-sensitive diseases in Jakarta between 2019 and 2023, focusing on temporal variation, demographic disparities, spatial distribution, and differences by healthcare reporting sources.

1. Temporal Trends by Disease Type

Stroke remained the leading cause of death across the study period, rising from 2,794 in 2020 to 3,790 in 2023. Ischemic heart disease showed fluctuations, peaking in 2021. Notably, pneumonia and influenza cases declined steadily from 2019 to 2022 before surging 48% in 2023, likely reflecting post-pandemic vulnerabilities. Hypertensive disease deaths were stable, while COPD showed minimal variation. These trends mirror global and regional findings that link PM_{2.5} exposure with

cardiovascular mortality spikes and post-infection respiratory vulnerability (Chen et al., 2017; Cortes et al., 2023; Dong et al., 2018).

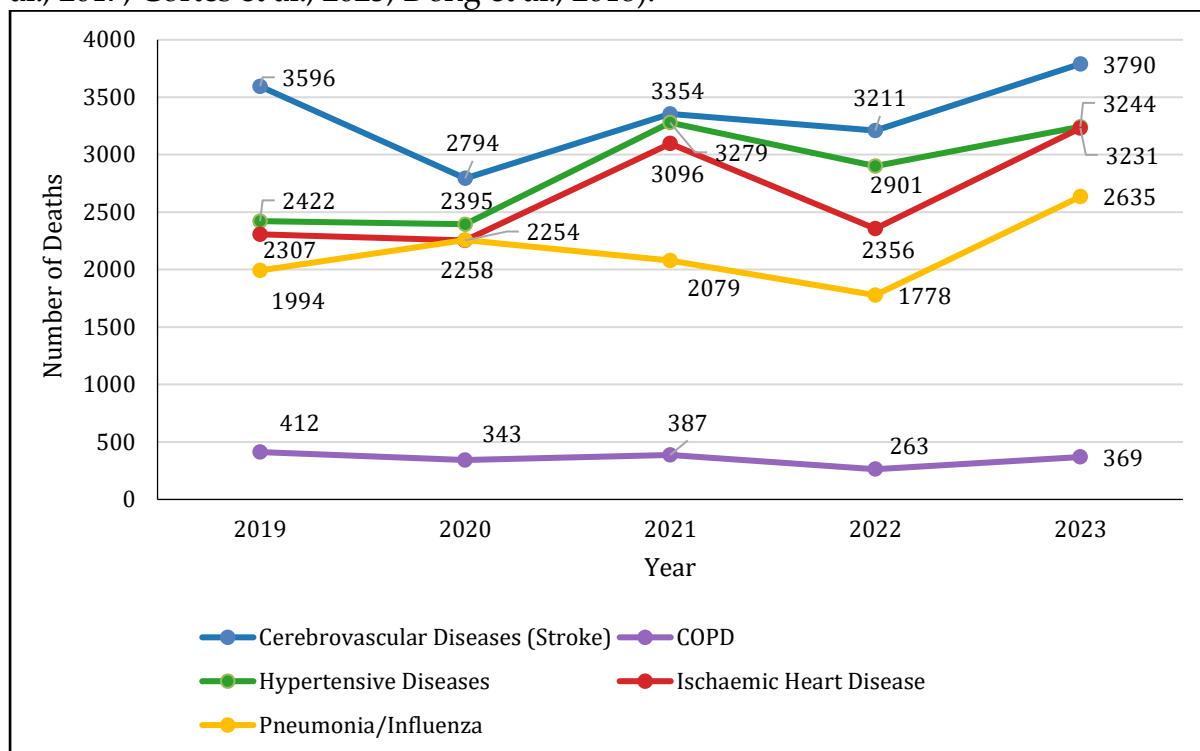


Figure 1. Annual Mortality from Air Pollution-Sensitive Diseases in Jakarta

Comparative data from Chinese cities and Rio de Janeiro support Jakarta's mortality dynamics, reinforcing that both chronic and acute exposures influence outcomes. For instance, short-term pollution surges significantly increased stroke and heart disease mortality (Cortes et al., 2023; Dong et al., 2018). The sharp pneumonia rebound in 2023 aligns with studies showing heightened respiratory vulnerability following COVID-19, particularly in elderly populations under continued pollution stress (Ho et al., 2019; Liu et al., 2024).

2. Demographic Patterns

Adults ≥ 60 years consistently bore the highest mortality burden, rising from 6,874 deaths in 2022 to 8,858 in 2023. Middle-aged adults were second most affected, while younger individuals had stable, lower mortality. These patterns underscore global findings that elderly populations have elevated susceptibility to PM_{2.5} due to compromised immunity and comorbidities (Chen et al., 2017; Liu et al., 2024; Wang et al., 2023).

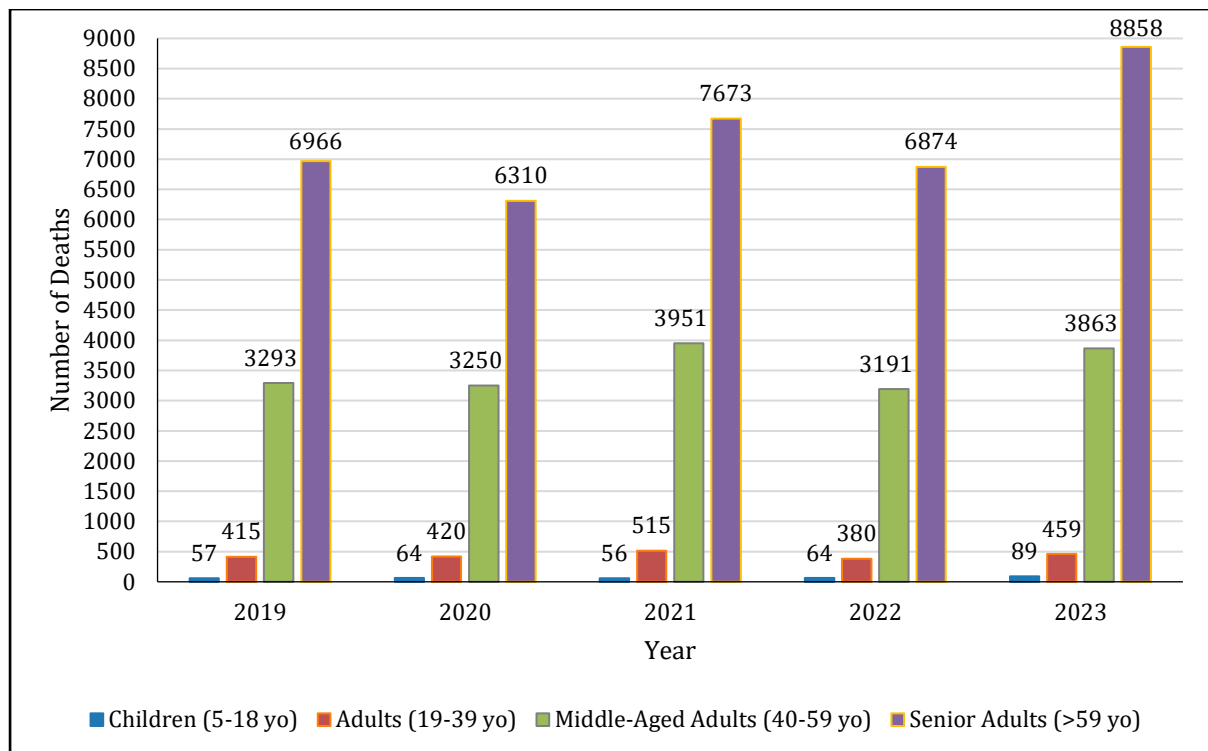


Figure 2. Age-Specific Mortality from Air Pollution-Sensitive Diseases in Jakarta

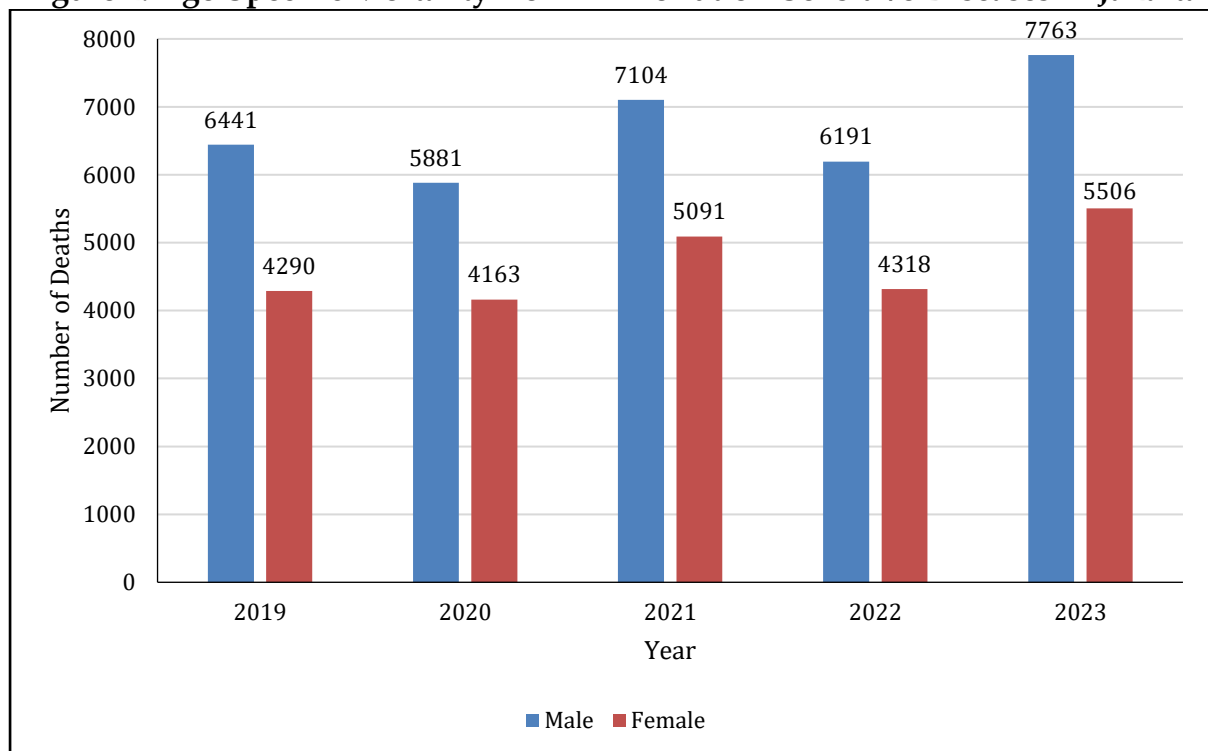


Figure 3. Sex-Specific Mortality from Air Pollution-Sensitive Diseases in Jakarta

Male mortality consistently exceeded female mortality, with 7,763 male deaths versus 5,506 female deaths in 2023. This disparity may stem from occupational exposures, behavioral differences, and underlying comorbidities. Prior research affirms that men may be more affected by pollution due to higher outdoor activity levels and smoking prevalence (Chen et al., 2017; R. A. Liu et al., 2022).

3. Spatial Distribution

Regionally, East Jakarta recorded the highest mortality, followed by South and West Jakarta. These areas face compounded environmental burdens from traffic, industrial activities, and limited green space. The spatial trends reflect findings in Beijing and other Asian megacities, where high-density urbanization correlates with elevated mortality risks (Han et al., 2023; Shairsingh et al., 2023).

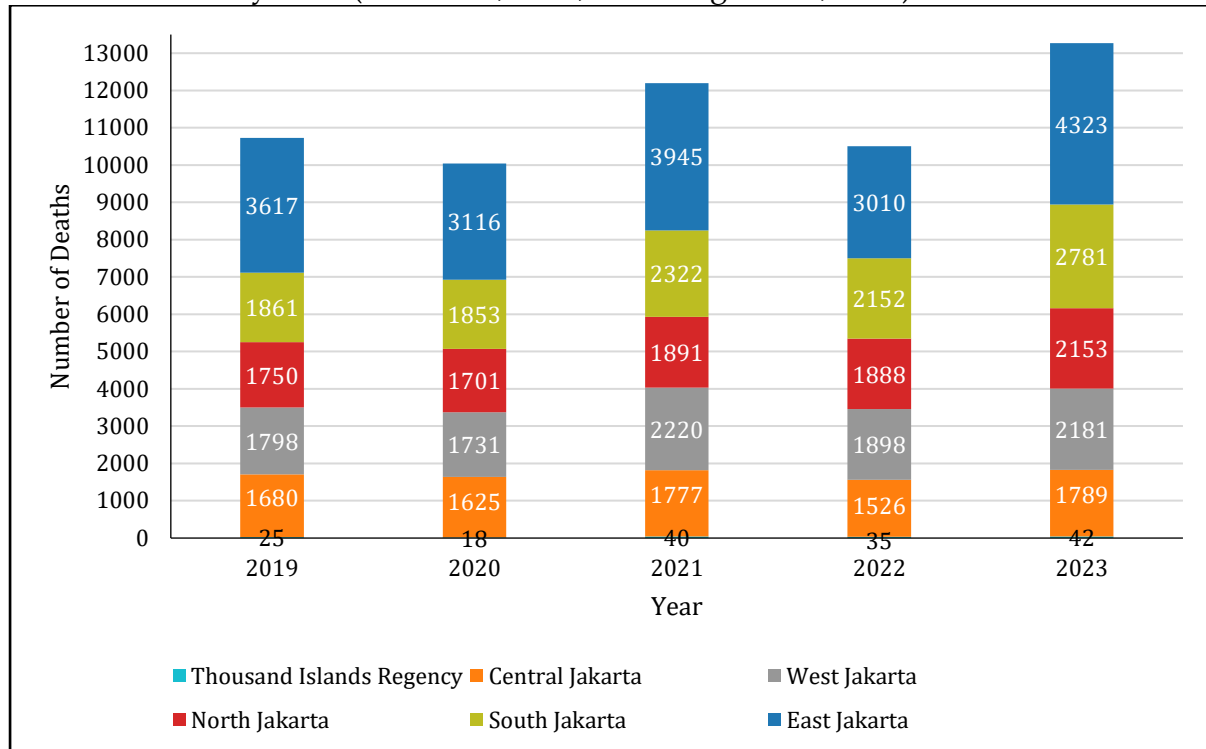


Figure 4. Regional Mortality from Air Pollution-Sensitive Diseases in Jakarta

In contrast, the Thousand Islands reported fewer than 50 annual deaths. While this may reflect lower pollution exposure, underreporting in remote districts remains a concern. Research underscores the need for enhanced surveillance in low-density and remote areas to capture accurate mortality patterns (IQAir, 2024; Sannoh et al., 2024).

4. Reporting Source Discrepancies

Reporting by community health centers (Puskesmas) rose from 4,637 deaths in 2019 to 6,413 in 2023, nearing parity with hospital reports. This shift suggests improving surveillance capacity at the primary care level. Yet, studies from Brazil and China highlight that hospital-based death attribution tends to be more accurate due to diagnostic resources (Chen et al., 2017; Cortes et al., 2023).

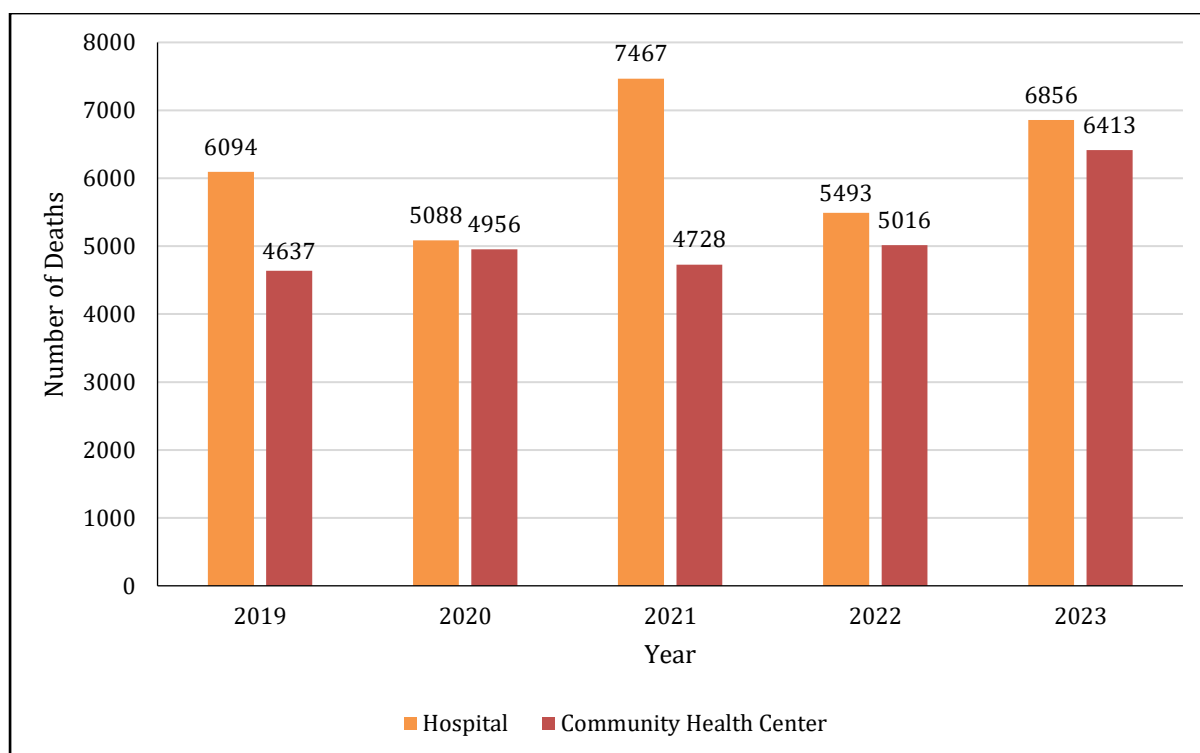


Figure 5. Annual Deaths from Air Pollution-Sensitive Diseases by Health Facility Reporting Sources in Jakarta

The gap between registry-based deaths and modelled estimates remains wide. Global Burden of Disease models predict that actual air pollution mortality in Indonesia likely exceeds reported figures, due to underreporting and limitations in local air monitoring infrastructure (Murray et al., 2020; Wu et al., 2021). Integrating mortality data with pollution metrics is critical for accurate burden assessments and policy guidance.

D. CONCLUSION

This study reveals a persistent and growing mortality burden from stroke, ischemic heart disease, and respiratory illnesses in Jakarta, particularly affecting older adults and men. Regional disparities, with East Jakarta bearing the highest burden, reflect environmental and infrastructural inequalities. While the increasing role of Puskesmas in death reporting signals progress in health surveillance, diagnostic limitations and underreporting remain challenges—especially in peripheral regions. Given the city's high air pollution levels and limited monitoring infrastructure, integrating mortality data into environmental health policy is essential. Enhancing diagnostic capacity, expanding monitoring coverage, and embedding mortality analysis into urban air governance will be critical to reduce the health impact of air pollution in Jakarta.

ETHICAL CONSIDERATIONS

The study protocol was approved by Faculty of Health Science UIN Syarif Hidayatullah Jakarta Ethics Committee (No. Un.01/F.10/KP.01.1/KE.SP/05.08.033/2025).

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