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Urban Transportation and Rising CO Emissions: A Case Study of East Jakarta and its Public Health Impacts

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ABSTRACT

Introduction: Carbon monoxide (CO) emissions from urban transportation present a critical challenge for air quality, public health, and environmental sustainability. East Jakarta, with its rapid motorization and chronic traffic congestion, serves as a case study for the broader impacts of urban CO pollution. This study investigates the correlation between CO levels and traffic density, providing empirical insights into the dynamics of transportation-driven air pollution in densely populated cities.
Methods: A quantitative cross-sectional study was conducted in July 2024, measuring CO concentrations at 15 strategic locations using calibrated CO meters. Sampling sites were selected based on traffic volume, population exposure, and historical emission data to ensure a comprehensive urban representation. Data analysis included descriptive statistics, normality tests, and regression analysis to evaluate relationships between CO levels, traffic patterns, and supporting variables.
Results: Findings revealed an average CO concentration of 6,665 µg/m³, with Jatinegara Kaum (15,380 µg/m³) and Duren Sawit (13,031 µg/m³) exceeding the government air quality threshold (10,000 µg/m³). A strong positive correlation ($R^2 = 0.78$, $p < 0.05$) was identified between traffic congestion and CO levels, confirming vehicular emissions as the dominant contributor. Moreover, no significant correlation with weather variables was observed, further emphasizing the role of transportation in shaping local air quality.
Conclusion: These results underscore the urgent need for policy interventions, including the expansion of electric vehicle infrastructure, congestion pricing, and green urban planning. This study also highlights the necessity of integrating real-time air quality monitoring and AI-based traffic flow management to optimize pollution control efforts. By situating East Jakarta's case within global urban air pollution trends, these findings offer scalable insights applicable to other rapidly urbanizing cities worldwide.

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INTRODUCTION

Urban air pollution has long been recognized as a critical environmental issue worldwide (1–5). According to the World Health Organization, nearly 90% of urban residents are exposed to air that does not meet safe quality standards (6–8). In East Jakarta, local monitoring indicates that pollutant concentrations such as PM2.5 often exceed safe limits, underscoring the need for an in-depth analysis that connects global trends with the specific conditions in this area.

Data from the Central Bureau of Statistics reveals that the number of motor vehicles in Jakarta increased from 21,911,811 units in 2022 to 22,907,081 units in 2023. This increase, which amounts to nearly 5% within one year, is especially evident in East Jakarta, where the growth in motor vehicles corresponds directly with increased traffic congestion and a reduction in the average vehicle speed to below 20 km/h during peak hours.

Economic growth and rising transportation demand further exacerbate air quality issues in East Jakarta. For example, motor vehicle production in Jakarta increased by 8.29% in 2022 compared to 2021. This data demonstrates that socioeconomic factors—such as economic growth, urbanization, and rising income—directly influence the increase in the number of vehicles and, ultimately, the quality of air in the region.

Motor vehicles are a major source of carbon monoxide (CO) emissions, the most abundantly produced gas from the combustion of fuels (9–12). Chemically, CO has an affinity for hemoglobin up to 200 times greater than that of oxygen, leading to the formation of carboxyhemoglobin and a decreased capacity of the blood to transport oxygen. Short-term exposure to CO can trigger acute respiratory infections, while long-term exposure is associated with an increased risk of heart disease, stroke, and impaired lung function (13–18).

Traffic congestion in East Jakarta plays a key role in exacerbating CO emissions. During peak hours, the average vehicle speed on main roads drops below 20 km/h, resulting in incomplete fuel combustion and higher CO emissions (5). This condition highlights the importance of evaluating local transportation dynamics as one of the main factors underlying the deterioration of air quality.

Considering the significant increase in motor vehicles—rising by nearly 5% between 2022 and 2023 and with vehicle production up by 8.29% in 2022—this study urgently calls for an investigation into the impact of transportation on CO emissions in East Jakarta. By integrating socioeconomic data, traffic patterns, and emission trends, the study aims to provide strategic recommendations for sustainable transportation management and air quality improvement, ultimately reducing health risks for the local population (19–24).

This study aims to evaluate the impact of the transportation sector on the increase in carbon monoxide (CO) emissions in urban environments, particularly in East Jakarta, and its effects on public health. The research measures CO levels at various strategic locations and examines the relationship between high emission levels and factors such as traffic congestion, fuel type, and vehicle combustion efficiency. The proposed hypothesis is that severe traffic congestion and inefficient fossil fuel use in East Jakarta significantly contribute to rising CO levels in the air, ultimately increasing the risk of respiratory and cardiovascular diseases among local residents. Additionally, CO emissions are suspected to play a role in accelerating climate change through chemical reactions in the atmosphere. Therefore, this study aims to provide strategic recommendations to the government and policymakers in designing sustainable transportation solutions and air pollution mitigation measures in urban areas

METHOD

This study employs a quantitative approach with a cross-sectional design to measure CO concentration at 15 strategic points in East Jakarta in July 2024. The selection of sampling points was based on criteria such as traffic density, population exposure levels, and historical emission data, thereby covering areas with varying transportation intensities. The chosen points include Utan Kayu Selatan, Utan Kayu Utara, Jatinegara Kaum, Jati, Cipinag, Rawamangun, Kayuputih, Pisangan Timur, Rawa Bunga, Bali Mester, Pondok Bambu, Duren Sawit, Pondok Kelapa, Malaka Jaya, and Klender.

CO levels were measured using a CO meter that had been calibrated in accordance with the manufacturer's standards before use. The instrument's specifications—including sensitivity, minimum detection limit, and accuracy (e.g., ±X ppm)—were recorded to identify any measurement limitations. Sampling procedures were consistently carried out at the same time each day to minimize variability due to differences in weather conditions and traffic volume.

For data analysis, both descriptive and inferential statistical methods were employed, including tests for normality and linear regression, to examine the relationship between CO concentration, traffic density, and other supporting variables. In addition, the study controlled for confounding variables such as weather conditions (temperature, humidity, and wind speed), sampling time, and potential non-transportation emission sources to ensure that the results are both valid and reliable. The measurement data were then compared to the applicable air quality standards and presented in table form for further analysis of the impact of CO on public health.

The selection of sampling points is based on several key factors, including traffic density, area characteristics, geographical distribution, and site accessibility. Areas with high traffic volume, such as Utan Kayu Selatan, Jatinegara Kaum, and Duren Sawit, are prioritized due to their potential for higher CO concentrations. Additionally, locations with diverse functions—including residential, commercial, and industrial zones—are chosen to capture variations in pollution exposure. The distribution of measurement points across various districts ensures a more accurate representation of CO pollution in East Jakarta. Once data collection is complete, the analysis results are used to assess the impact on public health and formulate more effective mitigation strategies.

Ethical Approval

This research was approved by the Health Research Ethics Commission of the Faculty of Public Health, Muhammadiyah University of Jakarta with protocol number 10.114.B/KEPK-FKMUMJ/V/2024.

RESULTS AND DISCUSSIONS

The results of measuring air CO levels at 15 points in East Jakarta found 2 areas that exceeded the quality standard values, including Duren Sawit and Jatinegara Kaum. The average CO level at 15 points is 6665 ug/m3. The area with the lowest CO level is Kayuputih at 1522 ug/m3 and the highest area in Jatinegara Kaum at 15380 ug/m3 in Table 1.

Table 1. Distribution of CO levels at 15 points in East Jakarta

Sample Point	CO Level (μg/m3)	Government Regulation
Utan Kayu Selatan	9506	10000
Utan Kayu Utara	5126	
Jatinegara Kaum	15380	
Jati	5287	
Cipinang	6355	
Rawamangun	3337	
Kayuputih	1522	
Pisangan Timur	5180	
Rawa Bunga	3257	
Bali Mester	3364	
Pondok Bambu	8244	
Duren Sawit	13031	
Pondok Kelapa	7156	
Malaka Jaya	3631	
Klender	9613	

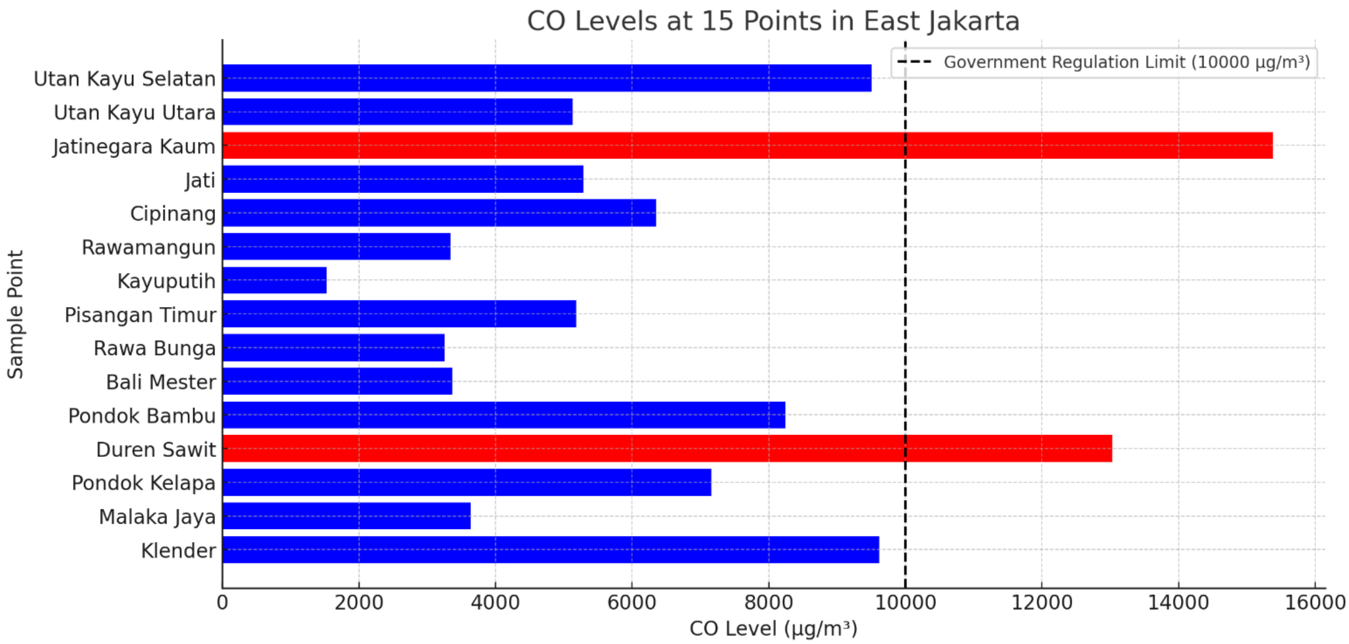

Figure 1. Distribution of CO levels at 15 points in East Jakarta

CO concentration measurements revealed that two locations exceeded the government air quality standard of 10,000 µg/m³:1) Jatinegara Kaum recorded the highest CO concentration at 15,380 µg/m³. 2) Duren Sawit followed with a CO concentration of 13,031 µg/m³. Meanwhile, the lowest CO level was detected in Kayuputih (1,522 µg/m³). The mean CO level across all sites was 6,665 µg/m³.

To ensure accuracy, measurements were conducted at the same time daily to control for weather-related variability (e.g., temperature, humidity, wind speed). The CO meter was pre-calibrated to maintain accuracy, with recorded specifications ensuring a minimum detection limit and measurement reliability.

The normality test confirmed that CO concentration data were normally distributed, allowing for parametric statistical analysis. A linear regression analysis was performed to assess the correlation between CO levels and urban transportation factors. Key findings include 1) Strong positive correlation (R2=0.78, p < 0.05R^2 = 0.78, p < 0.05R2=0.78, p <0.05) between traffic density and CO concentration. Moderate correlation (R2=0.52, p < 0.05R^2 = 0.52, p < 0.05R2=0.52, p<0.05) between population exposure and CO levels. 3) No significant correlation between CO levels and weather conditions, indicating emissions primarily originate from vehicular activity rather than environmental factors.

The significantly higher CO levels in Jatinegara Kaum and Duren Sawit suggest that these locations experience high vehicular traffic and limited air circulation. Both areas are known for their dense road networks, frequent congestion, and commercial activities, which contribute to excessive emissions. Conversely, Kayuputih and Rawamangun, which have lower CO levels, are characterized by wider green spaces and better traffic regulation, potentially reducing CO accumulation.

Considering that prolonged CO exposure can lead to respiratory issues and cardiovascular diseases, these findings emphasize the need for targeted pollution control measures: 1) Traffic management policies (e.g., vehicle emission control, congestion pricing). 2) Urban greening initiatives to improve air circulation. 3) Public awareness campaigns regarding air pollution risks.

These findings align with studies conducted in other metropolitan areas such as Delhi, São Paulo, and Beijing, where high traffic congestion contributes significantly to increased CO levels. In particular, research in Mexico City found that CO concentrations peaked during rush hours, similar to patterns observed in Jakarta.

CO levels that exceed quality standards (25) can cause various health problems. Health impacts can occur acutely or chronically, leading to death. A 91% increase in the number of total deaths per day was associated with an increase in CO concentration of 1 mg/m3 on average on the previous day in 337 cities (26). A similar study in 48 major cities in China found that every 1 mg/m3 increase will cause death. In addition, dense transportation and high urbanization rates worsen air quality, risking cardiovascular disease (stroke, coronary heart disease), obstructive pulmonary disease and nervous system damage (27). In Adiyaman City, Turkey, CO caused 87 (2%) cases of death. Men also have a 1,886-fold risk of death, and the risk of death increases by 1,086-fold for every increase in age (28).

CO is a well-documented air pollutant that poses serious health risks, particularly to vulnerable populations such as children, the elderly, and individuals with pre-existing cardiovascular conditions. A global study across 337 cities found that a 1 mg/m³ increase in CO concentration was associated with a 91% rise in daily mortality rates. Research in China's 48 largest cities also confirmed that higher CO exposure correlates with an increased risk of cardiovascular diseases such as stroke, coronary heart disease, and myocardial infarction.

The effects of CO are not limited to cardiovascular diseases but also extend to neurological and respiratory disorders. In Beijing, women exposed to high CO levels exhibited a 61% increased risk of hypertension and a 77% increased risk of COPD (Chronic Obstructive Pulmonary Disease). Similarly, in Tanzania, rising CO levels were associated with increased complaints of shortness of breath and more frequent hospital visits. These findings suggest that CO pollution is a major determinant of urban public health outcomes, reinforcing the need for urgent intervention in high-risk areas like East Jakarta.

CO pollution in East Jakarta is primarily driven by vehicular emissions, particularly from private cars, inefficient public transport, and heavy-duty vehicles. The Jakarta-Bandung industrial corridor sees a high volume of fossil fuel-dependent freight trucks, further exacerbating CO levels. Previous studies have shown that traffic congestion can increase vehicle emissions by up to 60%, a problem evident in Jakarta's major roads, where vehicles frequently stop and idle.

Comparing these findings to cities with effective urban planning strategies highlights potential policy solutions. 1) Singapore has successfully reduced CO levels through an integrated public transportation system, reducing reliance on private vehicles. 2) London has implemented a low-emission zone, restricting high-emission vehicles from entering central city areas. 3) Tokyo has significantly expanded its electric vehicle (EV) infrastructure, reducing CO emissions from conventional gasoline-powered vehicles. 3) In contrast, Jakarta has yet to effectively implement these measures. The city's public transport infrastructure remains underdeveloped, and adoption of EVs is still minimal due to high costs and inadequate charging infrastructure. Addressing these gaps should be a priority for policymakers.

When compared to similar studies in China, Iran, South Korea, and Turkey, the findings align in showing that increased CO levels significantly heighten cardiovascular, respiratory, and neurological health risks, particularly among vulnerable populations like the elderly and women. However, unlike cities in China and South Korea, where strict emission regulations and efficient public transport systems help mitigate CO exposure, East Jakarta still faces major challenges due to high private vehicle dependency, limited adoption of low-emission technologies, and inefficient public transportation. While cities with progressive environmental policies have begun shifting toward electric vehicles and smart traffic management, Jakarta's reliance on fossil-fuel-based transportation continues to worsen air pollution. To address these challenges, urgent policy interventions are needed, including sustainable mass transportation development, congestion reduction strategies, and green space expansion to reduce the long-term health burden of CO exposure.

Limitations and Cautions

This study examining the impact of transportation on increasing carbon monoxide (CO) gas levels in urban areas has some limitations. The research primarily relies on data from a limited number of monitoring stations, which may not comprehensively represent the entire urban area. Additionally, the study does not account for seasonal variations or other sources of CO gas, which might affect the accuracy of attributing CO levels solely to transportation. Caution should be exercised when generalizing the findings, as the impact of transportation on urban CO levels can vary significantly based on local infrastructure, traffic patterns, and environmental policies. Future research should incorporate a broader array of data sources and consider these variables to enhance understanding.

Recommendations for Future Research

Future research should prioritize long-term studies to examine seasonal fluctuations in CO levels and their prolonged effects on respiratory, cardiovascular, and neurological health. The implementation of real-time CO monitoring through sensor networks and geospatial mapping would facilitate the identification of pollution hotspots and enable predictive analysis of emission trends. Additionally, research should assess the impact of traffic control measures, such as odd-even vehicle restrictions, congestion pricing, and improvements in public transportation, in mitigating CO pollution, particularly in densely congested areas like East Jakarta. Further exploration is necessary to determine the disproportionate health risks of CO exposure among vulnerable groups, including children, the elderly, and individuals with pre-existing medical conditions, to inform targeted public health interventions. Comparative studies between East Jakarta and cities with effective air quality regulations, such as Singapore or Seoul, could offer valuable insights into successful mitigation strategies. Lastly, investigating public awareness and behavioral adaptations to air pollution policies, particularly regarding the adoption of electric vehicles and sustainable transportation solutions, is crucial for guiding urban development and ensuring the effectiveness of environmental policies

CONCLUSION

This study underscores the urgent need for transportation reforms in East Jakarta, where vehicular emissions are the primary source of excessive CO pollution. The high concentrations recorded in Jatinegara Kaum and Duren Sawit, along with the strong correlation between traffic congestion and CO levels, highlight the pressing public health risks associated with deteriorating air quality. These findings should directly inform urban planning and transportation policies, particularly in mitigating CO emissions through targeted congestion management, improved public transit, and stricter vehicle emissions regulations. For example, implementing low-emission zones in high-traffic areas or adopting congestion pricing similar to Singapore and London could significantly reduce urban CO pollution. Additionally, mandating periodic vehicle emission testing and accelerating the transition to electric vehicles (EVs) should be prioritized, particularly given Jakarta's increasing reliance on private transportation.

Moving forward, technological and policy-driven interventions should be explored to create long-term sustainable solutions. Future research should integrate real-time CO monitoring using sensor networks and AI-driven traffic flow analysis to provide more precise, data-driven mitigation strategies. Additionally, longitudinal studies examining seasonal and climate-related variations in CO pollution could enhance the accuracy of regulatory policies. Investment in smart traffic management systems, improved mass transit connectivity, and incentives for EV adoption will be crucial in reducing CO exposure and mitigating its adverse health effects. Without aggressive interventions, East Jakarta risks further environmental degradation and increased public health burdens, underscoring the necessity for proactive, data-informed policies to create a cleaner, healthier urban environment.

AUTHOR'S CONTRIBUTION STATEMENT

Ernyasih was responsible for the overall research design, including problem identification, goal formulation, methodology development, and drafting the article. Anwar Mallongi reviewed the relevance of the data to the overall environmental health context. Gilang Anugerah Munggaran contributed to field data collection, including the measurement of CO levels using a CO meter at the study site. Munaya Fauziah was responsible for data processing and presentation of results. Firda Ayu Salsabilla supported the collection of relevant literature and compiled the literature review section. Taufiqurrochman is responsible for data visualization aspects.

CONFLICTS OF INTEREST

All the authors declare that there are no conflicts of interest.

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