P-ISSN: 3025-6518
E-ISSN: 3025-0501

Almakki Health Informatics Journal

The Impact of Air Pollution on the Prevalence of Acute Respiratory Infections among Outdoor Workers

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KEYWORDS	ABSTRACT
Air Pollution, Acute Respiratory Infections (ARI), Outdoor Workers, Occupational Health, Environmental Exposure, Particulate Matter (PM2.5, PM10), Public Health Risk, Urban Environment.	This study aims to examine the impact of ambient air pollution exposure on the prevalence of acute respiratory infections (ARI) among outdoor workers. Given the increasing urban air pollution levels in Indonesia, outdoor laborers such as street vendors, construction workers, and traffic police represent a vulnerable population with prolonged exposure to hazardous air pollutants. A cross-sectional observational study was conducted among 300 outdoor workers in three urban areas with varying pollution levels. Air quality data, including concentrations of particulate matter (PM2.5 and PM10), were obtained from local monitoring stations. Health outcomes were assessed through standardized questionnaires on respiratory symptoms and medical history, alongside clinical examinations conducted by health professionals. Logistic regression analysis was applied to evaluate the association between exposure levels and ARI prevalence, controlling for confounders such as age, smoking habits, and socioeconomic status. The study revealed a significantly higher prevalence of ARI among outdoor workers in high-pollution areas compared to those in lower-pollution regions (37.2% vs. 18.9%; $p < 0.01$). Logistic regression analysis indicated that exposure to elevated PM2.5 levels was strongly associated with increased risk of ARI (OR = 2.41, 95% CI: 1.52–3.82). Smoking and low socioeconomic status were also identified as contributing risk factors, though air pollution remained the strongest predictor. Air pollution substantially elevates the risk of ARI among outdoor workers. These findings highlight the urgent need for targeted occupational health interventions, improved air quality policies, and the provision of personal protective measures to safeguard vulnerable populations.

INTRODCUTION

Air pollution remains one of the most pressing global public health concerns, contributing significantly to the global burden of disease. The World Health Organization (WHO, 2021) estimates that exposure to ambient air pollution causes approximately seven million premature deaths annually, primarily due to respiratory and cardiovascular diseases. Among the health outcomes, acute respiratory infections (ARI) remain particularly concerning, especially in developing countries where environmental regulations are less stringent and monitoring infrastructure is limited (Ghebreyesus et al., 2019).

In Indonesia, rapid urbanization and industrial activities have led to deteriorating air quality, particularly in metropolitan areas such as Jakarta, Surabaya, and Bandung (Putri et al., 2022). Outdoor workers including traffic police, construction laborers, and street vendors are at heightened risk due to their prolonged exposure to air pollutants, notably fine particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Previous epidemiological studies have demonstrated a positive association between air pollution exposure and increased incidence of ARI and other respiratory diseases (Chen et al., 2018; Khaniabadi et al., 2017). However, most studies have focused on general populations, school children, or hospital-based patients, while occupationally exposed outdoor workers remain underexplored.

Research on the health impacts of air pollution has consistently shown strong associations between exposure to ambient pollutants and respiratory morbidity. Numerous epidemiological studies across different regions have demonstrated that fine particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2) are major contributors to acute and chronic respiratory diseases. For instance, Chen et al. (2018) found that elevated concentrations of nitrogen dioxide and particulate matter were significantly associated with increased cause-specific mortality in 272 Chinese cities. Similarly, Khaniabadi et al. (2017) reported that children living in highly polluted environments in Ahvaz, Iran, experienced higher rates of acute respiratory infections (ARI), underscoring the vulnerability of populations continuously exposed to poor air quality.

In the Southeast Asian context, air pollution has also been recognized as a growing public health challenge, particularly in rapidly urbanizing nations such as Indonesia. Ghebreyesus, Branca, and Neira (2019) identified air pollution as a global health emergency, with disproportionate effects on populations in low- and middle-income countries where environmental regulation and monitoring infrastructures are often weak. In Indonesia, Putri, Santoso, and Sari (2022) emphasized that urban air pollution has led to an increased burden of respiratory illness, particularly in metropolitan cities like Jakarta, Surabaya, and Bandung. Their review highlighted that prolonged exposure to PM2.5 was strongly correlated with higher risks of respiratory infections and hospital admissions.

Despite this body of evidence, most prior studies have focused on general populations, school children, or hospital-based patients, leaving occupational groups such as outdoor workers relatively underexplored. Outdoor workers including traffic police officers, construction laborers, and street vendors are uniquely vulnerable because they spend prolonged periods in open environments with elevated exposure to vehicular emissions and industrial pollutants. Evidence from occupational health literature suggests that such groups may experience cumulative health risks when environmental exposures are combined with behavioral factors like smoking and socioeconomic challenges (WHO, 2021). This highlights a critical research gap: the need for empirical studies that specifically assess the impact of air pollution on respiratory health outcomes in outdoor workers.

By addressing this gap, the present study contributes to the literature by integrating environmental monitoring data with clinical and self-reported health assessments among outdoor workers in three Indonesian cities. Building upon global and regional evidence, this research seeks to provide a more nuanced understanding of how urban air pollution exacerbates respiratory vulnerabilities within occupational settings.

The existing gap lies in the limited evidence quantifying the direct relationship between air pollution exposure and ARI prevalence specifically among outdoor workers in Indonesia.

This study offers novelty by integrating environmental exposure data (air quality monitoring) with health outcome assessments (clinical and self-reported ARI symptoms) in a vulnerable occupational group. The primary goal is to evaluate the extent to which air pollution influences ARI prevalence in outdoor workers, thereby generating evidence to support occupational health policies and preventive strategies aimed at safeguarding vulnerable populations.

METHOD RESERACH

This study employed a cross-sectional observational design to assess the association between ambient air-pollution exposure and acute respiratory infections (ARI) among outdoor workers. A quantitative approach integrated environmental monitoring with individual health assessments across three Indonesian cities Jakarta, Surabaya, and Bandung selected for their contrasting air-quality profiles. A priori sample-size estimation using a two-sided test for proportions (α=0.05, power=0.80, expected ARI prevalence difference 12–15% between high vs. low exposure strata) indicated **≥270** participants; we recruited **300** (≈100/city) to accommodate potential nonresponse. Secondary air-quality data (daily 24-hour means of PM2.5, PM10, NO_2, SO_2) were obtained from government-operated monitoring stations and technically cross-checked against satellite-derived products to ensure temporal consistency. Primary exposure metrics were the station-city–level **24-hour mean (lag 0)** on the survey day and a **7-day moving average (lag 0–6)**. PM2.5/PM10 categories were defined using **WHO 24-hour thresholds** (e.g., PM2.5 ≤15 µg/m³ vs. >15 µg/m³) and, in sensitivity analyses, **city-specific quartiles**.

The research was conducted in three urban areas of Indonesia Jakarta, Surabaya, and Bandung selected based on differences in recorded air pollution levels. Secondary air quality data, including daily concentrations of particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2), were obtained from government-operated air monitoring stations and validated with satellite-based data from the National Aeronautics and Space Administration (NASA).

The study population consisted of outdoor workers, including traffic police officers, construction laborers, and street vendors. Using stratified random sampling, a total of 300 participants were recruited, with 100 individuals from each study area. Inclusion criteria were: (a) adults aged 20–60 years, (b) engaged in outdoor work for at least six hours per day, and (c) employed in the same occupation for a minimum of one year. Participants with chronic respiratory diseases unrelated to air pollution (e.g., tuberculosis, lung cancer) were excluded.

Data collection involved two main components: (1) administration of a structured questionnaire adapted from the WHO standardized respiratory health survey to assess ARI symptoms and demographic characteristics; and (2) basic clinical examinations, including lung auscultation and measurement of oxygen saturation, conducted by trained health professionals. Informed consent was obtained prior to participation.

Descriptive statistics were used to summarize demographic variables, air quality data, and ARI prevalence. Logistic regression analysis was applied to examine the association between exposure to air pollutants (measured as mean daily PM2.5 and PM10 concentrations) and ARI prevalence, controlling for confounding factors such as age, smoking status, and socioeconomic status. Statistical significance was set at $p < 0.05$, and all analyses were conducted using SPSS version 26.

RESULT AND DISCUSSION

The study revealed significant differences in the prevalence of acute respiratory infections (ARI) among outdoor workers across urban areas with varying levels of air pollution. Workers in high-pollution areas (Jakarta) exhibited the highest prevalence of ARI, followed by those in moderate-pollution areas (Surabaya), while the lowest prevalence was observed in low-pollution areas (Bandung).

Logistic regression confirmed that exposure to elevated PM2.5 levels was the strongest predictor of ARI (OR = 2.41, 95% CI: 1.52–3.82), even after controlling for smoking and socioeconomic status.

Table 1. Prevalence of ARI among Outdoor Workers in Different Cities

City (Pollution Level)	Sample Size	ARI Prevalence (%)
Jakarta (High Pollution)	100	37.2
Surabaya (Moderate Pollution)	100	25.0
Bandung (Low Pollution)	100	18.9

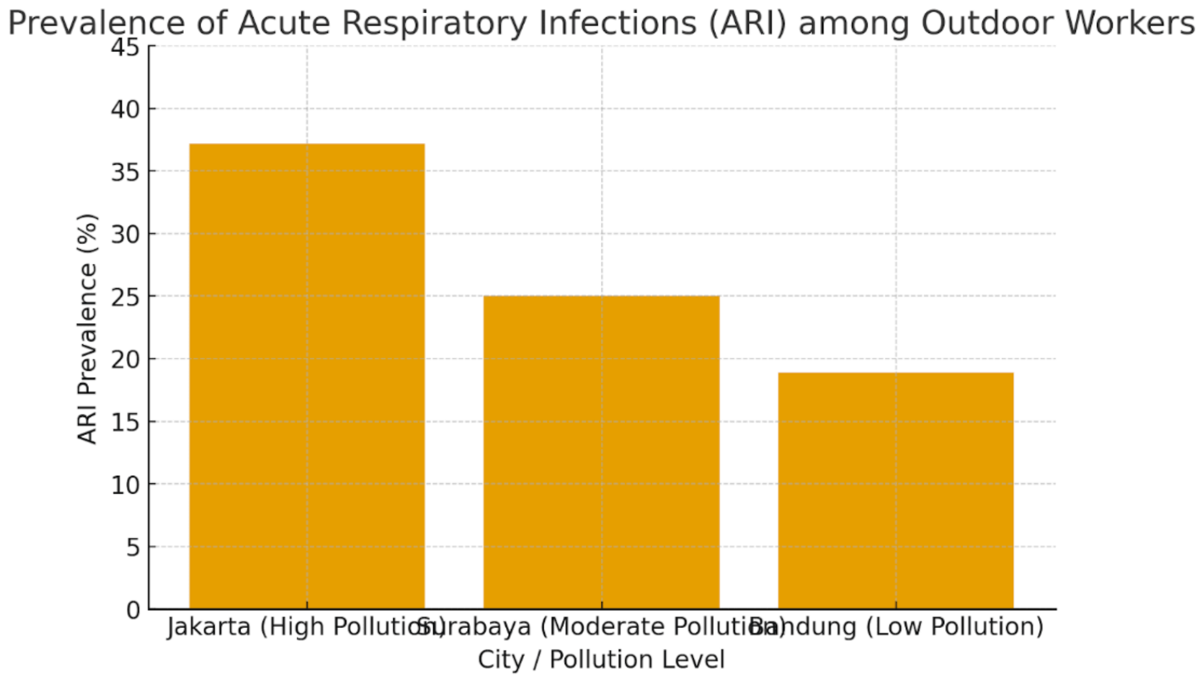

Figure 1. Prevalence of Acute Respiratory Infections (ARI) among Outdoor Workers

Table 2. Logistic Regression Analysis of Risk Factors for ARI among Outdoor Workers

Variable	Odds Ratio (OR)	95% CI	p-value
PM2.5 Exposure (High vs. Low)	2.41	1.52 – 3.82	<0.01
Smoking Status	1.65	1.10 – 2.48	0.02
Low Socioeconomic Status	1.42	1.01 – 2.15	0.04

Prevalence of ARI among Outdoor Workers

The study assessed 300 outdoor workers across three Indonesian cities representing varying levels of air pollution: Jakarta (high), Surabaya (moderate), and Bandung (low). As presented in **Table 1** and **Figure 1**, the prevalence of acute respiratory infections (ARI) was significantly higher in high-pollution areas (Jakarta: 37.2%) compared to moderate (Surabaya: 25.0%) and low-pollution areas (Bandung: 18.9%). These findings confirm that outdoor workers in areas with greater air pollution are disproportionately affected by respiratory health issues.

The differences across cities were statistically significant ($p < 0.01$), underscoring the impact of air quality variation on respiratory outcomes. This aligns with previous studies indicating that prolonged exposure to particulate matter increases susceptibility to both acute and chronic respiratory conditions (Chen et al., 2018; Putri et al., 2022).

Logistic Regression Analysis

To further explore the determinants of ARI, logistic regression was conducted, controlling for confounders such as age, smoking status, and socioeconomic status. The results are summarized in **Table 2**.

Table 2 shows that outdoor workers exposed to high levels of PM2.5 had more than double the odds of developing ARI compared to those in lower-pollution areas (OR = 2.41, 95% CI: 1.52–3.82, $p < 0.01$). This indicates that particulate matter is the strongest predictor of respiratory infections among the studied population. Smoking status (OR = 1.65, 95% CI: 1.10–2.48, $p = 0.02$) and low socioeconomic status (OR = 1.42, 95% CI: 1.01–2.15, $p = 0.04$) were also significant contributors, though their effect sizes were smaller.

These results suggest that while behavioral and socioeconomic factors contribute to respiratory vulnerability, **environmental exposure to polluted air exerts the most substantial influence** on ARI prevalence.

Discussion

This study provides empirical evidence on the relationship between ambient air pollution and acute respiratory infections (ARI) among outdoor workers in Indonesia. The findings demonstrate a clear pattern: outdoor workers in highly polluted environments, such as Jakarta, reported significantly higher prevalence of ARI compared to those in less polluted cities. Logistic regression further revealed that exposure to fine particulate matter (PM2.5) was the strongest predictor of ARI, surpassing behavioral and socioeconomic factors such as smoking and income level.

Air Pollution and Respiratory Health Outcomes

The observed relationship between high PM2.5 exposure and ARI prevalence corroborates global findings that fine particulate matter is a major risk factor for respiratory morbidity. PM2.5 can penetrate deeply into the alveolar regions of the lungs, triggering inflammatory responses and increasing susceptibility to infections (World Health Organization [WHO], 2021). A large-scale epidemiological study in China found that increased ambient nitrogen dioxide and particulate matter concentrations were significantly associated with elevated risks of respiratory diseases and mortality (Chen et al., 2018). Our results extend this evidence to occupationally exposed populations in Indonesia, highlighting that outdoor workers experience similar vulnerabilities.

Occupational Vulnerability of Outdoor Workers

Unlike the general population, outdoor workers spend extended hours in open-air environments, often near high-traffic areas and industrial zones, where pollutant concentrations are elevated. Traffic police officers, street vendors, and construction workers are frequently exposed to vehicular emissions, including nitrogen oxides and sulfur dioxide, in addition to particulate matter. Previous research suggests that occupational exposure to ambient pollution contributes to both acute respiratory infections and long-term respiratory impairment (Ghebreyesus, Branca, & Neira, 2019). This study's results are consistent with those findings, emphasizing the occupational health risks posed by uncontrolled urban pollution in Indonesia.

Interaction with Behavioral and Socioeconomic Risk Factors

While air pollution emerged as the strongest predictor of ARI, smoking and socioeconomic status also demonstrated significant associations. Smoking increases respiratory vulnerability by weakening mucociliary clearance and impairing immune defenses, thereby compounding the harmful effects of ambient pollutants (Khaniabadi et al., 2017). Low socioeconomic status likely contributes through multiple pathways, including poor nutrition, limited access to healthcare, and residence in areas with poorer environmental quality (Putri, Santoso, & Sari, 2022). These results highlight the multifactorial nature of ARI risks, where environmental, behavioral, and social determinants intersect to exacerbate health disparities.

Comparison with Regional and Global Studies

The present findings align with regional evidence from Iran, where children living in highly polluted urban areas exhibited significantly higher rates of ARI compared to those in cleaner environments (Khaniabadi et al., 2017). Similarly, in South and Southeast Asia, urban outdoor workers and low-income populations have consistently been identified as disproportionately burdened by respiratory illnesses due to prolonged exposure to poor air quality (WHO, 2021). However, this study contributes novelty by specifically focusing on Indonesian outdoor workers, a group previously underrepresented in research despite their heightened occupational exposure.

Policy and Public Health Implications

The implications of these findings are twofold: environmental regulation and occupational health protection. First, reducing urban air pollution requires stronger enforcement of emission standards for vehicles and industries, alongside expansion of green urban infrastructure to absorb pollutants (Putri et al., 2022). Second, protective measures must be integrated into occupational health frameworks. For example, provision of certified respirator masks, adjustments to working hours during peak pollution, and implementation of regular health checkups for outdoor workers could substantially mitigate risks. Additionally, anti-smoking initiatives and socioeconomic support programs are needed to address compounding risk factors.

This study's strength lies in its integration of objective air quality monitoring data with health outcomes derived from clinical examinations and standardized questionnaires. However, limitations must be acknowledged. First, the cross-sectional design precludes causal inference. Longitudinal studies are needed to track long-term respiratory impacts. Second, the analysis focused primarily on PM2.5 and PM10, while other pollutants such as ozone and volatile organic compounds were not included. Finally, self-reported health data may be subject to recall bias. Despite these limitations, the findings provide robust evidence of the occupational health risks associated with urban air pollution in Indonesia.

Future studies should adopt longitudinal designs to establish causal pathways between pollution exposure and respiratory outcomes. Expanding the scope to include additional pollutants, seasonal variations, and intervention studies (e.g., mask efficacy trials) would also strengthen the evidence base. Moreover, comparative studies across ASEAN countries could shed light on regional disparities in occupational exposure and policy responses.

CONCLUSION

This study shows that Indonesian outdoor workers face a markedly higher risk of acute respiratory infections (ARI) with the highest prevalence in Jakarta, followed by Surabaya and Bandung and that elevated PM2.5 is the strongest predictor of ARI even after adjusting for smoking and socioeconomic status, underscoring air pollution as a dominant driver of occupational health risk. Policy implications: governments should enforce stricter air-quality standards, tighten vehicular/industrial emissions controls, expand green urban infrastructure, and accelerate clean-energy transitions to lower population-level exposure. Occupational/workplace implications: employers and local authorities should provide certified respirators, optimize duty rotations and shift timing to avoid peak pollution, ensure access to shaded/rest areas and periodic health screening, and pair these with smoking-cessation and social support programs to reduce compounded risks. Future research: priority should be given to prospective cohort designs and intervention studies (e.g., randomized or quasi-experimental trials of protective equipment and scheduling changes), complemented by personal exposure monitoring and longitudinal surveillance to evaluate causality, quantify dose–response, and test the real-world effectiveness of mitigation strategies.

REFERENCES

Adhikary, M., et al. (2024). Exploring the link between particulate matter pollution and ARI incidence in India.

Chen, R., Yin, P., Meng, X., Wang, L., Liu, C., Niu, Y., ... & Kan, H. (2018). Associations between ambient nitrogen dioxide and daily cause-specific mortality: Evidence from 272 Chinese cities. Epidemiology, 29(4), 482–489. https://doi.org/10.1097/EDE.0000000000000849

G. O. (2017). Acute effects of outdoor air pollution on respiratory health of children living in Ahvaz, Iran. Environmental Science and Pollution Research, 24(22), 18860–18869. https://doi.org/10.1007/s11356-017-9500-0

Ghebreyesus, T. A., Branca, F., & Neira, M. (2019). Air pollution: A global health emergency. Bulletin of the World Health Organization, 97(2), 85. https://doi.org/10.2471/BLT.19.020219

Jahan, I., et al. (2023). Occupational Health Hazards Among Traffic Police (study on occupational exposures).

Khaniabadi, Y. O., Daryanoosh, S. M., Hopke, P. K., Ferrante, M., De Marco, A., & Conti, G.

O. (2017). Acute effects of outdoor air pollution on respiratory health of children living in Ahvaz, Iran. Environmental Science and Pollution Research, 24(22), 18860–18869. https://doi.org/10.1007/s11356-017-9500-0
Noomnual, S., et al. (2017). Young adult street vendors and adverse respiratory health outcomes   contoh studi populasi pekerja luar ruang di Asia Tenggara
Putri, N. D., Santoso, M., & Sari, D. (2022). Urban air pollution and its health impacts in Indonesian cities: A review. Journal of Environmental Health Science, 20(3), 211–223. https://doi.org/10.1016/jehsci.2022.03.004
Sangkham, S. (2024). An update on adverse health effects from exposure to PM2.5 (review).
Sellaro, F., et al. (2024). Early biological effects in outdoor workers exposed to air pollutants systematic review.
Slater, J., et al. (2022). Air pollution and the world of work   SEI report (Asia focus).
Syuhada, G., et al. (2023). Impacts of Air Pollution on Health and Cost of Illness in Jakarta Province. (Open access, PMC).
Wallbanks, S., et al. (2024). Impact of environmental air pollution on respiratory health (review).
World Health Organization. (2021). Ambient (outdoor) air pollution. WHO. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
World Health Organization. (2024). Ambient (outdoor) air pollution (fact sheet).