International Journal of Public Health Science (IJPHS)
Vol. 15, No. 3, September 2026, pp. 868~878
ISSN: 2252-8806, DOI: 10.11591/ijphs.v15i3.27111

Association between occupational NO_2 exposure and hypertension risk: a PRISMA-based systematic review with risk-of-bias assessment

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Article Info

Article history:

Received Feb 27, 2026
Revised Jun 2, 2026
Accepted Jul 21, 2026

Keywords:

Air pollution
Hypertention
Nitrogen dioxide
Occupational exposure
Workers

ABSTRACT

Nitrogen dioxide (NO_2) is a major air pollutant generated from fossil fuel combustion in transportation and industrial activities and is associated with adverse health effects. Prolonged exposure to NO_2 may induce chronic inflammation and endothelial dysfunction, which contribute to the development of hypertension. This study aimed to systematically review the association between NO_2 exposure and the incidence of hypertension among workers. The review was conducted in accordance with PRISMA guidelines, with literature searches performed in Google Scholar, PubMed, and ScienceDirect for publications from 2020 to 2025. Inclusion criteria comprised full-text articles in English or Indonesian employing observational study designs (cross-sectional, cohort, case-control, or ecological) and involving workers in both formal and informal sectors. Eligible studies examined NO_2 exposure as the independent variable and hypertension as the outcome. Of 2,051 records identified, five studies met the inclusion criteria, originating from China and Nigeria. Risk of bias was assessed using the office of health assessment and translation (OHAT) risk of bias tool. The findings demonstrated a consistent association between NO_2 exposure and an increased risk of hypertension, particularly in poorly ventilated work environments. These results underscore the importance of improving workplace air quality management, strengthening exposure monitoring, and implementing preventive occupational health strategies.

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1. INTRODUCTION

Air pollution remains a critical global environmental health challenge, driven by the increasing complexity of human activities and rapid industrialization. The extensive reliance on fossil fuels to support industrial, energy, and transportation sectors has led to a substantial rise in atmospheric emissions [1]-[3]. Furthermore, accelerated urbanization that is not accompanied by sustainable transportation policies has resulted in a surge in motorized vehicles, further deteriorating urban air quality and elevating public health risks [4], [5]. The State of Global Air 2024 report indicates that air pollution contributed to approximately 8.1 million deaths worldwide in 2021, with an estimated 91% of the global population residing in areas where air quality exceeds the World Health Organization's recommended safety thresholds [6]. This situation aligns with the increasing prevalence of non-communicable diseases, including chronic respiratory disorders, cardiovascular diseases, and lung cancer [7]-[9].

Nitrogen dioxide (NO_2) is one of the most prevalent gaseous pollutants in urban settings, primarily generated from the combustion of fossil fuels in motor vehicles, power plants, and industrial facilities [6], [10]. NO_2 is characterized by its reddish-brown color at temperatures above 21 °C and its pungent odor [11]. Inhalation serves as the primary exposure route, with vulnerable groups including individuals living near emission sources, users of fossil-fuel-based household appliances (such as gas stoves and kerosene heaters), and smokers [12], [13]. Occupational exposure is particularly elevated among workers in industries such as nitric acid production, explosives manufacturing, and welding operations [14], [15]. Previous studies have shown that adults residing near steel industrial zones face increased exposure risks, with respiratory symptoms observed within 500 meters of industrial sites [16]. NO_2 exposure contributes to oxidative stress and inflammation, leading to endothelial dysfunction and impaired nitric oxide (NO) bioavailability [17]. Reduced NO production subsequently limits vasodilation, increases vascular resistance, and elevates blood pressure, thereby contributing to hypertension and other cardiovascular complications [18]-[20].

Although the health impacts of air pollution have been widely examined, evidence specifically addressing the association between NO_2 exposure and hypertension among workers remains limited. Workers represent a vulnerable population whose exposure levels are determined by duration, intensity, frequency of contact, and workplace environmental conditions [21], [22]. Prolonged occupational exposure to NO_2 may heighten the risk of hypertension and cardiovascular impairment, which in turn can significantly affect workforce productivity [23], [24]. Existing epidemiological studies have reported associations between NO_2 exposure and elevated blood pressure; however, their findings remain inconsistent because of differences in occupational settings, exposure assessment methods, study populations, and hypertension outcome measurements. Some studies have relied on ambient air monitoring, whereas others have estimated individual occupational exposure, resulting in considerable methodological heterogeneity. Moreover, most available evidence originates from observational studies conducted in specific industrial sectors, limiting the generalizability of their findings across diverse occupational environments.

Previous reviews have primarily focused on the broader cardiovascular effects of air pollution or on environmental NO_2 exposure in the general population, with limited attention to occupationally exposed workers. Consequently, they have not comprehensively evaluated how occupational exposure characteristics, including exposure intensity, duration, and workplace context, influence the relationship between NO_2 exposure and hypertension. This gap limits the current understanding of occupation-specific cardiovascular risks and hinders the development of evidence-based workplace prevention strategies. Therefore, this systematic review aims to synthesize and critically evaluate the available evidence on the association between occupational NO_2 exposure and hypertension among workers. By comparing findings across different occupational settings, exposure assessment approaches, and study methodologies, this review seeks to identify consistent patterns, explain discrepancies in the existing literature, and provide a more comprehensive understanding of occupational NO_2-related hypertension. This review also extends previous evidence by specifically focusing on occupational populations, thereby addressing an important gap that has received limited attention in earlier systematic reviews.

2. METHOD

This study employed a systematic review design guided by the preferred reporting items for systematic reviews and meta-analyses (PRISMA). A systematic review represents a rigorous, structured effort to collect, critically evaluate, synthesize, and present findings from multiple research studies to address a predefined research objective [25]. Prior to data collection, the study protocol was registered in the international prospective register of systematic reviews (PROSPERO) under the ID CRD420251153629. The review process followed the PRISMA framework, which included four sequential stages: identification, screening, eligibility assessment, and final inclusion of eligible studies. Several stages were undertaken during the data collection process, including:

2.1. Selection of databases and keywords

The literature search was conducted using electronically published research articles from national and international journals indexed in Google Scholar, PubMed, and ScienceDirect for the period 2020–2025. Keyword formulation was based on inclusion criteria structured using the PICO framework as shown in Table 1. The PICO model was applied to guide the research question and eligibility criteria, while PRISMA ensured a transparent and systematic reporting process. The inclusion criteria consisted of:

i) Articles written in Indonesian or English;
ii) Published between 2020 and 2025;
iii) Accessible in full text;
iv) Employing observational study designs, including cross-sectional, cohort, case study, or ecological studies;

v) Study populations focused on workers in formal or informal sectors;

vi) Articles examining NO_2 exposure (exposure variable), hypertension (outcome variable), and the relationship between the two.

The exclusion criteria included review articles, conference proceedings, editorials, commentaries, study protocols, articles without full-text access, duplicate publications, and studies that did not report occupational NO_2 exposure or hypertension outcomes relevant to the review objective.

Table 1. PICO indicators for keyword formulation

PICO indicator	Criteria
Population	Workers
Intervention	Nitrogen dioxide exposure
Comparison	Variation in NO_2 exposure concentrations among workers
Outcome	Risk of hypertension

2.2. Data searching

The literature search was performed using Indonesian keywords ("NO_2" OR "Nitrogen Dioksida" AND "Hipertensi" OR "Tekanan Darah" AND "Pekerja") and English keywords ("NO_2" OR "Nitrogen Dioxide" AND "Hypertension" OR "Blood Pressure" AND "Worker") within the 2020–2025 publication range. The article identification process adhered strictly to PRISMA guidelines.

All records retrieved from the selected databases were exported and compiled for screening. Duplicate records identified across databases were removed prior to the screening process. Subsequently, two independent reviewers screened the titles and abstracts of the remaining articles against the predefined inclusion and exclusion criteria. Articles that were clearly unrelated to occupational NO_2 exposure or hypertension among workers were excluded at this stage. The full texts of potentially eligible studies were then retrieved and assessed independently by both reviewers to determine their eligibility. Studies that fulfilled all inclusion criteria were included in the final qualitative synthesis, whereas studies with insufficient data, irrelevant outcomes, or populations outside the review scope were excluded. The complete study selection process is presented in the PRISMA flow diagram as shown in Figure 1.

2.3. Article appraisal

Article appraisal was conducted to assess study quality and potential risk of bias by two independent reviewers (MCT and MAF). Study quality was evaluated using the JBI Critical Appraisal Checklist, while risk of bias was assessed using the office of health assessment and translation (OHAT) risk of bias tool. A Kappa Agreement Value was subsequently calculated to determine the level of inter-reviewer agreement in evaluating study quality and risk of bias. Any disagreements between the two reviewers during the screening, eligibility assessment, quality appraisal, or risk of bias evaluation were resolved through discussion until consensus was reached. When necessary, a third reviewer was consulted to ensure consistency in the study selection and appraisal process.

3. RESULTS

Based on the literature search conducted between 2020 and 2025 regarding nitrogen dioxide (NO_2) exposure and the risk of hypertension among workers, five articles were identified that met the predefined eligibility criteria. These articles underwent the three-stage PRISMA screening process, as illustrated in Figure 1. Subsequently, each article was subjected to quality assessment and risk-of-bias evaluation by two independent reviewers (MCT and MAF). Overall, the quality appraisal indicated that all five studies demonstrated good methodological quality, each achieving a score of 100%. The inter-rater reliability analysis using the Kappa Agreement Value yielded a score of 1.0 (indicating perfect agreement between reviewers), with a p-value of 0.025. The risk-of-bias assessment showed that all included articles were categorized as having a "low likelihood of bias." The corresponding Kappa Agreement Value for this assessment was 0.5 (indicating moderate agreement between reviewers), with a p-value of 0.012.

The consistently high-quality scores were primarily attributed to the fact that all included studies clearly defined their study populations, exposure variables, and hypertension outcomes, employed appropriate observational study designs, and reported statistical analyses that adequately addressed the research objectives. Furthermore, the studies provided sufficient methodological detail regarding participant selection, exposure assessment, and outcome measurement, supporting their overall methodological rigor. The low risk-of-bias ratings indicate that the included studies were considered reliable sources of evidence, although differences in exposure assessment methods and study settings remained potential sources of methodological heterogeneity. These results affirm that the included studies possess strong methodological rigor and a relatively low risk of bias, supporting their suitability for inclusion in the present systematic review.

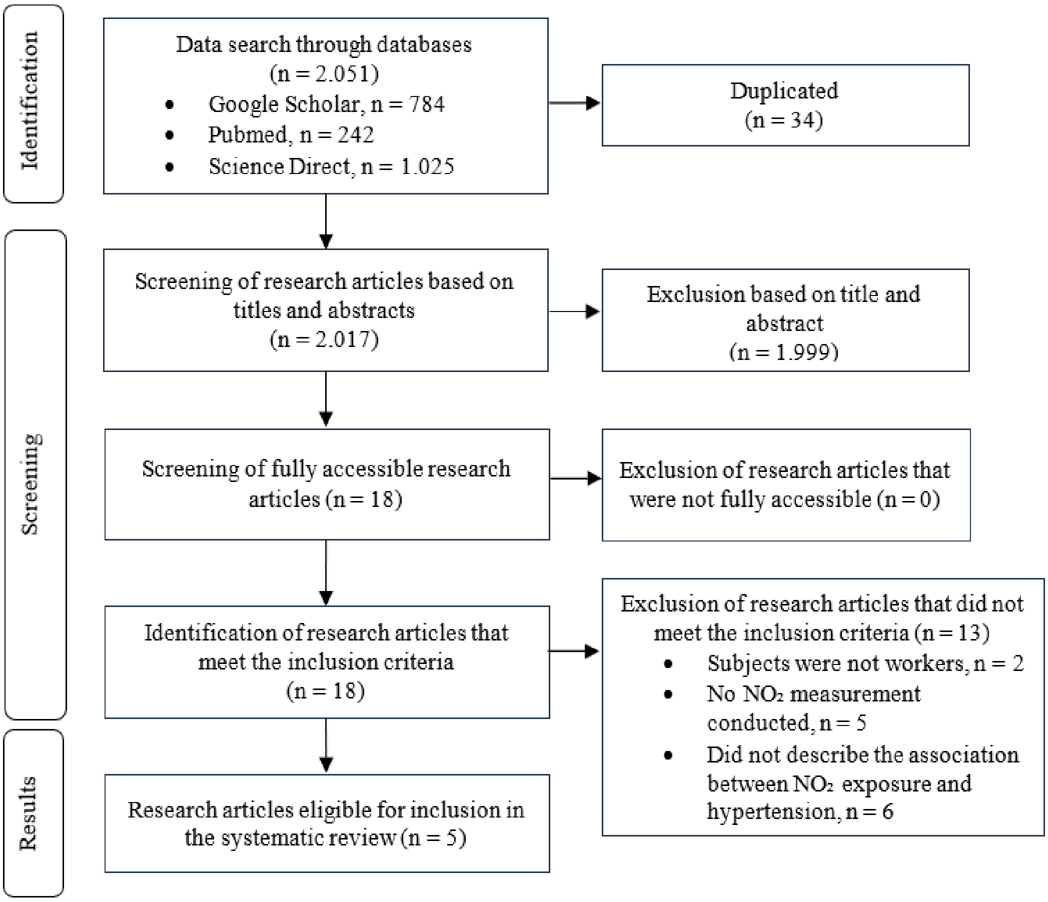

Figure 1. Flow diagram of the article screening process

A summary of the literature search results from the five articles examining nitrogen dioxide (NO_2) exposure and the risk of hypertension among workers during the period 2020–2025 is presented in Table 2. The distribution of publication years shows that relevant studies were not published annually. One article was published in 2022, one in 2024, and three in 2025. In terms of study location, the majority of research was conducted in China (four articles). Over the past several decades, China has undergone rapid economic expansion characterized by intensive industrial activity, which has contributed to increased environmental pollution, including heightened NO_2 levels in ambient air [26].

Of the five included studies, three employed a cross-sectional design, while two utilized cohort designs. Regarding worker categories, three articles focused on specific occupational groups, namely oil mining workers, coal mining workers, and roadside workers (including drivers, conductors, street laborers, and vendors). The transportation sector is recognized as a major contributor to outdoor air pollution, where fossil-fuel combustion generates NO_2 emissions. Similarly, mining activities are also significant sources of NO_2, which may arise from coal extraction and transportation processes as well as emissions from diesel-powered machinery [27], [28]. Collectively, these characteristics illustrate that occupational environments with high reliance on fuel combustion and heavy industrial operations pose substantial risks for NO_2 exposure, thereby underscoring the relevance of examining hypertension outcomes among exposed worker populations.

Across the included studies, several consistent patterns emerged. First, all studies reported occupational exposure to NO_2 in environments characterized by combustion-related emissions, such as mining operations, industrial activities, and roadside occupations. Second, despite substantial differences in NO_2 concentrations across occupational settings, each study consistently suggested an association between NO_2 exposure and adverse cardiovascular outcomes, particularly hypertension or elevated blood pressure. These findings support the biological plausibility that prolonged occupational exposure to NO_2 may contribute to cardiovascular dysfunction through oxidative stress, systemic inflammation, and endothelial impairment.

Nevertheless, considerable heterogeneity was observed among the included studies. The reported NO_2 concentrations varied markedly, ranging from less than 2 µg/m³ among roadside workers in Nigeria to 2,140 µg/m³ among underground coal miners in China. Likewise, hypertension prevalence ranged from 7.2% to 71.3%, reflecting differences in occupational environments, exposure duration, worker characteristics, and exposure assessment methods. While some studies estimated long-term ambient NO_2 exposure, others measured occupational exposure directly within industrial settings, making direct quantitative comparison challenging. In addition, one study evaluated ocular hypertension rather than systemic hypertension, indicating variation in outcome definitions across the available evidence.

Table 2. Summary of articles included in the study

No	Author	Title	Location	Research design	Results	Discussion
1	Gong *et al.* [29]	The Impact of Blood Lead and Its Interaction with Occupational Factors and Air Pollution on Hypertension Prevalence	China	Cross-sectional	From a total of 22,022 workers, 2,805 individuals (12.75%) were identified as having hypertension, with a mean (standard deviation) NO_2 exposure of 29.16 µg/m³ (6.29 µg/m³).	There was a significant interaction effect of NO_2 between blood lead levels and the prevalence of hypertension ($P_{interaction}$= 0.04).
2	Li *et al.* [30]	Effects of air pollution and noise exposure on occupational hearing loss in oil workers: a prospective cohort study	China	Cohort	From 1,179 oil mining workers, 185 individuals (15.70%) were identified as having hypertension, with a mean (standard deviation) NO_2 exposure of 41.20 µg/m³ (8.90 µg/m³).	Long-term exposure to nitrogen dioxide (NO_2) is significantly associated with an increased risk of hearing impairment and hypertension through mechanisms involving oxidative stress and systemic inflammation, which contribute to endothelial dysfunction and elevated blood pressure.
3	Chen *et al.* [31]	Association between Combined Exposure to Underground Air Pollutants and Hypertension in Coal Miners: A Cross-Sectional Study	China	Cross-sectional	From 3,432 coal miners, 630 individuals (18.40%) were identified as having hypertension, with an average NO_2 exposure level of 2,140 µg/m³.	There was a strong and significant contribution of NO_2 exposure to hypertension risk, with an odds ratio (OR) of 1.68, compared with CO_2 and NO.
4	Huang *et al.* [32]	Long-term ambient air pollution exposure and DNA methylation of peripheral brain-derived neurotrophic factor promoter	China	Cohort	In 2011, among 101 workers, 72 individuals (71.30%) were identified as having hypertension, with a mean (standard deviation) NO_2 exposure of 60.17 µg/m³ (2.17 µg/m³) in 2011 and 57.66 µg/m³ (2.32 µg/m³) in 2015.	Long-term NO_2 exposure is associated with significant alterations in Brain-Derived Neurotrophic Factor (BDNF) promoter methylation levels, contributing to an increased risk of hypertension among workers.
5	Nwakamma *et al.* [33]	Influence of Air Pollutants on Ocular Health Among Road Transport Workers in Imo State, Nigeria	Nigeria	Cross-sectional	From 374 roadside workers, 27 individuals (7.22%) were identified as having ocular hypertension, with mean (standard deviation) NO_2 exposure levels at three locations measuring 0.79 µg/m³ (1.04 µg/m³), 1.90 µg/m³ (0.50 µg/m³), and 1.79 µg/m³ (1.10 µg/m³).	Roadside workers who adopted preventive measures were significantly less likely to experience ocular problems, including ocular hypertension, compared with those who did not implement such measures (OR = 0.06; p = 0.001, χ^2 = 142.89, df = 1).

Based on the magnitude of NO_2 exposure among workers, the study by Chen *et al.* [31] reported the highest exposure level at 2,140 µg/m³, whereas the study by Nwakamma *et al.* [33] documented the lowest exposure range at 0.79–1.90 µg/m³. These two studies were conducted in markedly different settings, with the highest NO_2 concentrations observed at coal mining sites.

Although the magnitude of exposure differed substantially across studies, the direction of the findings remained largely consistent. Studies involving higher occupational NO_2 exposure generally reported a greater burden of hypertension or stronger statistical associations between NO_2 exposure and hypertension-related outcomes. Conversely, studies conducted in lower-exposure settings reported lower prevalence estimates but still identified adverse health effects associated with NO_2 exposure. This overall consistency strengthens the evidence supporting an association between occupational NO_2 exposure and hypertension, while also highlighting that differences in occupational setting, study design, and exposure assessment contribute to variability in the reported effect sizes. Furthermore, the prevalence of hypertension among workers reported across the five included studies ranged from 7.2% to 71.3%, depending on the occupational sector and duration of exposure as shown in Figure 2.

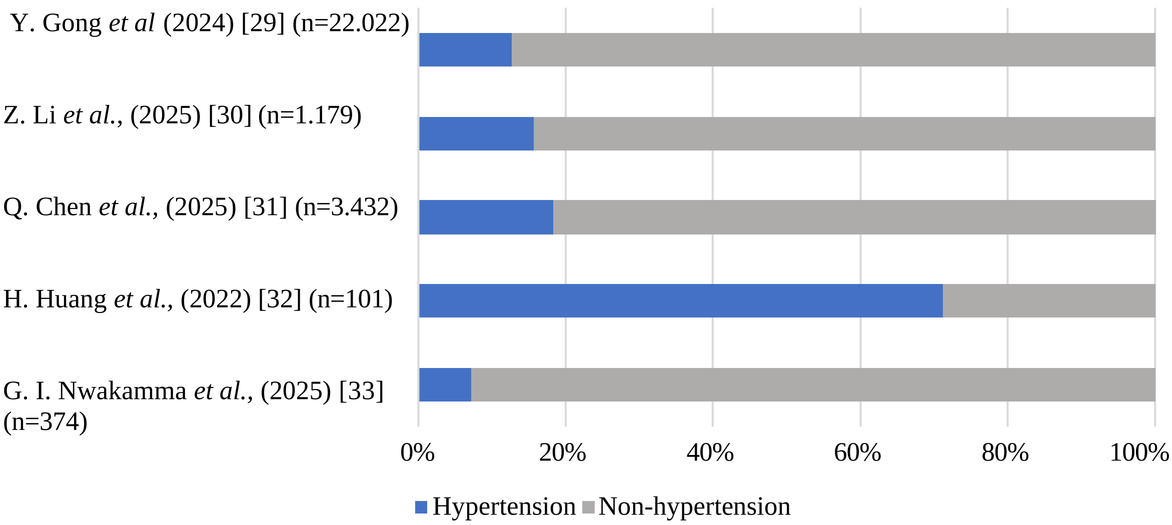

Figure 2. Prevalence of hypertension among workers based on the reviewed research articles

4. DISCUSSION

4.1. Interpretation of findings

Overall, all reviewed articles consistently reported a significant association between NO_2 exposure and an increased risk of hypertension among workers across various occupational sectors. These findings align with the study by Meo *et al.* [34], which demonstrated that environmental pollutants such as $PM_{2.5}$, PM_{10}, NO_2, SO_2, and VOCs significantly elevate hypertension risk. One of the most important findings of this systematic review is the consistency of the direction of the association across studies despite considerable heterogeneity in study design, occupational settings, and exposure levels. Although the included studies differed in worker populations, methods of NO_2 exposure assessment, and hypertension outcome definitions, all consistently indicated that occupational NO_2 exposure was associated with adverse cardiovascular outcomes. This consistency strengthens the overall body of evidence and suggests that the observed association is unlikely to be attributable solely to differences in study methodology.

Evidence further indicates that NO_2 is four times more toxic than NO; under normal ambient conditions, NO readily oxidizes into NO_2, which is more hazardous [35], [36]. NO_2, primarily generated from fossil fuel combustion, is particularly concentrated in occupational environments with high emission sources such as mining, transportation, and heavy industry, leading to elevated exposure levels both outdoors and in confined workspaces [30], [31], [33]. Several studies have shown that NO_2 concentrations exceeding 100 ppm can be lethal for most laboratory animals, with nearly 90% of deaths attributed to pulmonary edema. Acute NO_2 exposure damages cellular membranes within lung tissue and causes airway constriction [36], [37]. Inhalation of NO_2 triggers multiple pathological responses, including systemic inflammation, oxidative stress, endothelial dysfunction, and autonomic nervous system imbalance [34], [38]. Once inhaled, NO_2 dissolves within the epithelial lining fluid of the lungs, generating reactive nitrogen species (RNS) and reactive oxygen species (ROS). Elevated ROS levels promote oxidative stress, damage vascular endothelial cells, and stimulate the release of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α), ultimately impairing endothelial function and disrupting vascular homeostasis [39]-[41].

The reaction between NO and superoxide produces peroxynitrite ($ONOO^-$), a highly reactive nitrogen species that oxidizes tetrahydrobiopterin (BH_4), an essential cofactor for nitric oxide synthase (NOS) [42]. This oxidation uncouples NOS, causing it to generate superoxide instead of nitric oxide (NO), thereby reducing NO bioavailability. Reduced NO levels impair endothelial relaxation, increase vascular resistance, and consequently elevate blood pressure [43], [44]. Endothelial injury diminishes vascular elasticity and promotes vasoconstriction, contributing to chronic hypertension [20], [45]. Additionally, NO_2 exposure disrupts autonomic regulation by enhancing sympathetic activity and suppressing parasympathetic tone, further increasing heart rate and blood pressure [46]. Given that NO plays a central role in vascular dilation and blood pressure regulation, reduced NOS activity inevitably leads to vasoconstriction and hypertension [36], [47]. These mechanisms collectively explain the strong biological link between long-term NO_2 exposure and heightened hypertension risk in workers exposed to poor air quality [34], [48].

Several studies also highlight the cumulative and synergistic effects of NO_2 with other pollutants such as CO, $PM_{2.5}$, and O_3. Chen *et al.* [31] reported that combined exposure to multiple pollutants in underground mining environments contributed significantly to hypertension risk, with an odds ratio of 1.68—substantially higher than exposure to NO_2 alone. This finding underscores the intensified toxicity of NO_2 in poorly ventilated workspaces. Similarly, Huang *et al.* [32] identified associations between long-term NO_2 exposure and alterations in brain-derived neurotrophic factor (BDNF) promoter methylation, suggesting that NO_2 may exert epigenetic effects influencing neuroregulatory pathways associated with blood pressure control.

The included studies also indicate that occupational context may substantially modify exposure levels and associated health risks. Workers employed in underground mining, oil extraction, and roadside occupations experience continuous exposure to combustion-related pollutants over prolonged periods. These occupational characteristics may explain the higher prevalence of hypertension observed in several studies and highlight the importance of considering workplace-specific exposure scenarios when evaluating cardiovascular risks.

Workers in transportation and mining sectors appear to carry the highest risk due to continuous proximity to emission sources and insufficient protective measures [49], [50]. A study from Nigeria by Nwakamma *et al.* [33] reported that roadside workers who consistently used personal protective equipment (PPE) had significantly lower risks of hypertension and ocular complications compared with those who did not adopt preventive strategies (OR = 0.06; p = 0.001). Another important finding is that preventive measures appeared to reduce adverse health outcomes even in occupations with unavoidable exposure. This suggests that occupational hypertension related to NO_2 exposure is not only preventable through emission reduction but may also be mitigated through workplace interventions, including engineering controls, administrative controls, and consistent PPE use. These findings reinforce the importance of integrating exposure control into occupational health management systems rather than relying solely on medical surveillance.

These results emphasize the need for both behavioral and technical interventions, including PPE utilization, improved ventilation systems, and routine workplace air-quality monitoring. Geographic context also plays an important role; developing countries such as China and Nigeria face challenges in occupational air-pollution control due to limited monitoring infrastructure and low worker awareness. These findings align with the World Health Organization (2023) report stating that every 10 $\mu g/m^3$ increase in NO_2 concentration raises hypertension risk by approximately 3–5% [51]. From a public health perspective, the findings have broader implications because hypertension remains one of the leading risk factors for cardiovascular disease and premature mortality worldwide. Occupational exposure to NO_2 therefore represents not only an environmental issue but also an important occupational health concern that may contribute to the growing burden of non-communicable diseases. Reducing workplace, NO_2 exposure has the potential to improve workers' cardiovascular health, reduce productivity losses associated with hypertension, and decrease healthcare costs attributable to work-related chronic diseases.

Consequently, comprehensive prevention and control measures are urgently needed, including occupational health policies, air-quality surveillance, and enhanced worker and industry awareness regarding pollution hazards. Collectively, this review reinforces the critical role of NO_2 exposure control in preventing work-related non-communicable diseases, particularly hypertension. The findings also support strengthening occupational exposure standards and incorporating routine environmental monitoring into workplace health programs, particularly in industries with intensive fossil-fuel combustion. Policymakers should encourage collaboration among environmental agencies, occupational health services, and employers to implement evidence-based interventions aimed at reducing long-term NO_2 exposure among workers.

These findings provide a strong scientific basis for incorporating NO_2 exposure mitigation into occupational hypertension prevention strategies. Therefore, cross-sectoral collaboration among industry, government, and occupational health professionals is essential to reduce air-pollutant exposure in high-risk sectors such as mining and transportation.

4.2. Clinical and research implications

The findings of this systematic review suggest that occupational exposure to NO_2 should be recognized as an important risk factor for hypertension among workers, particularly in high-exposure sectors such as mining, transportation, and industry. These results highlight the need for routine blood pressure screening, workplace air-quality monitoring, improved ventilation systems, and consistent use of PPE as part of occupational health programs. From a research perspective, the identified associations and underlying biological mechanisms, including oxidative stress, inflammation, endothelial dysfunction, and epigenetic changes, support the integration of environmental exposure assessment into cardiovascular risk evaluation and occupational health policies aimed at preventing work-related non-communicable diseases.

Beyond clinical practice, these findings have important implications for occupational health policy. Regular environmental monitoring, integration of air-quality indicators into workplace risk assessments, and enforcement of occupational exposure standards should become integral components of workplace health management. Furthermore, identifying NO_2 exposure as a modifiable occupational risk factor provides opportunities for primary prevention strategies that may reduce the long-term burden of cardiovascular diseases among workers.

4.3. Directions for future research

Future studies should focus on large-scale longitudinal and multicenter investigations to strengthen causal evidence regarding the relationship between occupational NO_2 exposure and hypertension. Research is also needed to determine dose–response relationships, identify safe exposure thresholds, and evaluate the combined effects of NO_2 with other workplace pollutants such as $PM_{2.5}$, PM_{10}, CO, and O_3. In addition, future studies should explore molecular and epigenetic mechanisms underlying pollutant-induced hypertension while accounting for potential confounding factors, including smoking, lifestyle, and pre-existing health conditions, to provide a more comprehensive understanding of cardiovascular risks among exposed workers. Future systematic reviews should also explore quantitative evidence through meta-analysis where sufficient homogeneous studies become available. Standardization of NO_2 exposure assessment methods and hypertension outcome definitions across studies would improve comparability and facilitate more robust estimates of the occupational cardiovascular risks associated with NO_2 exposure.

5. CONCLUSION

This systematic review provides comprehensive evidence that occupational exposure to NO_2 is associated with an increased risk of hypertension among workers, particularly in high-exposure settings such as mining, transportation, and industrial sectors. By synthesizing findings from recent studies, this review contributes to the growing body of evidence linking occupational air pollution to cardiovascular health and highlights potential biological mechanisms involving oxidative stress, systemic inflammation, endothelial dysfunction, and epigenetic alterations. These findings underscore the importance of integrating air-quality management, exposure monitoring, and cardiovascular health surveillance into occupational health programs to reduce the burden of work-related hypertension. Future research should prioritize large-scale prospective studies across diverse occupational settings, standardized exposure assessment methods, and investigations of combined pollutant exposures and underlying molecular pathways. Such efforts will strengthen causal evidence, inform evidence-based occupational health policies, and support the development of targeted interventions that can deliver greater public health benefits by protecting workers from pollution-related cardiovascular diseases.

ACKNOWLEDGMENTS

We would like to express our sincere gratitude to all parties who contributed to the preparation of this research article, especially the Department of Environmental Health, Faculty of Public Health, Mulawarman University.

FUNDING INFORMATION

This review was completed without external funding, and all expenses for the search, data extraction, and analysis were independently covered by the authors.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

This study did not require ethical approval because it utilized a systematic review methodology that relied solely on secondary data obtained from published literature and publicly accessible databases. Since no human subjects or animals were directly involved in the research process, ethical review and approval were not necessary.

DATA AVAILABILITY

The data analyzed in this study were exclusively obtained from publicly available scholarly articles accessed through recognized academic databases and Open Journal System (OJS) repositories.

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