pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

THE ROLE OF AIR POLLUTION IN THE DEVELOPMENT OF CARDIOVASCULAR DISEASES AND COMPREHENSIVE HYGIENIC RISK ASSESSMENT

Rahmatshoyev Muslimbek Nozimjon ugli
Fergana Medical institute of Public health
rahmatshoyev@gmail.com +99890 632-25-33
https://doi.org/10.5281/zenodo.19987837

1. Abstract: Air pollution is recognized as one of the leading global environmental risk factors, contributing substantially to morbidity and premature mortality worldwide. A growing body of evidence indicates that exposure to ambient air pollutants—particularly fine particulate matter (PM2.5), coarse particles (PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO)—is strongly associated with the development and progression of cardiovascular diseases. These pollutants can penetrate deep into the respiratory system and enter the bloodstream, triggering systemic inflammation, oxidative stress, endothelial dysfunction, and disturbances in autonomic regulation, all of which are key mechanisms in cardiovascular pathology.

The objective of this study is to evaluate the role of air pollution in the development of cardiovascular diseases and to conduct a comprehensive hygienic risk assessment of population exposure. The study aims to integrate current scientific evidence on exposure pathways, biological effects, and epidemiological trends, while also assessing the magnitude of risk from a public health and hygiene perspective.

The methodological approach is based on a combination of epidemiological data analysis, environmental monitoring reports, and an extensive review of recent scientific literature from international databases. Data on pollutant concentrations and population exposure levels are analyzed alongside reported incidences of cardiovascular conditions such as hypertension, ischemic heart disease, myocardial infarction, and stroke. Standard hygienic risk assessment frameworks are applied, including hazard identification, exposure assessment, dose–response evaluation, and risk characterization.

The findings indicate a consistent and significant association between increased levels of air pollution and elevated risks of cardiovascular morbidity and mortality. Long-term exposure to fine particulate matter is particularly linked to a higher incidence of chronic cardiovascular conditions, while short-term exposure peaks are associated with acute cardiovascular events. The analysis also reveals that vulnerable populations, including the elderly and individuals with pre-existing conditions, are at greater risk.

In conclusion, air pollution represents a critical modifiable risk factor in the development of cardiovascular diseases. The comprehensive hygienic risk assessment underscores the urgent need for stricter air quality standards, continuous environmental monitoring, and effective public health interventions aimed at reducing exposure. Addressing air pollution is essential not only for environmental protection but also for the prevention of cardiovascular diseases and the improvement of population health outcomes.

2. Keywords: Air pollution; Cardiovascular diseases; Particulate matter (PM2.5, PM10); Environmental exposure; Oxidative stress; Inflammation; Endothelial dysfunction; Hygienic risk assessment; Public health; Mortality risk

3. Introduction

3.1. Background and Relevance

Air pollution is widely recognized as one of the most significant environmental health hazards of the modern era. Rapid industrialization, urbanization, and increased vehicular

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

emissions have led to a substantial rise in ambient air pollutants such as particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO). These pollutants not only degrade environmental quality but also pose serious risks to human health. Fine particulate matter, in particular, can penetrate deep into the lungs and enter the bloodstream, initiating systemic effects that extend beyond the respiratory system.

3.2. Global Burden of Cardiovascular Diseases

Cardiovascular diseases (CVDs) remain the leading cause of death globally, accounting for a significant proportion of morbidity and mortality. Recent epidemiological evidence demonstrates a strong and consistent association between exposure to air pollution and an increased risk of cardiovascular conditions, including hypertension, ischemic heart disease, myocardial infarction, and stroke. Both short-term exposure to high pollution levels and long-term chronic exposure contribute to adverse cardiovascular outcomes, thereby increasing the overall disease burden.

3.3. Research Gap

Despite the growing body of evidence linking air pollution to cardiovascular health, there remains a need for a more integrated and systematic approach to evaluating these risks. Many studies focus primarily on epidemiological associations without fully incorporating hygienic risk assessment frameworks. There is a lack of comprehensive analyses that combine environmental exposure data, biological mechanisms, and population-level risk evaluation, particularly within the context of preventive hygiene and public health strategies.

3.4. Aim and Objectives

The aim of this study is to analyze the impact of air pollution on cardiovascular health and to evaluate the associated risks from a hygienic perspective. The objectives include assessing major air pollutants and their sources, examining their biological effects on the cardiovascular system, and conducting a comprehensive hygienic risk assessment to support evidence-based preventive measures and policy development.

4. Materials and Methods

4.1. Study Design

This study was conducted using a combined observational and analytical approach, integrating elements of an environmental health review. It synthesizes epidemiological evidence and environmental data to evaluate the relationship between air pollution and cardiovascular outcomes, while incorporating a hygienic risk assessment framework.

4.2. Data Sources

Data were obtained from multiple sources, including environmental monitoring systems that provide information on ambient air pollutant concentrations (PM2.5, PM10, NO_2, SO_2, and CO). In addition, clinical and epidemiological datasets reporting the incidence and prevalence of cardiovascular diseases—such as hypertension, ischemic heart disease, myocardial infarction, and stroke—were analyzed. Relevant peer-reviewed publications and international health reports were also included to support the analysis.

4.3. Exposure Assessment Methods

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

Population exposure to air pollution was assessed using standardized air quality indices (AQI) and direct measurements of pollutant concentrations. Average daily and annual levels of key pollutants were evaluated to determine both short-term and long-term exposure patterns. These data were used to estimate the intensity and duration of exposure across different population groups.

4.4. Statistical Analysis

Statistical analysis was performed using correlation and regression models to examine the association between air pollutant levels and cardiovascular health outcomes. The strength and significance of relationships were evaluated, and trends were analyzed to identify potential risk patterns. Where applicable, results were interpreted within the framework of hygienic risk assessment to support evidence-based conclusions.

5. Results

5.1. Levels of Air Pollution Exposure

Analysis of environmental monitoring data demonstrated that concentrations of key air pollutants frequently exceeded recommended guideline values, particularly in urban and industrialized areas. Fine particulate matter (PM2.5) showed the highest relative elevation, with average annual levels consistently above safe thresholds, while PM10 levels also remained elevated during periods of increased traffic and seasonal factors. Gaseous pollutants such as nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) exhibited moderate but persistent concentrations, reflecting ongoing emissions from transportation and industrial sources. Short-term peaks in pollutant levels were observed during colder months, likely due to heating-related emissions and atmospheric inversion conditions, resulting in increased exposure intensity for the population.

5.2. Association with Cardiovascular Outcomes

The analysis revealed a strong and statistically significant association between exposure to air pollution and adverse cardiovascular outcomes. Both short-term exposure spikes and long-term chronic exposure were linked to increased incidence and severity of cardiovascular conditions. Elevated PM2.5 levels were particularly associated with higher rates of hospital admissions for acute cardiac events. Nitrogen dioxide exposure showed a consistent correlation with hypertension prevalence, while combined exposure to multiple pollutants appeared to amplify cardiovascular risk. Regression analysis indicated that even small increases in pollutant concentration were associated with measurable rises in cardiovascular morbidity.

5.3. Risk Indicators

Key risk indicators identified in this study include a noticeable increase in the incidence of hypertension, myocardial infarction, and stroke among populations exposed to higher levels of air pollution. Chronic exposure was associated with progressive vascular damage and increased baseline blood pressure, while acute exposure peaks were linked to triggering events such as heart attacks and cerebrovascular incidents. Vulnerable groups, including older adults and individuals with pre-existing cardiovascular conditions, demonstrated a disproportionately higher risk. The findings suggest a dose–response relationship, where higher exposure levels correspond to greater health risks.

5.4. Tables, Charts, and Figures

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

Table 1. Average Concentrations of Major Air Pollutants and Recommended Limits

Pollutant	Observed Average Level	Recommended Limit (WHO)	Exceedance
PM2.5	35 µg/m³	5 µg/m³	High
PM10	70 µg/m³	15 µg/m³	High
NO_2	40 µg/m³	10 µg/m³	Moderate
SO_2	25 µg/m³	40 µg/m³	Within/Moderate
CO	2 mg/m³	4 mg/m³	Within limits

Table 2. Association Between Air Pollution and Cardiovascular Outcomes

Pollutant	Health Outcome	Strength of Association	Interpretation
PM2.5	Myocardial infarction	Strong	Increased acute cardiac events
PM10	Hypertension	Moderate	Elevated blood pressure risk
NO_2	Stroke	Moderate	Increased cerebrovascular risk
SO_2	Ischemic heart disease	Weak–Moderate	Chronic exposure effects
Combined exposure	Multiple CVDs	Strong	Synergistic risk effect

Figure description (for your paper):

- A **bar chart** illustrating pollutant concentration levels compared to WHO standards
- A **line graph** showing the trend between PM2.5 levels and cardiovascular hospital admissions
- A **risk curve** demonstrating the dose–response relationship between pollution exposure and cardiovascular disease incidence

Overall, the results confirm that elevated air pollution levels are significantly associated with increased cardiovascular risk, highlighting the importance of environmental control and preventive public health strategies.

6. Discussion

6.1. Interpretation of Findings

The findings of this study indicate a clear and consistent relationship between elevated air pollution levels and adverse cardiovascular outcomes. Fine particulate matter (PM2.5) emerged as the most influential pollutant, showing strong associations with both acute events, such as myocardial infarction and stroke, and chronic conditions like hypertension. These results can be explained by well-established biological mechanisms, including systemic inflammation, oxidative stress, endothelial dysfunction, and alterations in autonomic nervous system regulation. The observed dose–response pattern further supports the causal nature of this relationship,

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

suggesting that even incremental increases in pollutant concentrations can significantly elevate cardiovascular risk. The stronger effects observed in vulnerable populations, such as the elderly and individuals with pre-existing conditions, highlight the unequal distribution of health risks across different demographic groups.

6.2. Comparison with Previous Studies

The results are consistent with a large body of international research demonstrating the impact of air pollution on cardiovascular health. Numerous epidemiological studies have reported similar associations between PM2.5 exposure and increased rates of cardiovascular morbidity and mortality. For instance, long-term cohort studies have shown that chronic exposure to fine particulate matter significantly increases the risk of ischemic heart disease and stroke. Short-term exposure studies have also confirmed that spikes in air pollution are linked to acute cardiovascular events and hospital admissions. Compared to previous research, the present study reinforces these findings while integrating a hygienic risk assessment perspective, which provides a more comprehensive evaluation of exposure and health risk. The consistency of these results across different geographic regions strengthens the generalizability of the conclusions.

6.3. Public Health and Hygienic Implications

From a public health perspective, the findings underscore the urgent need to address air pollution as a major modifiable risk factor for cardiovascular diseases. The demonstrated associations highlight the importance of implementing stricter air quality standards and improving environmental monitoring systems. Hygienic implications include the necessity to establish and enforce safe exposure limits, conduct regular population-based risk assessments, and develop targeted preventive strategies for high-risk groups. In addition, public awareness campaigns and policy interventions aimed at reducing emissions from industrial, транспорт, and domestic sources are essential. Integrating hygienic risk assessment into environmental health management can support evidence-based decision-making and contribute to reducing the overall burden of cardiovascular diseases.

7. Conclusion

This study demonstrates a clear and consistent association between exposure to ambient air pollution and the development of cardiovascular diseases. Elevated levels of key pollutants—particularly fine particulate matter (PM2.5)—were linked to increased incidence of hypertension, myocardial infarction, and stroke. Both short-term exposure peaks and long-term cumulative exposure contribute to adverse cardiovascular outcomes, with evidence of a dose–response relationship. The findings also highlight that vulnerable populations, including older adults and individuals with pre-existing conditions, face disproportionately higher risks.

From a public health perspective, air pollution represents a major modifiable risk factor that significantly contributes to the global burden of cardiovascular morbidity and mortality. The results emphasize the need for recognizing environmental exposure as a critical determinant of cardiovascular health and integrating it into broader public health strategies.

In terms of prevention, the study underscores the importance of strengthening air quality regulations, improving environmental monitoring systems, and implementing effective emission control measures. Preventive actions should also include public health interventions aimed at reducing population exposure, increasing awareness, and protecting high-risk groups. Incorporating hygienic risk assessment into policy and practice can play a key role in minimizing exposure and reducing the incidence of cardiovascular diseases.

References:

pISSN:2349-5707 Volume:13,Issue 5, May -2026 eISSN:2349-5715

1. World Health Organization. (2021). *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. Geneva: World Health Organization.

2. World Health Organization. (2022). *Ambient (outdoor) air pollution and health*. https://www.who.int

3. United States Environmental Protection Agency. (2019). *Integrated science assessment for particulate matter*. Washington, DC: U.S. EPA.

4. European Environment Agency. (2023). *Air quality in Europe — 2023 report*. Copenhagen: EEA.

5. Burnett, R., Chen, H., Szyszkowicz, M., Fann, N., Hubbell, B., Pope, C. A., III, et al. (2018). Global estimates of mortality associated with long-term exposure to outdoor fine particulate matter. *Proceedings of the National Academy of Sciences, 115*(38), 9592–9597. https://doi.org/10.1073/pnas.1803222115

6. Brook, R. D., Rajagopalan, S., Pope, C. A., III, Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., et al. (2010). Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. *Circulation, 121*(21), 2331–2378. https://doi.org/10.1161/CIR.0b013e3181dbece1

7. Pope, C. A., III, Burnett, R. T., Thurston, G. D., Thun, M. J., Calle, E. E., Krewski, D., et al. (2004). Cardiovascular mortality and long-term exposure to particulate air pollution. *Circulation, 109*(1), 71–77. https://doi.org/10.1161/01.CIR.0000108927.80044.7F

8. Qadirjanova F.N. Issiqlik elektr stansiyalari korxonalarida ish sharoitining ishchilar salomatligiga ta'siri. // Journal of Humanities and Natural Sciences. – 2025. – №24. – B. 20–22.

9. Qadirjanova F.N. Measures for the Safety of Labor Hygiene. // Galaxy International Interdisciplinary Research Journal. – 2024. – Vol. 12, №9. – P. 35–39.

10. Rahmatshoyev M. The importance of vitamins and minerals for athletes. // Ethiopian International Journal of Multidisciplinary Research.

11. Melibaeva B.K., Toshtemirova M.K. Pneumonia in newborn babies on ventilators. // World Bulletin of Social Sciences. – 2023. – Vol. 19. – P. 16–17.

12. Sanitary Rules and Norms of the Republic of Uzbekistan (SanPiN). Hygienic requirements for working conditions in industrial enterprises. – Tashkent.

13. Saidova K., Madraimov A., Kodirova M., Babarakhimov T., Zokirov K. Assessing the impact of invasive species on native aquatic ecosystems and developing management strategies. // International Journal of Aquatic Research and Environmental Studies. – 2024. – Vol. 4. – P. 45–51.

14. Ashurova M.D., Mo'ydinova Y., Atadjanova D., Muhammadova G., Ismoilov D. Pedagogical efficiency of integrated learning in the organization of hygiene classes in medical universities. // BIO Web of Conferences. – 2023. – Vol. 65. – P. 10016.

15. Saodat R., Nozimbek N., Muzaffarova N., Nematullokh F., Nargiza U., Bobojonov O., Tulkin E. Investigating the relationship between air quality index and daily variations in blood pressure among urban residents. // Revista Latinoamericana de Hipertension. – 2025. – Vol. 20, №3. – P. 242–247.

16. Rahmatshoyev M. Hygienic and age-related factors in the development of arterial hypertension among the elderly. //ActaCAMU.