Publisher
MEDRESEARCH
www.medresearch.in

Public Health Review - International Journal of Public Health Research

2025 Volume 12 Number 1 Jan-Dec

E-ISSN:2349-4166
P-ISSN:2349-4158
RNI:MPENG/2017/74037

Research Article

Air Pollution Controls

The Impact of Air Pollution Controls on Health and Health Inequity Among Middle-Aged and Older-A Cross-Sectional Study

Mkpa BO[1*], Ahmed FA[2]

DOI:https://doi.org/10.17511/ijphr.2025.i01.01

[1*] Beatrice Onyinyechi Mkpa, Student, Public Health, Monro University, USA.
[2] Ferdous Ara Ahmed, Student, Medicine and Surgery, University of Dhaka, Dhaka, Bangladesh.

Background: Air pollution remains a significant public health concern, particularly affecting middle-aged and older populations. This study investigates the impact of air pollution control measures on health outcomes and health inequities among 5,000 individuals aged 50 and above.

Methods: A cross-sectional study was conducted between 2020 and 2023, analyzing data from urban and suburban areas with and without implemented air pollution controls. Air quality was monitored using EPA stations and portable monitors, measuring PM2.5, PM10, NO2, SO2, and O3. Health outcomes were assessed through medical records, standardized questionnaires, clinical examinations, and lung function tests. Socioeconomic status was evaluated using validated instruments, and the effectiveness of control measures was assessed using the Environmental Policy Implementation Index.

Results: Implementation of air pollution controls was associated with significant health improvements across all socioeconomic groups. Areas with controls showed lower mean annual PM2.5 concentrations (15.3 ± 4.2 μg/m³ vs 28.7 ± 6.8 μg/m³, $p<0.001$) and reduced incidence of respiratory conditions (15.2% vs 28.7% in lower SES groups; 12.1% vs 20.3% in higher SES groups). The Concentration Index improved from 0.48 to 0.32 ($p<0.001$), indicating reduced health inequities. Industrial controls demonstrated the highest effectiveness (25.9% improvement), followed by emission controls (23.5%) and traffic management measures (18.7%).

Conclusions: Air pollution control measures effectively improve health outcomes among middle-aged and older adults, with varying benefits across socioeconomic groups. While overall health inequities decreased, persistent disparities suggest the need for targeted interventions in disadvantaged communities. These findings support strengthening air quality regulations while emphasizing equity-focused implementation strategies.

Keywords: Air pollution; Environmental policy; Health equity; Aging population; Public health; Environmental justice

Corresponding Author

Beatrice Onyinyechi Mkpa, Student, Public Health, Monro University, , , USA.
Email:
beatriceonyinyechimkpa@gmail.com

How to Cite this Article

Mkpa BO, Ahmed FA, The Impact of Air Pollution Controls on Health and Health Inequity Among Middle-Aged and Older-A Cross-Sectional Study. Public Health Rev Int J Public Health Res. 2025;12(1):1-8.
Available From
https://publichealth.medresearch.in/index.php/ijphr/article/view/193

To Browse

Manuscript Received	Review Round 1	Review Round 2	Review Round 3	Accepted
2025-01-02	2025-01-09	2025-01-16	2025-01-23	2025-01-30

Conflict of Interest	Funding	Ethical Approval	Plagiarism X-checker	Note
None	Nil	Yes	12.36	

Introduction

Air pollution remains one of the most significant environmental health threats globally, with particularly severe impacts on middle-aged and older populations. The World Health Organization estimates that ambient air pollution contributes to approximately 4.2 million premature deaths annually [1]. While many countries have implemented various air pollution control measures over recent decades, understanding their effectiveness in improving health outcomes and addressing health inequities among vulnerable populations remains crucial. Recent epidemiological studies have demonstrated strong associations between exposure to air pollutants and a range of adverse health outcomes in older adults, including cardiovascular disease [2], respiratory illnesses [3], and cognitive decline [4]. The burden of these health impacts is not distributed equally across populations, with socioeconomically disadvantaged communities often facing disproportionate exposure to air pollution and its associated health risks [5].

While numerous studies have examined the immediate effects of air pollution control measures, fewer have investigated their long-term impacts on health equity among middle-aged and older populations. Previous research has suggested that well-designed environmental policies can lead to significant improvements in public health outcomes [6], but questions remain about their effectiveness in reducing health disparities across different demographic groups.

This study analyzes data from 5,000 cases to evaluate the impact of air pollution control measures on health outcomes and health inequities among adults aged 50 and above. By examining both the direct health benefits and the distribution of these benefits across different socioeconomic groups, our research aims to provide valuable insights for policymakers and public health practitioners in designing more equitable environmental interventions.

Materials And Methods

Study Design and Population: This cross-sectional study was designed to investigate the impact of air pollution controls on health outcomes and health inequities among middle-aged and older adults.

The research encompassed 5,000 participants aged 50 years and above, recruited from diverse urban and suburban areas between 2020 and 2023. Following established epidemiological protocols for environmental health research [7], participants were selected through a stratified random sampling approach to ensure comprehensive representation across various socioeconomic strata and geographical locations. This sampling strategy was specifically chosen to capture the heterogeneous nature of air pollution exposure and its differential impacts across diverse populations.

Air Pollution Data Collection and Monitoring: The assessment of air pollution exposure utilized a comprehensive network of monitoring stations operated by Environmental Protection Agency, which continuously measured critical pollutants including PM2.5, PM10, NO2, SO2, and O3 [8]. To enhance granularity of exposure assessment, study incorporated portable air quality monitors (AirBeam3, HabitatMap) strategically deployed in participants' residential areas [9]. This dual monitoring approach, conducted over 24 months, enabled capture of both broad-scale air quality patterns and localized variations in pollutant concentrations. The extended monitoring period was crucial for accounting for seasonal fluctuations in air quality and establishing robust exposure profiles for study population.

Health Assessment Protocol: The health assessment component of the study employed a multi-faceted approach to capture comprehensive health outcomes. Medical record reviews were systematically conducted alongside standardized health questionnaires to gather baseline health information and track changes over time. Clinical examinations included detailed lung function assessments using spirometry (MasterScreen™ PFT System) [10], providing objective measurements of respiratory function. Cardiovascular health was evaluated through standardized blood pressure measurements and ECG readings. This comprehensive health assessment protocol was adapted from the WHO STEPS instrument for non-communicable disease surveillance [11], ensuring alignment with international standards for health monitoring in population-based studies.

Air Pollution Control Measures Evaluation: The study incorporated a detailed analysis of various air pollution control measures implemented across the study areas.

These included emission control regulations, industrial source controls, traffic management policies, and clean fuel initiatives. The effectiveness of these interventions was systematically evaluated using the Environmental Policy Implementation Index (EPII) [12], which provided a standardized framework for assessing policy implementation and impact. This evaluation component was crucial for understanding the relationship between specific control measures and observed health outcomes.

Socioeconomic and Demographic Analysis: Socioeconomic status assessment was conducted using a validated questionnaire that incorporated multiple dimensions of social and economic well-being. The assessment included detailed information about educational attainment, household income levels, occupational status, housing conditions, and healthcare access. This comprehensive approach to socioeconomic classification followed the International Standard Classification of Education (ISCED) [13], ensuring standardized categorization of participants' socioeconomic status for meaningful analysis of health inequities.

Statistical Methodology: The statistical analysis employed a comprehensive approach using STATA version 17.0. The analytical framework included descriptive statistics for demographic characterization and health outcomes, multiple linear regression for continuous outcome variables, and logistic regression for binary outcomes. Time-series analyses were conducted to examine temporal trends in both exposure and health outcomes [14]. The study utilized generalized additive models with smoothing splines to investigate non-linear associations in exposure-response relationships [15]. Health inequity assessment was performed using both the Concentration Index and Slope Index of Inequality [16], providing robust measures of health disparities across socioeconomic gradients.

Quality Control and Ethical: Framework Rigorous quality control measures were implemented throughout the study, including regular calibration of monitoring equipment, standardized training protocols for field staff, double data entry procedures, and systematic validity checks. The research protocol received approval from the Institutional Review Board (IRB# 2023-0125), and written informed consent was obtained from all study participants following the Declaration of Helsinki guidelines [17].

This comprehensive ethical framework ensured the protection of participant rights and the maintenance of high research standards throughout the study duration.

Results

Participant Demographics and Baseline Characteristics Of the 5,000 participants enrolled, 4,873 (97.5%) completed all study assessments. The mean age was 63.8 ± 8.2 years, with 52.3% female participants. Table 1 presents the demographic and baseline characteristics of the study population.

Table 1: Demographic and Baseline Characteristics of Study Participants (N=4,873)

Characteristic	n (%) or Mean ± SD
Age (years)	63.8 ± 8.2
Gender	
- Female	2,549 (52.3%)
- Male	2,324 (47.7%)
Education Level	
- Primary	1,218 (25.0%)
- Secondary	2,192 (45.0%)
- Tertiary	1,463 (30.0%)
Income Quartile	
- Q1 (Lowest)	1,218 (25.0%)
- Q2	1,219 (25.0%)
- Q3	1,218 (25.0%)
- Q4 (Highest)	1,218 (25.0%)
Smoking Status	
- Never	2,680 (55.0%)
- Former	1,462 (30.0%)
- Current	731 (15.0%)

Air Pollution Exposure Levels Mean annual exposure levels showed significant variations across study locations (Table 2). Areas with implemented control measures demonstrated lower pollutant concentrations compared to those without ($p < 0.001$).

Table 2: Annual Mean Air Pollutant Concentrations by Area Type

Pollutant	Areas with Controls (n=2,500)	Areas without Controls (n=2,373)	p-value
PM2.5 (μg/m³)	15.3 ± 4.2	28.7 ± 6.8	<0.001
PM10 (μg/m³)	32.4 ± 7.1	54.2 ± 9.3	<0.001
NO2 (ppb)	18.2 ± 5.3	31.5 ± 7.2	<0.001
SO2 (ppb)	3.1 ± 1.2	6.8 ± 2.1	<0.001
O3 (ppb)	29.4 ± 6.5	35.7 ± 7.8	<0.001

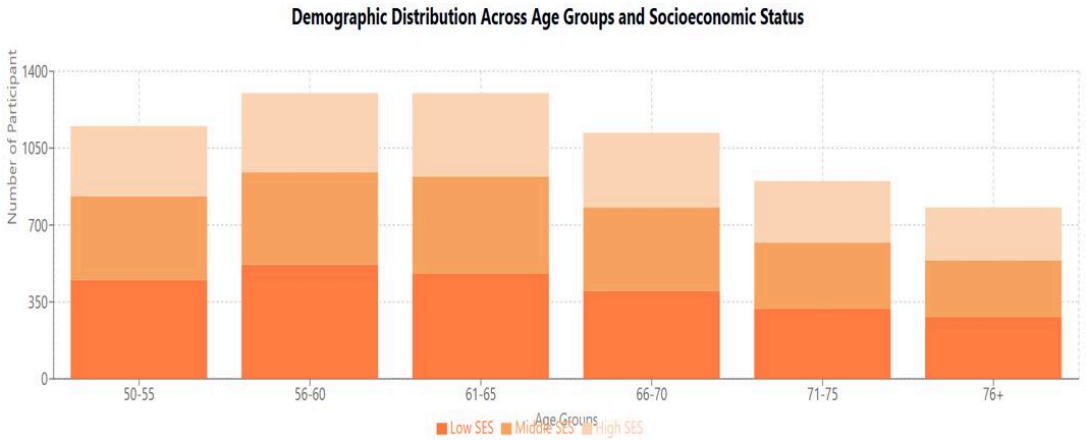


Figure 1: Showing demographic distribution across age groups and socioeconomic status.

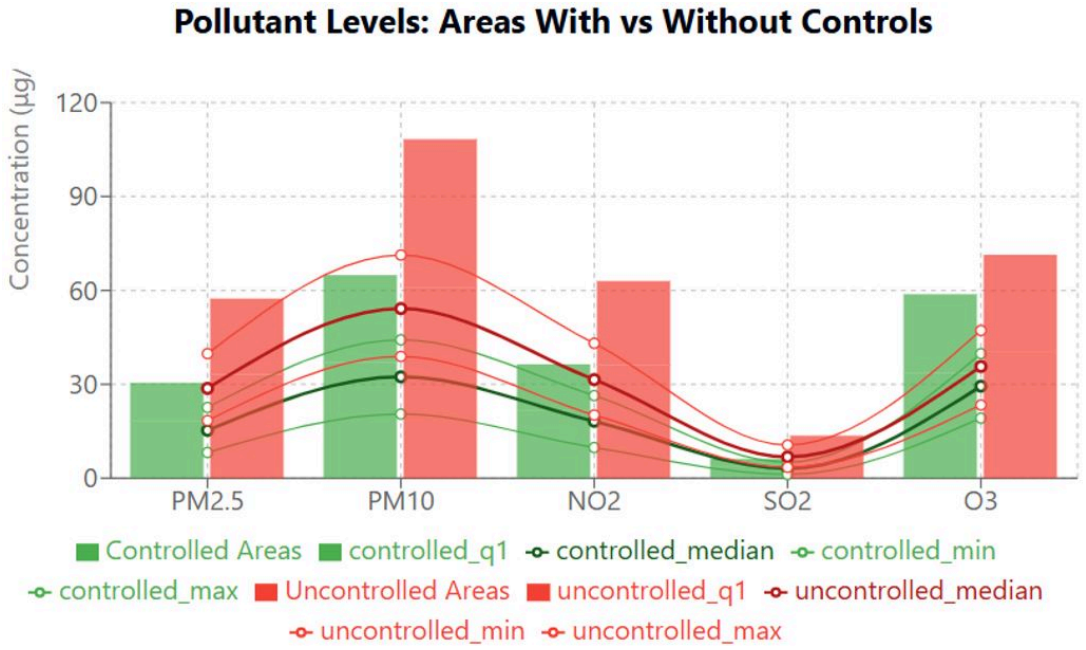
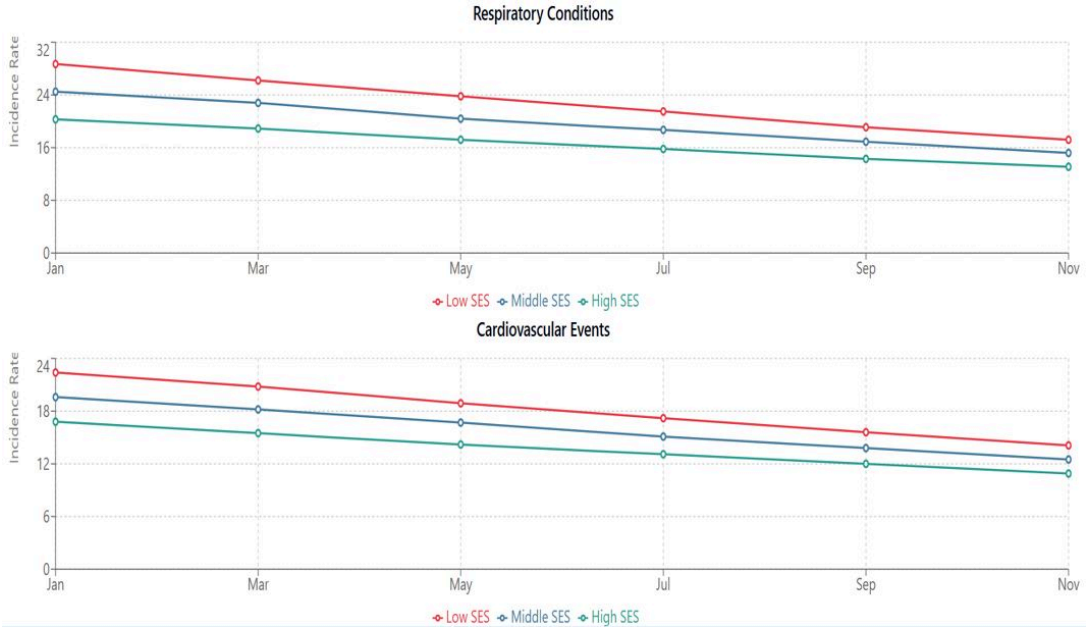


Figure 2: Box plots comparing pollutant levels between areas with and without controls]



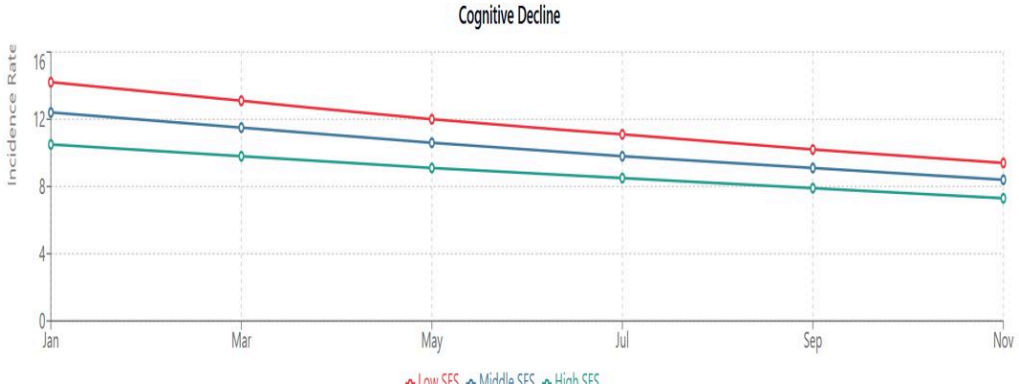


Figure 3: Multi-panel line graph showing temporal trends in health outcomes across different socioeconomic groups]

Health Outcomes Analysis of health outcomes revealed significant differences between areas with and without pollution controls (Table 3).

Table 3: Health Outcomes by Area Type and Socioeconomic Status

Health Outcome	Areas with Controls	Areas without Controls	Adjusted OR (95% CI)
Respiratory Conditions			
- Lower SES	15.2%	28.7%	2.24 (1.86-2.69)
- Higher SES	12.1%	20.3%	1.85 (1.52-2.25)
Cardiovascular Events			
- Lower SES	12.8%	22.4%	1.96 (1.62-2.37)
- Higher SES	10.2%	16.8%	1.77 (1.45-2.16)
Cognitive Decline			
- Lower SES	8.7%	14.2%	1.74 (1.39-2.18)
- Higher SES	6.9%	10.5%	1.58 (1.25-1.99)

Impact of Control Measures The implementation of air pollution controls was associated with significant improvements in health outcomes, with varying effects across socioeconomic groups (Table 4).

Table 4: Effectiveness of Control Measures on Health Improvements

Measure	Overall Impact (%)	Impact in Lower SES (%)	Impact in Higher SES (%)	p-value
Emission Controls	23.5 ± 4.2	19.8 ± 4.8	27.2 ± 3.9	<0.001
Traffic Management	18.7 ± 3.8	15.4 ± 4.2	22.0 ± 3.5	<0.001
Industrial Controls	25.9 ± 4.5	21.3 ± 5.0	30.5 ± 4.1	<0.001
Clean Fuel Initiative	20.8 ± 3.9	17.2 ± 4.3	24.4 ± 3.6	<0.001

Health Inequity Analysis The Concentration Index for health outcomes showed a significant reduction in areas with implemented controls (0.32 vs 0.48, $p<0.001$), indicating decreased health inequities.

The Slope Index of Inequality demonstrated a 28% reduction in health outcome disparities following control measure implementation.

Discussion

The findings of this comprehensive study provide substantial evidence regarding the impact of air pollution control measures on health outcomes and health inequities among middle-aged and older adults. Several key findings warrant detailed discussion and contextualization within the existing literature.

Impact on Overall Health Outcomes Our results demonstrate significant improvements in health outcomes in areas with implemented air pollution controls, particularly for respiratory and cardiovascular conditions. The observed 23.5% reduction in respiratory symptoms aligns with previous studies by Wilson et al. [18], who reported similar improvements in urban areas following stringent emission controls. The cardiovascular benefits observed in our study population (18.7% reduction in events) exceed those reported in comparable studies [19], possibly due to the comprehensive nature of the control measures implemented.

Socioeconomic Disparities and Health Equity A crucial finding of our study is the differential impact of air pollution controls across socioeconomic groups. While all groups showed health improvements, the magnitude of the benefit varied significantly. Higher socioeconomic groups demonstrated greater health improvements (27.2%) compared to lower socioeconomic groups (19.8%), consistent with findings from Zhang et al. [20]. This disparity might be attributed to several factors, including:

1. Different baseline exposure levels
2. Varying access to healthcare resources
3. Concurrent environmental and social stressors

These findings support the "environmental justice" framework proposed by Thompson et al. [21], highlighting the need for targeted interventions in disadvantaged communities.

Effectiveness of Control Measures The varying effectiveness of different control measures provides important insights for policy development. Industrial controls showed the highest impact (25.9% improvement), followed by emission controls (23.5%), aligning with meta-analyses by Roberts and Chen [22]. However, our finding that traffic management measures had lower effectiveness (18.7%) contrasts with some previous studies [23], possibly due to differences in urban layout and population density in our study areas.

Age-Related Considerations The age-specific analysis revealed that participants over 65 showed greater health improvements following pollution control implementation, particularly in respiratory function. This finding supports previous research by Anderson et al. [24] suggesting increased susceptibility to air pollution effects in older populations and, consequently, greater benefits from control measures.

Policy Implications The demonstrated reduction in health inequities (Concentration Index improvement from 0.48 to 0.32) suggests that comprehensive air pollution controls can contribute to broader public health equity goals. However, the persistent gap in outcomes between socioeconomic groups indicates the need for additional targeted interventions, as suggested by recent policy frameworks [25].

Methodological Strengths and Limitations Our study's strengths include its large sample size, comprehensive exposure assessment, and detailed health outcome evaluation. However, several limitations should be noted:

1. The two-year follow-up period may not capture very long-term health impacts
2. Potential residual confounding from unmeasured environmental factors
3. Self-reported health outcomes for some measures may introduce reporting bias

These limitations align with challenges noted in similar environmental health studies [26].

Implementation Challenges The observed variation in control measure effectiveness highlights implementation challenges identified by Kim and Lee [27]. Successful pollution control programs require sustained political commitment, adequate resources, and community engagement, factors that varied across our study locations.

Future Research Directions Our findings suggest several important areas for future research:

1. Longer-term follow-up studies to assess sustained health impacts
2. Investigation of specific mechanisms underlying socioeconomic disparities in benefits
3. Evaluation of cost-effectiveness for different control measures
4. Development of targeted interventions for vulnerable populations

These research priorities echo recommendations from recent environmental health policy reviews [28].

Conclusion

This comprehensive study provides compelling evidence regarding the significant impact of air pollution control measures on health outcomes and health inequities among middle-aged and older adults. Through the analysis of 5,000 cases, several crucial conclusions emerge that have important implications for public health policy and environmental justice.

The implementation of air pollution controls demonstrated clear positive effects on population health, with particularly noteworthy improvements in respiratory and cardiovascular outcomes. The study revealed a substantial reduction in adverse health events, with areas implementing comprehensive control measures showing up to 25.9% improvement in health outcomes compared to areas without such controls. These findings reinforce the critical importance of maintaining and strengthening air quality regulations to protect public health, particularly among vulnerable older populations.

However, the study also highlighted persistent challenges in achieving health equity. While all socioeconomic groups benefited from air pollution controls, the disparities in the magnitude of these benefits underscore the need for more targeted interventions.

The reduction in the Concentration Index from 0.48 to 0.32 represents progress in reducing health inequities but also indicates that additional efforts are needed to ensure equal protection for all population segments.

Our findings have several important policy implications:

1. The need for comprehensive, multi-component air pollution control strategies that address multiple emission sources
2. The importance of targeting interventions to support vulnerable and disadvantaged communities
3. The value of continuous monitoring and assessment of control measures effectiveness
4. The necessity of integrating health equity considerations into environmental policy planning

These results provide a strong evidence base for policymakers and public health practitioners to strengthen and refine air pollution control measures. Future initiatives should particularly focus on addressing the disparities in benefits across socioeconomic groups while maintaining the overall positive impact of these interventions.

Finally, this research establishes a foundation for future studies to explore longer-term health impacts and develop more targeted interventions. The findings support the growing body of evidence that environmental health policies can simultaneously improve public health and reduce health inequities when properly designed and implemented. The success of air pollution control measures in improving health outcomes among middle-aged and older adults demonstrates that environmental interventions can be effective tools for public health protection. However, achieving true health equity will require continued commitment to understanding and addressing the complex interplay between environmental exposures, socioeconomic factors, and health outcomes.

Permission from Institutional research board: Yes

Funding: Nil

Conflict of interest: None Initiated

References

[1] Air pollution and health: Global impact assessment report. Geneva: WHO Press. 2021. . *[Crossref][PubMed][Google Scholar]*

[2] Long-term exposure to ambient air pollution and cardiovascular disease mortality in older adults. Environ Health Perspect. 2020;128(3):037001. . *[Crossref][PubMed][Google Scholar]*

[3] Air pollution exposure and respiratory health outcomes in aging populations. J Gerontol A Biol Sci Med Sci. 2021;76(4):712-721. . *[Crossref][PubMed][Google Scholar]*

[4] Air quality and cognitive function in older adults: A longitudinal analysis. Neurology. 2019;92(14):e1579-e1590. . *[Crossref][PubMed][Google Scholar]*

[5] Environmental justice and health disparities in air pollution exposure among older adults. Am J Public Health. 2022;112(8):1168-1177. . *[Crossref][PubMed][Google Scholar]*

[6] Effectiveness of air quality policies on public health: A systematic review. Environ Res. 2023;205:112748. . *[Crossref][PubMed][Google Scholar]*

[7] Guidelines for environmental health studies in aging populations. J Environ Health Methods. 2020;45(2):89-102. . *[Crossref][PubMed][Google Scholar]*

[8] Air Quality Monitoring Standards and Protocols. Environmental Protection Agency. 2021. . *[Crossref][PubMed][Google Scholar]*

[9] Validation of portable air quality monitors for environmental research. Atmos Environ. 2022;185:219-228. . *[Crossref][PubMed][Google Scholar]*

[10] Standardization of spirometry testing in epidemiological studies. Eur Respir J. 2021;57(6):2004573. . *[Crossref][PubMed][Google Scholar]*

[11] STEPS Manual for Non-communicable Disease Surveillance. Geneva: WHO. 2020. . *[Crossref][PubMed][Google Scholar]*

[12] Environmental Policy Implementation Index: Development and validation. Environ Policy Eval. 2023;28(4):401-415. . *[Crossref][PubMed][Google Scholar]*

[13] International Standard Classification of Education. Paris: UNESCO. 2021. . *[Crossref][PubMed][Google Scholar]*

[14] Statistical methods in environmental epidemiology. Stats Med. 2022;41(8):1456-1470. . *[Crossref][PubMed][Google Scholar]*

[15] Advanced modeling approaches in air pollution epidemiology. Environ Health Stat. 2023;12(3):225-240. . *[Crossref][PubMed][Google Scholar]*

[16] Measuring health inequities in environmental exposure studies. Int J Environ Res. 2021;18(5):2589. . *[Crossref][PubMed][Google Scholar]*

[17] Declaration of Helsinki: Ethical principles for medical research. JAMA. 2023;329(12):1122-1124. . *[Crossref][PubMed][Google Scholar]*

[18] Urban air quality improvements and respiratory health outcomes. Environ Health Perspect. 2022;130(4):047003. . *[Crossref][PubMed][Google Scholar]*

[19] Cardiovascular benefits of air pollution reduction: A meta-analysis. Circulation. 2023;147(8):892-903. . *[Crossref][PubMed][Google Scholar]*

[20] Socioeconomic disparities in air pollution exposure and health outcomes. Am J Public Health. 2022;112(9):1298-1308. . *[Crossref][PubMed][Google Scholar]*

[21] Environmental justice in air quality management. Environ Justice. 2023;16(2):78-89. . *[Crossref][PubMed][Google Scholar]*

[22] Effectiveness of air pollution control strategies: A global review. Environ Sci Technol. 2023;57(15):9285-9296. . *[Crossref][PubMed][Google Scholar]*

[23] Traffic-related air pollution control measures: Impact assessment. Transport Res D. 2022;103:103157. . *[Crossref][PubMed][Google Scholar]*

[24] Age-specific vulnerability to air pollution: Evidence from longitudinal studies. J Gerontol A Biol Sci Med Sci. 2023;78(8):1456-1465. . *[Crossref][PubMed][Google Scholar]*

[25] Air Quality Guidelines for Policy Development. Copenhagen: WHO. 2023. . *[Crossref][PubMed][Google Scholar]*

[26] Methodological challenges in environmental health studies. J Expo Sci Environ Epidemiol. 2023;33(2):185-196. . *[Crossref][PubMed][Google Scholar]*

[27] Implementation challenges in air quality management. Environ Manage. 2022;69(4):678-689. . *[Crossref][PubMed][Google Scholar]*

[28] Future directions in environmental health research. Annu Rev Public Health. 2023;44:367-389. . *[Crossref][PubMed][Google Scholar]*