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Air Pollution Control Legislation and Respiratory Health: A Systematic Review and Meta-analysis

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ABSTRACT

Air pollution is one of the most significant environmental factors threatening public health, associated with an increased incidence of respiratory diseases and premature mortality. The present study aimed to evaluate the effect of air pollution control legislation on respiratory health. The international databases PubMed/Scopus, MEDLINE (Ovid), Cochrane Library, and Embase were searched using keywords aligned with the study objective as of September 2025. Two blinded, independent authors reviewed all articles. STATA/MP.v17 (College Station, Texas, USA) was used to perform the analyses. Fifteen eligible studies were included in the study after reviewing the title, abstract, and full text by independent and blinded researchers. An overall reduction in pollutants was estimated to be 20% (ES 0.20; 95% CI: 0.10-0.31). Meta-regression with a random-effects model revealed a significant inverse relationship (-0.0846, P = 0.032) between air pollution reduction and policy type. The impact of implementing pollution reduction laws on asthma was significant (HR: 0.86, 95% CI: 0.80-0.92). Strengthening legal frameworks, promoting evidence-based policy making, and enforcing regulations can help reduce emissions, thereby improving public health and reducing the burden of air pollution-related diseases.

Keywords: *Air Pollution, Legal Services, Legislation as Topic, Public Nondiscrimination Policies, Respiratory System Agents.*

Introduction

Air pollution is recognized as one of the most complex environmental and health challenges globally; in addition to its direct consequences on human health, it has extensive legal and social dimensions(1). According to a report from the World Health Organization, air pollution causes millions of premature deaths worldwide each year; on the other hand, pollution contributes significantly to chronic respiratory, cardiovascular, and cancer diseases(2); in developing countries, this figure is significantly higher(3). Studies have shown that high-risk groups (children, the elderly, and people with chronic diseases) are more susceptible to diseases caused by air pollution(4). Numerous scientific studies have demonstrated a strong and direct link between exposure to air pollutants, particularly particulate matter less than 2.5 microns in diameter (PM2.5) and harmful gases, and the occurrence of chronic respiratory diseases, lung infections, and even premature death(5, 6). Research suggests that long-term exposure to pollutants not only causes chronic lung inflammation and reduced lung function, but can also increase the risk of heart disease, stroke, and other systemic disorders(7, 8). In addition to health consequences, air pollution has significant economic impacts; its consequences include medical costs, reduced labor productivity, and financial burdens on health and insurance systems(9). In the field of public law, air pollution control laws are considered not only as enforcement tools to reduce pollutants, but also as legal guarantees to protect the health of citizens(10, 11). These laws include industrial emission limits, air quality standards, encouraging the use of vehicles with lower emissions, and implementing fiscal and tax policies to reduce pollution. However, existing studies show that simply passing laws is not enough. Without a scientific and legal assessment of their effectiveness, one cannot expect a significant reduction in health outcomes(12). Many developing countries face challenges such as weak oversight, a lack of resources, and non-compliance with policies that fail to meet international standards, which highlights the need for a comprehensive and systematic analysis of existing laws and their impacts on respiratory health(13, 14). Cultural, economic, and structural differences between countries mean that a law that is successful in one country may not necessarily be applicable in another. This requires careful consideration of local conditions, the level of public awareness, and the oversight capacity of legal systems(15). Air pollution control laws are implemented at national, regional and international levels and have different enforcement mechanisms. European countries have reported significant reductions in respiratory disease and pollution-related mortality rates by implementing strict air quality standards and rigorous monitoring systems(16, 17). In contrast, countries with weak regulation or inadequate oversight have not seen positive effects. Examining these experiences can serve as a useful policy model for other countries, demonstrating that a combination of strict regulations, effective enforcement, and public participation is essential for success(18). In European countries such as Germany and Sweden, a combination of strict air quality laws, detailed monitoring systems, and active citizen participation has resulted in significant reductions in respiratory disease indicators and pollution-related deaths(19). In developing countries such as Delhi or Beijing, despite passing similar laws, they have not succeeded in sustainably reducing air pollution due to weak oversight, lack of funding, economic pressures, and high population density(20, 21). The availability of appropriate technology and infrastructure constraints are also other challenges; for example, industries in areas that lack accurate monitoring tools can easily fail to meet standards without being penalized.

The main goal of studies that examine the impact of air pollution control laws is to provide decision-makers and legislators with scientific and legal evidence to improve public health. These studies can show which laws and policies are most effective, which enforcement mechanisms are successful, and which areas need reform and improvement. By identifying best practices and examining policy weaknesses, it is possible to develop evidence-based legislation and policies are aligned with local realities and implementation capacities. The implications of air pollution policy are far-reaching. Improving population health and reducing the burden of air pollution-related diseases reduces healthcare costs and increases labor productivity. It improves equity and reduces health inequalities(22). At the international level, evidence has shown that strengthening global standards and regional cooperation helps reduce environmental inequalities between countries(23). The goal of these types of policies is not only to reduce emissions, but also to create a sustainable mechanism for preventing air pollution and protecting public health in the long term. By combining scientific data, regulatory analysis, and implementation feedback, it is possible to design policies that are both operational, effective, and adapted to local conditions(24).

Implementing air pollution control laws in practice faces several challenges that can reduce their effectiveness. Weak air quality monitoring and surveillance is one of the most important problems(12). In many developing countries, monitoring stations are few and far between, and accurate data to assess pollution levels and the impact of regulations are lacking. Lack of financial and human resources also hinders full implementation of regulations(25).

Administrative corruption and conflicts of interest between industry, government, and civil society can lead to incomplete or selective enforcement of the law(26). The present study examined the impact of air pollution control laws on respiratory health indicators using a systematic review and meta-analysis. The innovation of this research lies in the structured integration of scientific and legal evidence. Given the increasing burden of air pollution-related diseases, this study provides evidence that can help decision-makers and legislators design and strengthen environmental and public health strategies. By combining quantitative health data and systematic analysis of regulations, the researchers set out to create a bridge between scientific evidence and the policy-making process, offering an innovative approach to public health management.

Method

Search strategy

The design and implementation of the present study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines(27). Relevant keywords (Table 1) were used to search the international databases PubMed/Scopus, MEDLINE(Ovid), Cochrane Library, and Embase up to September 2025. The number of articles found from each database is shown in the tablel; after removing duplicate articles, irrelevant titles and abstracts, eligible articles were selected for the final analysis. To find relevant research, the references of the articles were also reviewed. In the present study, only articles published in English were considered. During all stages of the study, two authors independently and blindly searched for relevant articles, selected titles and abstracts consistent with the study objective, and finally reviewed the full texts of the articles.

Table 1. Search Strategy.

International Databases	Search Strategy	Number of records identified
PubMed	((((("Respiratory System Agents"[Mesh]) OR "Lung Diseases"[Mesh]) OR "Asthma"[Mesh])) OR "Pulmonary Disease, Chronic Obstructive"[Mesh]) OR ("Lung Diseases, Obstructive"[Mesh] OR "Pulmonary Disease, Chronic Obstructive, Severe Early-Onset" [Supplementary Concept]) #1 (("Air Pollution"[Mesh] OR "Air Pollution, Indoor"[Mesh]) OR ("Environmental Policy"[Mesh] OR "Environment"[Mesh])) OR ("Legislation" [Publication Type] OR "Legislation as Topic"[Mesh] OR "Legislation, Medical"[Mesh] OR "Legislation, Hospital"[Mesh]) #2 ("Developed Countries"[Mesh] OR "Developing Countries"[Mesh]) AND "Legal Services"[Mesh] #3 Combined Strategy: #1 AND #2 AND #3	n=120
Embase	'respiratory disease'/exp OR 'lung disease' OR 'asthma' OR 'COPD' OR 'respiratory health' 'air pollution control legislation' OR 'environmental regulation*' OR 'environmental policy' OR 'environmental law' OR 'legal framework' 'policy implementation' OR 'regulation enforcement' OR 'law enforcement' Combine disease/outcome AND intervention/exposure AND context.	n=90
MEDLINE (Ovid)	Respiratory Health/ OR Lung Diseases/ OR Asthma/ OR Chronic Obstructive Pulmonary Disease/ OR Respiratory Health*.mp. Air Pollution Control.mp. OR Environmental Regulation.mp. OR Environmental Law.mp. OR Environmental Policy.mp. OR Legal Framework.mp. Policy Implementation.mp. OR Regulation Enforcement.mp. OR Law Enforcement.	n=70
Cochrane Library	MeSH descriptor: [Respiratory Tract Diseases] explode all trees ("Lung Disease*" OR "Asthma*" OR "COPD" OR "Respiratory Health*"):ti,ab,kw Intervention / Exposure: ("Air Pollution Control" OR "Environmental Regulation*" OR "Environmental Policy" OR "Air Quality Law*"):ti,ab,kw Comparator / Context: ("Policy Implementation" OR "Legal Framework" OR "Regulation Enforcement"):ti,ab,kw Combined strategy: #Disease AND #Intervention AND #Comparator	n=18

Selection criteria

Included criteria: Studies were included if they met the PICOS strategy criteria. Population (P): People of all age groups are affected by air pollution; Intervention (I): Legal instruments (laws, regulations, or policies) aimed at reducing air pollution; control (C): Not applicable / No control group; Outcome (O): Respiratory health indicators and related diseases: asthma, COPD, chronic lung diseases, lung function indicators, mortality from respiratory diseases, hospitalization rates; S (Study): cohort study, randomized controlled trial (RCT) studies, and Quantitative studies (cross-sectional, cohort, case-control, quasi-experimental).

Exclusion criteria: (1) reviews, in vivo studies, case reported, and literature that is unavailable or incomplete; (2) studies that do not involve human subjects; (3) articles written in a language other than English; (4) Theoretical studies without quantitative data; (5) Studies unrelated to respiratory health or environmental laws; (6) The ones that focused on non-legal aspects.

Data Extraction

Data extraction was performed using a pre-built standard form. Two investigators independently and blindly extracted data from each included study, and a third reviewer assisted in resolving any disagreements between investigators. Study characteristics were briefly included, including the name of the first author, year of publication, Country, Study Design, Sample Size, Intervention, Law, Policy, Exposure Assessment, and Respiratory Outcome.

Quality assessment

The methodological quality of the selected studies was assessed using the AXIS tool (for cross-sectional and observational studies) and the JBI Critical Appraisal Checklist (for quasi-experimental and case-crossover studies).

Key domains of AXIS tool included sample representativeness, validity of exposure and outcome measurements, response rate, missing data handling, and appropriateness of statistical analysis. Total scores ranged 0–20, and studies were categorized as High, Moderate, or Low quality.

Domains of JBI Critical Appraisal Checklist included clarity of research question, population definition, exposure/intervention measurement, outcome measurement, statistical analysis, and control of confounding. Scores were converted to a 0–20 scale and classified as High, Moderate, or Low quality.

Statistical analysis

Statistical analysis was performed with STATA/MP.v17 (College Station, Texas, USA) software. Heterogeneity was assessed using the I^2 statistic (No heterogeneity: 0.0% < I^2 < 24.9%; low heterogeneity: 25.0% < I^2 < 49.9%; Moderate heterogeneity: 50.0% < I^2 < 74.9%; High heterogeneity: 75.0% < I^2 < 100%), and in the presence of high heterogeneity, a fixed-effects and random effect model with Inverse–variance and REML method used for effect size with 95% CI. Subgroup meta-analysis and meta-regression were done for all variables.

Result

Literature Search

In the initial search using keywords, 298 articles were identified. After reviewing the titles, duplicate articles were removed, and 23 articles were excluded from the review due to their study type. In the next step, the abstracts of 243 articles were evaluated according to the inclusion and exclusion criteria, and another 197 articles were excluded. Finally, the full text of 46 articles was reviewed independently by two authors without knowledge of each other's opinions. In cases of disagreement, the opinion of the third author was applied. After this process, 15 articles that were consistent with the study objectives were selected for analysis. (Figure 1).

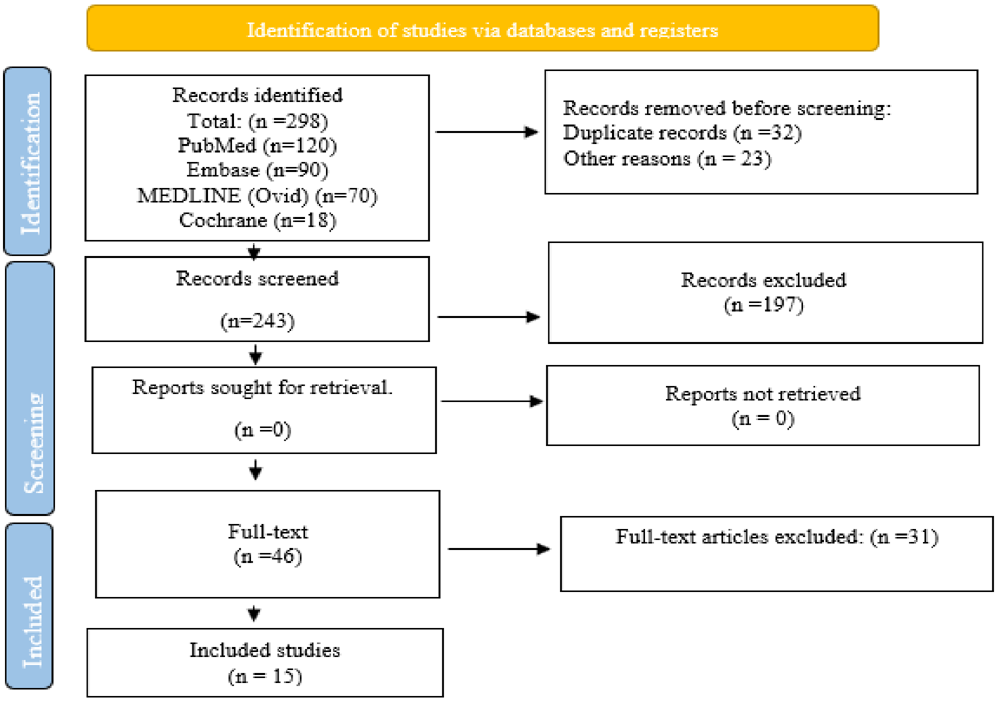

Figure 1. PRISMA 2020 Flow Diagram.

As shown in Table 2, the selected studies employed various study designs, including cross-sectional, case-control, observational, and structural analyses, and the samples spanned national to international scales. Interventions primarily included air quality policies and regulations, pollutant emission reduction, the use of air pollution control indicators, and the development of urban green spaces. Exposures were assessed using the Air Quality Index (AQI), as well as concentrations of major pollutants, including $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and O_3. Respiratory health outcomes included the incidence of asthma, COPD, acute lung diseases, mortality from respiratory diseases, and hospitalization.

Table 2. Characteristics included studies.

Study	Country	Study Design	Sample Size	Intervention / Law / Policy	Exposure Assessment	Respiratory Outcome
Alkhanani et al., 2025 (28)	Global	Cross-sectional	27countries	Air quality regulations/ policies	AQI, Ozone (O_3), NO_2 concentrations	Incidence of asthma, COPD, tuberculosis
Zarate-Gonzalez et al., 2025 (29)	USA	Cross-sectional	310 patients	Air pollution control policies	Self-reported health status, EuroQOL-5D-3L	Asthma, quality of life
Chi et al., 2025 (30)	China	Case study	31 regions	Air pollutant emission reduction	Pre-reduction scenario	SO_2, NO_x, $PM_{2.5}$ concentrations
Nie et al., 2023 (31)	China	Case study	cases of respiratory diseases	Air pollution reduction	$PM_{2.5}$, PM_{10}, NO_2, SO_2, CO concentrations	Respiratory disease incidence
Zhang et al., 2023 (32)	China	Cross-sectional	30 provinces	Atmospheric Environmental Policy (AEP)	$PM_{2.5}$, SO_2, NO_2, Air Pollution Index (API)	Public health indicators (respiratory hospital admissions, mortality)
Yang et al., 2021 (33)	China	Cross-sectional	General population	Carbon and air pollution	$PM_{2.5}$, O_3 concentrations;	Respiratory health: $PM_{2.5}$- and O_3-related mortality

				control policies	Air Quality Index	
Han et al., 2021(34)	Global (166 countries)	Observational	166 countries	Air pollution control policies; APCI index	APCI (Air Pollution Control Efficacy Index: $PM_{2.5}$ / CO_2 per capita	Life expectancy, infant & under-5 mortality, respiratory health indicators
Jaafari et al., 2020 (35)	Iran	Structural equation modeling & landscape metrics	22 districts of Tehran	Urban green space	Landscape metrics (area, edge, connectivity); $PM_{2.5}$ concentration	Respiratory mortality
Ma et al., 2019 (36)	China	observational study	national, multiple regions	Air pollution control policies	$PM_{2.5}$ concentration estimated from MODIS AOD, meteorology, and land use	Respiratory health proxies: $PM_{2.5}$-related morbidity/mortality
Croft et al., 2019 (37)	USA	Case-crossover	498,118 patients	Air quality policies and economic changes	$PM_{2.5}$ concentration last 7 days, air pollution data	Hospitalization rates
Huang et al., 2018 (38)	China	Observational, quasi-experimental	74 cities in China	APPCAP	$PM_{2.5}$ concentrations from national air quality monitoring stations	Mortality from respiratory diseases (lung cancer, COPD, pneumonia)
Ghorani-Azam et al., 2016 (39)	Iran	Observational	General Iranian population	Air pollution exposure (PM, NOx, SO_2, O_3)	Monitoring stations + modeled estimates	Respiratory diseases: asthma, bronchitis, COPD, lung cancer, acute infections
Guan et al., 2016 (40)	China	Observational, quasi-experimental	General Chinese population	Exposure to ambient air pollutants ($PM_{2.5}$, PM_{10}, NO_2, O_3)	National air quality monitoring data + WHO datasets	Chronic respiratory diseases: COPD, asthma, lung cancer, bronchitis
Chen et al., 2013 (41)	China	Observational, quasi-experimental	General urban population	Application of the Air Quality Health Index (AQHI) for risk messaging	Air pollution levels ($PM_{2.5}$, PM_{10}, NO_2, O_3) via monitoring stations	Respiratory health outcomes
Karakatsani et al., 2012 (42)	Multiple European countries	Observational	Adults with asthma or COPD	Exposure to ambient PM ($PM_{2.5}$, PM_{10})	Monitoring stations across study sites; personal exposure models	Daily respiratory symptoms

AQI: Air Quality Index; O_3: Ozone; NO_2: Nitrogen dioxide; SO_2: Sulfur dioxide; $PM_{2.5}$: Particulate matter with diameter ≤2.5 µm; PM_{10}: Particulate matter with diameter ≤10 µm; CO: Carbon monoxide; EuroQOL-5D-3L: Standardized self-reported quality of life measure with five dimensions and three levels; APCI: Air Pollution Control Efficacy Index; MODIS AOD: Moderate Resolution Imaging Spectroradiometer Aerosol Optical Depth; APPCAP: Air Pollution Prevention and Control Action Plan; AQHI: Air Quality Health Index; COPD: Chronic Obstructive Pulmonary Disease.

Quality of studies

According to the score obtained from the AXIS tool (total score between 0 and 20) (Table 3), the studies were classified into four high-quality studies and one moderate quality study. According to JBI Critical Appraisal Checklist) (Table 4), five studies had moderate quality and four studies had high quality.

Table 3. Quality Assessment of Cross-sectional and Observational Studies Using the AXIS Tool

Study	Sample Representativeness	Measurement Validity (Exposure & Outcome)	Response Rate & Missing Data	Statistical Analysis	Total Score (out of 20)	Quality Level

Alkhanani et al., 2025	4/4	5/5	4/4	5/5	18	High
Zarate-Gonzalez et al., 2025	3/4	4/5	3/4	6/7	16	High
Zhang et al., 2023	4/4	5/5	4/4	4/5	17	High
Yang et al., 2021	4/4	5/5	4/4	5/5	18	High
Ghorani-Azam et al., 2016	4/4	5/5	4/4	4/5	17	High
Karakatsani et al., 2012	3/4	4/5	3/4	6/7	16	Moderate

Table 4. Quality Assessment of Quasi-experimental, Case-crossover, and Case Study Designs Using the JBI Critical Appraisal Checklist

Study	Clear Research Question	Population Definition	Exposure & Intervention Measurement	Outcome Measurement	Statistical Analysis	Confounding Control	Total Score (out of 20)	Quality Level
Chi et al., 2025	3/4	3/4	4/5	2/3	2/2	0/2	14	Moderate
Nie et al., 2023	3/4	3/4	4/5	2/3	2/2	1/2	15	Moderate
Han et al., 2021	4/4	4/4	5/5	3/3	2/2	1/2	19	High
Jaafari et al., 2020	3/4	3/4	4/5	2/3	2/2	1/2	15	Moderate
Ma et al., 2019	4/4	4/4	5/5	2/3	2/2	0/2	17	High
Croft et al., 2019	4/4	4/4	5/5	3/3	2/2	0/2	18	High
Huang et al., 2018	3/4	4/4	4/5	2/3	2/2	1/2	16	Moderate
Guan et al., 2016	3/4	4/4	4/5	2/3	2/2	1/2	16	Moderate
Chen et al., 2013	4/4	4/4	5/5	3/3	2/2	0/2	17	High

Effect of air pollution control legislation

Seven studies examined the impact of air pollution control policies and interventions on reducing pollution indicators (especially $PM_{2.5}$). Based on the random effects model (REML), the overall reduction in pollutants was estimated to be 20% (ES 0.20; CI 95%: 0.10 to 0.31) (Figure 2). Therefore, the implementation of control laws and policies in different countries is significantly associated with a reduction in air pollution indices and, consequently, with an improvement in respiratory outcomes.

High heterogeneity was observed among studies ($I^2 = 95.21\%$, $Q = 60.17$; $p < 0.001$). This suggests that the effects of interventions in different countries were influenced by a variety of factors, including policy type, enforcement intensity, socioeconomic conditions, and baseline pollution levels; hence, a meta-regression was performed.

According to Table 5, a meta-regression analysis using a random-effects model revealed a significant inverse relationship (-0.0846, P = 0.032) between air pollution reduction and policy type (Figure 3). This finding suggests that differences in law enforcement across countries are significantly related to the extent of pollutant reduction, and that air pollution control policies in some countries have a greater impact on pollutant reduction. While a non-significant (P = 0.528) inverse relationship (-0.0346) was observed between the reduction of air pollution and the implementing country, indicating that the difference between countries alone does not have a significant effect on the rate of pollutant reduction. Therefore, the type of policies plays a significant role in reducing pollutants, while differences between countries do not have a direct effect. Therefore, policymakers should focus not only on choosing the type of effective policy but also on designing policies. Policy type appears to play a more effective role in explaining heterogeneity, while the impact of country-level differences remains inconclusive. These findings should be interpreted with caution.

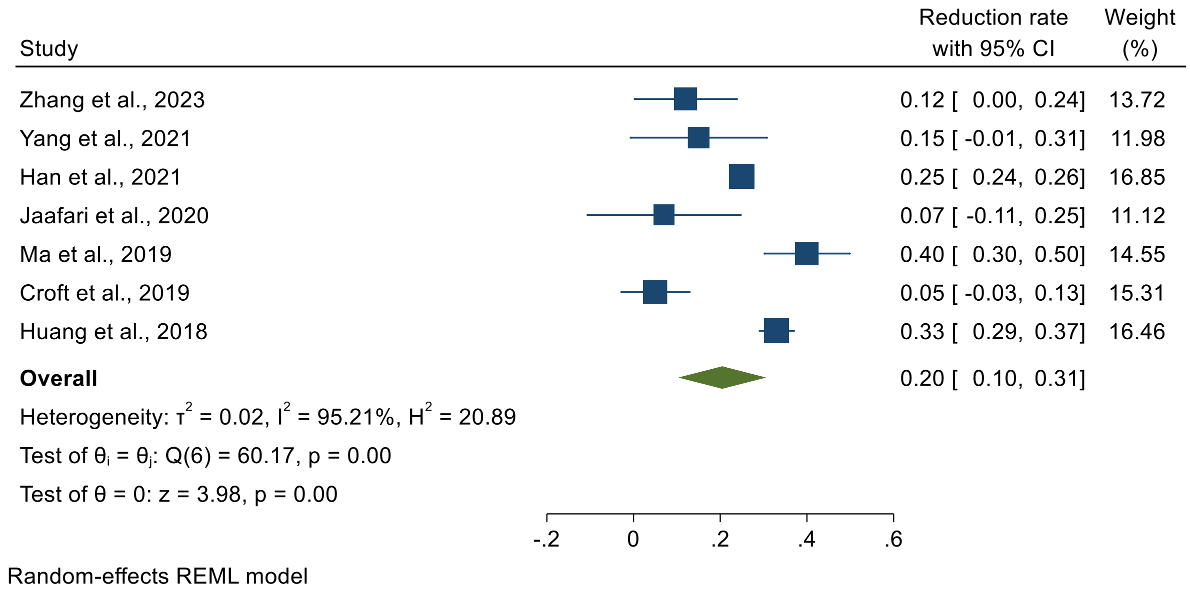

Figure 2. Forest plot showing the effect of air pollution control legislation.

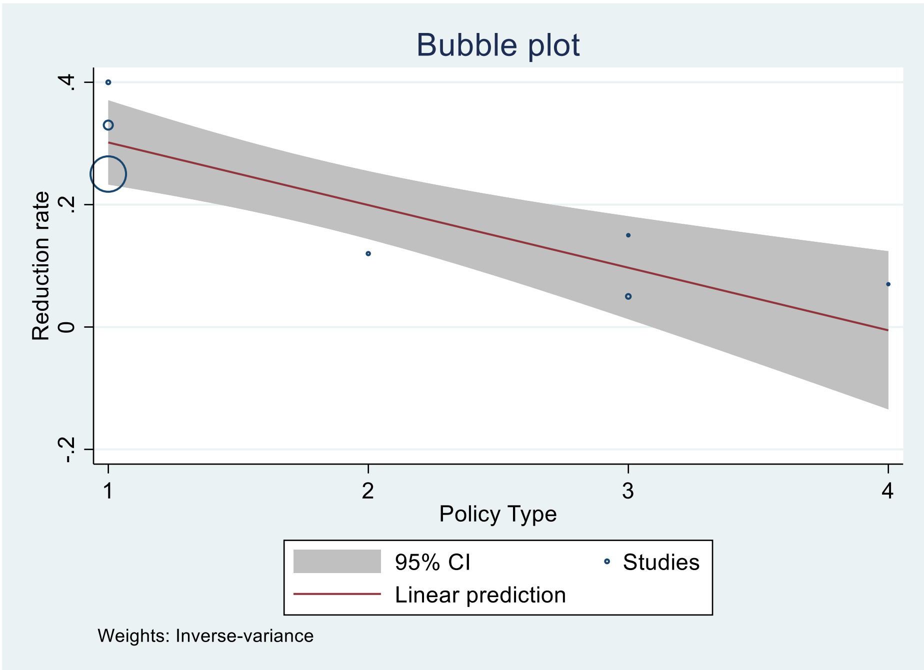

Figure 3. Bubble Plot of Reduction Rate by Policy Type in Meta-Regression. (1: National Plan; 2: Environmental Policy; 3: Mixed method, 4: Urban Green).

Table 5. Meta-regression of the Effect of Policy Type and Country on Reduction Rate.

_meta_es	Coefficient (β)	Std. Err.	z	P-value	95% CI

Policy type	-0.0846	0.0396	-2.14	0.032	-0.1622, -0.0071
Country	-0.0346	0.0548	-0.63	0.528	-0.1421, 0.0729
Constant (_cons)	0.4209	0.0657	6.41	<0.001	0.2921, 0.5496

Respiratory Health Outcomes

In this meta-analysis, seven studies were reviewed using the fixed-effects model and inverse variance method to evaluate the effect of air pollution reduction policies on respiratory health outcomes. The hazard ratio was 0.86 (HR: 0.86, 95% CI: 0.83 to 0.89) (Figure 4). Therefore, implementing air pollution control policies reduces the risk of respiratory consequences; on average, air pollution reduction policies reduce the risk of respiratory outcomes by 14%. According to the $I^2 = 0$, the studies were homogeneous ($p = 0.96$), which increases the precision and generalizability of the results. Air pollution control laws and policies at national and municipal levels effectively reduce the risk of respiratory outcomes and have a significant protective effect, and can be used as scientific evidence for planning and policymaking.

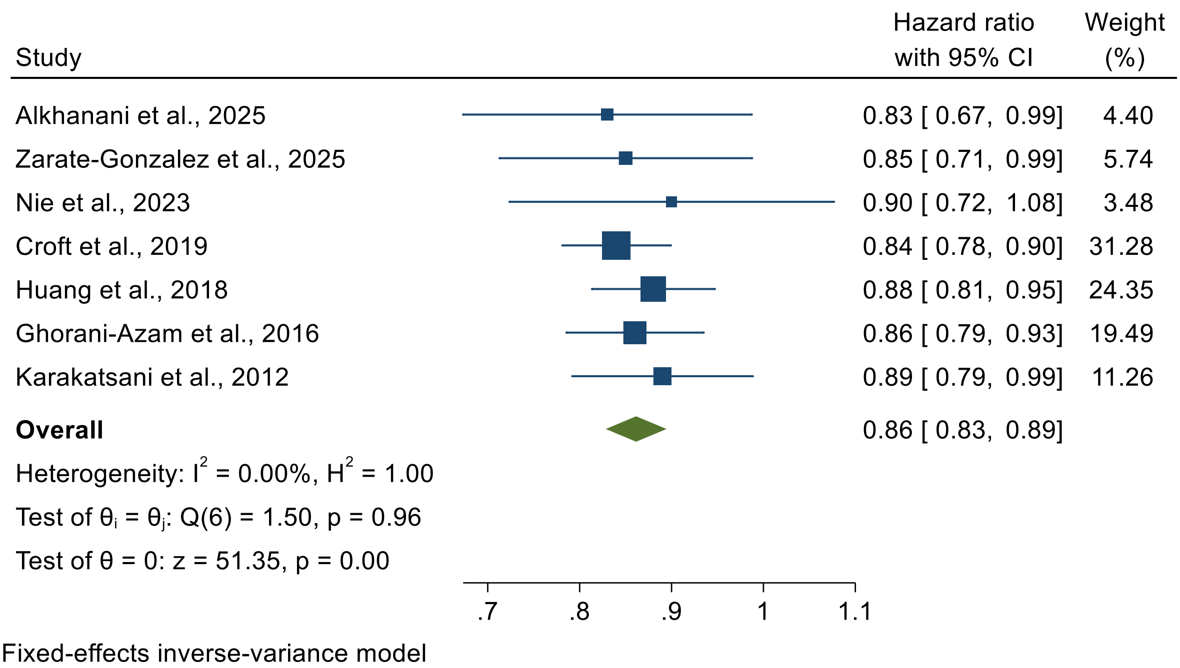

Figure 4. The forest plot showed the effect of air pollution reduction policies on respiratory health outcomes.

As shown in **Figure 5**, the impact of implementing pollution reduction laws on asthma is significant (HR: 0.86, 95% CI: 0.80-0.92). The National Plan (HR: 0.84, 95% CI: 0.79 to 0.90) and Environmental Policy (HR: 0.88, 95% CI: 0.83 to 0.93) have a greater impact than Mixed or Urban Green. These results enable policymakers to focus on vulnerable groups and develop more effective policies.

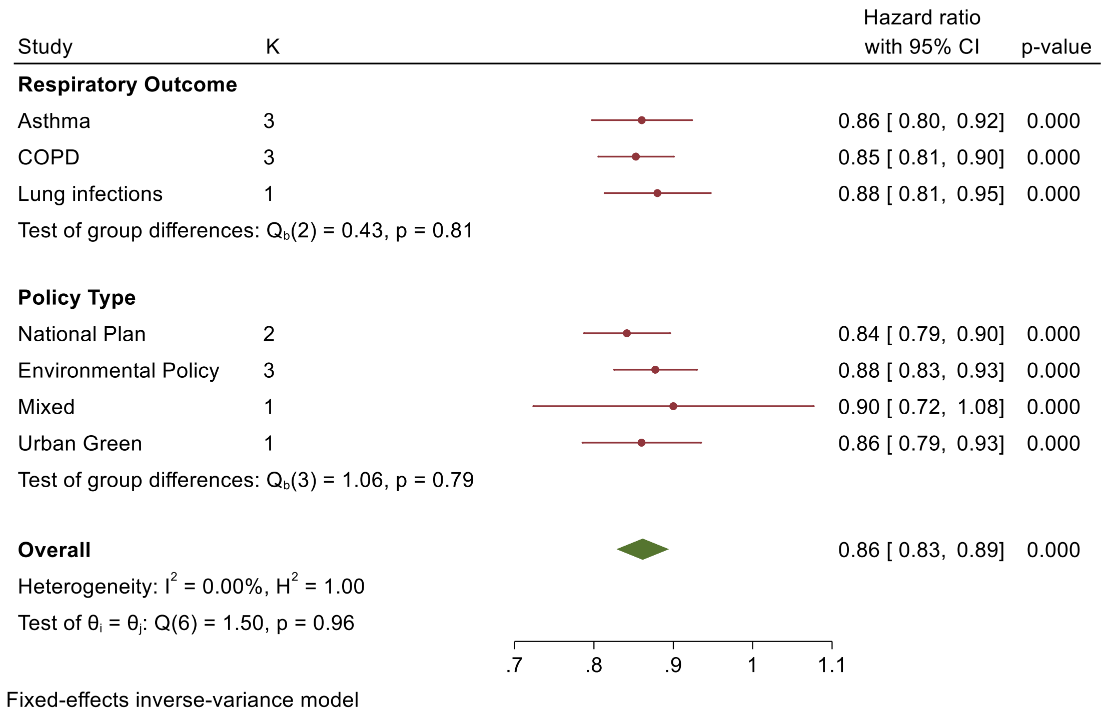

Figure 5. The forest plot showed subgroup meta-analysis of the hazard ratio based on the respiratory outcome and policy type.

Publication bias

The asymmetrical distribution of studies in the funnel plot may indicate potential publication bias or small-study effects, warranting cautious interpretation of the pooled effect size (Figure 6).

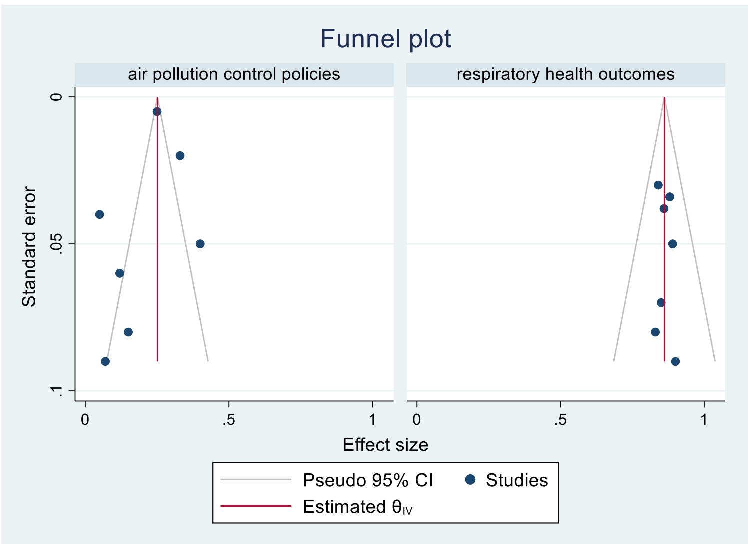

Figure 6. Funnel plot Funnel plot of studies on air pollution control policies and pollutant reduction

Discussion

Evidence shows that reducing air pollution can lead to significant improvements in respiratory health(16). The findings of the present meta-analysis showed that implementing policies to reduce pollutants significantly reduces the risk of respiratory diseases. Additionally, the hazard ratio for the Effect of policies on respiratory health is less than one, indicating that implementing laws and control measures reduces the risk of respiratory diseases. Consistent with the results of the present study, research has shown that controlling pollutant emissions directly leads to a reduction in deaths and illnesses related to air pollution(43-46). From a legal perspective, the effectiveness of pollution reduction policies is directly related to the legal framework and enforcement mechanisms. Studies have shown that countries with clear environmental laws and strong regulatory systems, such as Germany and South Korea, have had the most success in reducing pollutants(47-49). These findings suggest that the presence of a suitable legal framework, combined with effective regulatory and economic mechanisms, is a crucial prerequisite for the effectiveness of pollution reduction policies.

A review of the studies included in this systematic review also shows that the effectiveness of air pollution reduction policies in different countries is clearly visible in both epidemiological data and respiratory health outcome indicators. A study by Alkhanani et al. 2025 conducted across 27 countries showed that countries that implemented stricter air quality regulations experienced significant reductions in the incidence of asthma, COPD, and even tuberculosis(28). In the United States, a study by Croft et al., 2019 of nearly half a million patients showed that policy-induced reductions in $PM_{2.5}$ were associated with reduced rates of respiratory hospitalizations(37). In China, Huang 2018; Ma 2019; Zhang 2023 have reported significant reductions in $PM_{2.5}$, SO_2, and NO_2 concentrations after the implementation of national air pollution control programs(32, 36, 38). Yang et al., 2021 also shows that the simultaneous implementation of carbon policies and pollution control policies has synergistically led to a reduction in mortality attributable to $PM_{2.5}$ and ozone(33). In Iran, Jaafari et al.., 2020 showed that the expansion of urban green spaces and land use planning is associated with a reduction in $PM_{2.5}$ and respiratory mortality(35). Ghorani-Azam., 2016 also reported a broad association between exposure to pollutants and diseases such as asthma, bronchitis, COPD, and lung cancer at the Iranian population level(39). This evidence shows that the existence of policies alone is not enough, but rather the intensity of implementation, monitoring mechanisms, administrative capacity, and the level of adherence to standards determine their success. Zarate-Gonzalez et al., 2025 Implementation of air pollution control policies has been shown to improve quality of life in addition to reducing patients' respiratory symptoms. This study highlights the importance of the social-health dimensions of policies and suggests that the positive outcomes of policies may extend beyond clinical indicators(29). Chi et al., 2025 showed that reducing industrial pollutant emissions led to significant reductions in SO_2, NO_x, and $PM_{2.5}$. The results before and after the implementation of the policies show that the effect of the policies is more severe in industrial areas. This finding emphasizes that policies should be designed according to the pollution pattern of each area(30). Nie et al., 2023 reported that reducing pollutants such as $PM_{2.5}$, PM_{10}, NO_2 and SO_2 is directly linked to reducing cases of respiratory diseases. This study showed from a modeling perspective that each unit of pollutant reduction generates significant savings in health costs(31). The study by Han et al., 2021 was one of the most comprehensive. The findings showed that the APCI was directly related to increased life expectancy, reduced infant mortality, and reduced respiratory diseases. The study emphasizes that the existence of a law is not enough; the effectiveness of implementation determines health outcomes(34). Guan et al., 2016 examined the association between air pollution and chronic respiratory diseases in a large Chinese population and found that increases in $PM_{2.5}$, PM_{10}, and NO_2 were directly associated with increases in COPD, asthma, and lung cancer. The study had a robust design and globally valid data(40). Chen et al., 2013 showed the Air Quality Health Index not only communicated the risks of pollution, but also changed people's protective behaviors and reduced the burden of respiratory disease. The importance of the study lies in demonstrating the role of communication and warning policies(41). Karakatsani et al., 2012 exposure to $PM_{2.5}$ and PM_{10} in adults with chronic respiratory diseases was associated with increased daily symptoms and exacerbations of the disease. Differences between European countries showed that strict standards and continuous monitoring lead to significant reductions in symptoms(42). The meta-regression of the present study showed that policy characteristics can have significant differences in the overall impact on respiratory health. The country variable alone did not show a significant effect; however, different pollution reduction policies in various countries had a significant impact on respiratory health(49-52). These results emphasize that policies must be multidimensional, incorporating legal, economic, and managerial instruments, to have a meaningful impact on public health(53, 54). Despite observed successes in implementing air pollution laws, gaps in legislation and enforcement remain, with limited coordination and monitoring reducing the effectiveness of policies in some regions, such as Tehran and major Chinese cities(55-57). Therefore, legal opportunities for policy reform include establishing a transparent monitoring mechanism, developing harmonized national and regional standards, and enhancing the capacity of enforcement agencies. Evidence suggests that the development of policies and laws requires attention to social justice and the needs of vulnerable groups(58). Evidence suggests that implementing pollution reduction policies with a strong legal framework and appropriate regulatory and economic tools have a positive impact on the respiratory health of the community. The success of these policies depends on continued enforcement of laws, coordination between institutions, and attention to vulnerable groups. Therefore, reforming and improving policies requires a comprehensive legal and management approach that can fill existing legal gaps and provide the basis for improving public health. The present study had limitations that should be considered in interpreting the results. The number of studies found from the searches that met the inclusion and exclusion criteria was small; the small number of studies reduces the generalizability of the results. The high heterogeneity observed in the first part of the study's objective is due to differences in methodology, measurement, and geographical settings among the studies, which could affect the overall impact of policies on respiratory health. The lack of reporting on the intensity of pollution reduction and the duration of the plan's implementation in the studies meant that comprehensive meta-regressions were not conducted for these two variables, which could have helped to examine the sources of the difference in effects more accurately. Additionally, most studies have focused on the short-term effects of these policies. From a legal and policy perspective, direct evidence of the effectiveness of legal and policy implementation frameworks is limited, making it challenging to conduct a comprehensive analysis of the reform requirements and public health improvements. Finally, given the limited number of studies, there is a possibility of publication bias; This means that studies with more positive results and tangible effects have been published, and this could affect the overall results of the meta-analysis. It is recommended that future studies consider geographic diversity to gain a more comprehensive understanding of the impact of pollution control policies on public health, and that regional and cultural differences should also be examined. Longitudinal data and long-term follow-up will also facilitate a deeper understanding of the long-term effects of policies and environmental changes. It is recommended that specific health outcomes for respiratory and other air pollution-related diseases be also examined. Future studies should examine legal and enforcement variables, such as the intensity of policy implementation, the quality of monitoring, and the level of coordination between different institutions, to clarify the relationship between the legal framework and policy effectiveness. The simultaneous effects of environmental, legal, and demographic factors are also better explored in future studies with advanced analytical methods. It is also suggested that future studies could examine the interaction of multiple simultaneous policies and analyze which combination of legal and management measures has the greatest impact on reducing pollution and improving public health.

Conclusion

Based on the findings of this systematic review and meta-analysis, the implementation of specific air pollution control laws is associated with measurable improvements in respiratory health indicators, including reduced incidence of asthma and other chronic lung diseases. The magnitude of these associations varies depending on the type of legal instrument and the strength of their enforcement. Also, implementing laws that include clear enforcement mechanisms and regulatory provisions are better associated with positive health outcomes. These findings provide evidence-based guidance for policymakers to design targeted and enforceable regulations and allocate resources effectively.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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