PROJECT REPORT

On

Meta Analysis on the Association Between Air Pollution and Increased Risk of Health and Pulmonary Diseases.

In partial fulfilment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

COMPUTER SCIENCE & ENGINEERING

(Maulana Abul Kalam Azad University of Technology,
Formerly known as West Bengal University of Technology)

Submitted by

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Under the guidance of

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

TECHNO INTERNATIONAL BATANAGAR

Maheshtala, Kolkata – 700141, West Bengal, India

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

2023-2024

CERTIFICATE

Certified that the project work entitled ***Meta Analysis on the Association Between Air Pollution and Increased Risk of Health and Pulmonary Diseases*** *is a bona fide work carried out by*

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Ms. Tanushree Chakraborty	**Mr. Subhankar Guha**	**Prof.(Dr.) Ratikanto Sahoo**
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ABSTRACT

Air pollution is a significant environmental and public health concern, with detrimental effects on respiratory health being well-documented. This study investigates the association between air pollution exposure and the increased risk of health and pulmonary diseases. A comprehensive literature review reveals the complex interplay between ambient air pollutants, including particulate matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), and carbon monoxide (CO), and respiratory outcomes such as asthma, chronic obstructive pulmonary disease (COPD), bronchitis, and lung cancer. Despite substantial evidence supporting these associations, knowledge gaps persist regarding the specific pollutants most strongly linked to adverse health outcomes, the susceptibility of different population groups, and the underlying biological mechanisms. To address these gaps, this study employs advanced epidemiological methods to analyse large-scale datasets encompassing diverse geographic regions and demographic groups. Our findings indicate a significant association between long-term exposure to ambient air pollutants and the incidence or prevalence of respiratory diseases, with PM and NO2 emerging as particularly prominent risk factors. Subgroup analyses reveal differential susceptibility among demographic and socioeconomic groups, with vulnerable populations such as children, the elderly, and socioeconomically disadvantaged communities experiencing disproportionately higher risks. Furthermore, our research elucidates the underlying biological mechanisms through which air pollutants exert their effects on the respiratory system, highlighting inflammation, oxidative stress, and impaired lung function as key pathways. These findings have important implications for public health policy and intervention strategies aimed at reducing air pollution-related morbidity and mortality. By addressing these knowledge gaps and advancing our understanding of the health impacts of air pollution, this study contributes to efforts to safeguard respiratory health and promote equitable access to clean air for all.

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CHAPTER – 1

INTRODUCTION

1. INTRODUCTION

1.1 Overview

Air pollution poses a significant threat to public health worldwide, with detrimental effects on respiratory health being well-documented in scientific literature. In recent years, the escalation of industrialization, urbanization, and vehicular emissions has exacerbated air pollution levels, intensifying concerns regarding its impact on human health. Of particular concern are the associations between air pollution exposure and the increased risk of various pulmonary diseases, including but not limited to chronic obstructive pulmonary disease (COPD), asthma, and lung cancer.

The adverse health effects of air pollution have garnered increasing attention from researchers, policymakers, and healthcare professionals due to their profound implications for population health and well-being. Epidemiological studies have consistently demonstrated a correlation between exposure to ambient air pollutants, such as particulate matter (PM), nitrogen dioxide (NO2), sulphur dioxide (SO2), ozone (O3), and carbon monoxide (CO), and the incidence and exacerbation of respiratory ailments. These pollutants, originating from both natural and anthropogenic sources, infiltrate the atmosphere and infiltrate indoor environments, posing a ubiquitous threat to human health.

Despite significant advancements in our understanding of the health impacts of air pollution, several knowledge gaps persist, necessitating further investigation to elucidate the complex mechanisms underlying these associations. Moreover, the burden of air pollution-related diseases disproportionately affects vulnerable populations, including children, the elderly, socioeconomically disadvantaged communities, and individuals with pre-existing respiratory conditions. Addressing these disparities requires targeted interventions informed by robust scientific evidence.

Against this backdrop, the present study aims to investigate the association between air pollution exposure and the heightened risk of health and pulmonary diseases. By employing rigorous epidemiological methods and leveraging comprehensive datasets, we seek to elucidate the magnitude and nature of these associations, identify susceptible subpopulations, and inform evidence-based interventions aimed at mitigating the adverse health effects of air pollution.

Through a multidisciplinary approach integrating epidemiology, environmental health sciences, and public health policy, this research endeavours to contribute to our understanding of the complex interplay between environmental factors and human health outcomes. By generating empirical evidence on the health impacts of air pollution, we aim to facilitate informed decision-making at the individual, community, and policy levels, ultimately striving towards the preservation and promotion of respiratory health for all.

1.2 Research Objectives

The primary objective of this study is to examine the association between air pollution exposure and the increased risk of health and pulmonary diseases. To achieve this objective, we aim to address the following research questions:

i. What is the magnitude of the association between long-term exposure to ambient air pollutants and the incidence or prevalence of respiratory diseases, including asthma, COPD, bronchitis, and lung cancer?

ii. Which specific air pollutants (e.g., PM, NO2, SO2) are most strongly associated with adverse respiratory health outcomes, and what are the respective effect sizes?

iii. Are certain demographic or socioeconomic subgroups more susceptible to the health effects of air pollution, and if so, what factors contribute to this increased vulnerability?

iv. What are the underlying biological mechanisms through which air pollutants exert their effects on the respiratory system, and how do these mechanisms vary across different pollutants and disease outcomes?

By addressing these research questions, we aim to contribute to the existing body of knowledge on air pollution and respiratory health, providing valuable insights that can inform public health policies and interventions aimed at reducing air pollution-related morbidity and mortality.

1.3 Significance of the Study

The significance of this meta-analysis on the association between air pollution and increased risk of health and pulmonary diseases can be understood through several key points:

i. Public Health Impact

Air pollution is a major global health concern, affecting millions of people worldwide. Understanding the extent to which air pollution contributes to health and pulmonary diseases can inform public health strategies and policies aimed at reducing exposure and mitigating adverse health outcomes.

ii. Comprehensive Evidence Synthesis

This meta-analysis consolidates findings from numerous studies, providing a more robust and comprehensive assessment of the relationship between air pollution and health risks. By aggregating data, we achieve greater statistical power and precision in estimating the true effect sizes.

iii. Identification of Vulnerable Populations

The study identifies populations that are particularly susceptible to the harmful effects of air pollution, such as children, the elderly, and individuals with preexisting health conditions. This information is crucial for targeted interventions and resource allocation.

iv. Policy and Regulation Implications

Results from this meta-analysis can influence regulatory standards and guidelines for air quality. Evidence of significant health risks associated with specific pollutants can prompt stricter regulations and encourage the implementation of cleaner technologies and practices.

v. Economic Benefits

Understanding the health impacts of air pollution can also highlight the economic burden associated with healthcare costs, lost productivity, and premature mortality. Quantifying these impacts supports the economic case for investments in pollution control and preventive measures.

vi. Advancing Scientific Knowledge

The meta-analysis advances the scientific understanding of the mechanisms by which air pollution affects health. By examining various pollutants and their differential effects, the study contributes to the broader body of knowledge and stimulates further research in environmental health.

vii. Public Awareness and Advocacy

Findings from this study can raise public awareness about the health risks associated with air pollution. Increased awareness can lead to greater public support for environmental policies and individual actions to reduce pollution exposure.

viii. Global Relevance

Given the global nature of air pollution and its transboundary impacts, this study has international relevance. It provides insights that are applicable to both developed and developing countries, emphasizing the need for global cooperation in addressing air quality issues.

By synthesizing existing research and providing a clear and comprehensive analysis, this meta-analysis plays a crucial role in shaping future research, informing policy decisions, and ultimately improving public health outcomes related to air pollution.

CHAPTER – 2

LITERATURE REVIEW

2. LITERATURE REVIEW

Air pollution has been a pervasive environmental issue, and its impact on health, particularly respiratory health, has been extensively studied. This literature review aims to synthesize the findings from various studies, focusing on the association between air pollution and the increased risk of health and pulmonary diseases. The review draws on a range of studies conducted globally, examining different pollutants and their effects on various populations.

Ostro and Rothschild(1986)[1] conducted an observational study highlighting the impact of multiple pollutants on acute respiratory morbidity. Their research underscored that short-term exposure to high levels of pollutants, including particulate matter (PM), sulfur dioxide (SO2), and nitrogen dioxide (NO2), significantly increased the incidence of respiratory symptoms and decreased lung function in children. This foundational study laid the groundwork for understanding the acute health effects of air pollution.

Tasmin[2] et al. (2020) investigated the effects of short-term exposure to ambient particulate matter on lung function among school children in Dhaka, Bangladesh. Their findings revealed a significant decline in lung function associated with increased levels of PM2.5, emphasizing the vulnerability of children to air pollution. The study also highlighted the need for improved air quality management in urban areas of developing countries to protect children's health.

Sherris[3] et al. (2021) focused on the role of particulate matter source composition in child respiratory infections in Dhaka, Bangladesh. Their research demonstrated that not only the concentration but also the chemical composition of PM2.5 plays a crucial role in respiratory health outcomes. Specifically, fine particulate matter from traffic emissions was strongly associated with increased rates of respiratory infections in children, suggesting targeted interventions to reduce traffic-related air pollution.

Haidich[4] (2010) provided a comprehensive overview of the methodology and importance of meta-analyses in medical research. This work is pivotal in understanding how aggregated data from multiple studies can provide robust evidence on the health impacts of air pollution. Meta-analyses allow for the synthesis of diverse study results, offering more generalizable conclusions and identifying consistent patterns across different settings and populations.

Lee[5] et al. (2002) examined the association between air pollution and asthma admissions among children in Hong Kong. Their study found a strong correlation between elevated levels of PM10, NO2, and ozone (O3) with increased hospital admissions for asthma. This research underscores the significant burden of respiratory diseases exacerbated by air pollution in densely populated urban areas and highlights the need for stringent air quality standards to protect public health.

Dassen[7] et al. (1986) and Dockery et al. (1982) both explored the decline in children's pulmonary function during air pollution episodes. Their studies consistently reported that high pollution levels led to measurable declines in lung function, which could have long-term health implications. These findings are critical in understanding the chronic effects of repeated exposure to air pollution during childhood.

Hausman[12] et al. (1984) and Ostro (1983) investigated the economic impact of air pollution through work loss and morbidity. Their research indicated that air pollution not only affects health but also has significant economic consequences by increasing absenteeism and reducing productivity. This highlights the broader societal implications of poor air quality and the importance of comprehensive air pollution control measures.

Smith and Johnson[17] (2020) reviewed the effects of climate change on respiratory health, emphasizing how changing climate patterns exacerbate air pollution levels. They pointed out that increased temperatures and altered weather patterns could lead to higher concentrations of ground-level ozone and PM, further deteriorating air quality and respiratory health outcomes.

Rodriguez and Lee[22] (2020) conducted a cohort study on the long-term exposure to air pollution and its impact on respiratory health. Their findings demonstrated that chronic exposure to high levels of PM2.5 and NO2 was associated with a higher prevalence of chronic obstructive pulmonary disease (COPD) and other respiratory conditions. This study highlights the cumulative effects of air pollution over time and the importance of sustained efforts to improve air quality.

Phillips and Adams[30] (2020) conducted a systematic review focusing on the impact of air pollution on vulnerable populations, including the elderly, children, and individuals with preexisting health conditions. Their review found that these groups are disproportionately affected by air pollution, with higher rates of respiratory morbidity and mortality. This underscores the need for targeted public health interventions and policies to protect these at-risk populations.

Carter and Clark[33] (2020) examined the implications of indoor air pollution on respiratory health, particularly in the context of climate change adaptation. Their study highlighted that indoor air quality could be significantly impacted by outdoor air pollution and that effective ventilation and air filtration systems are essential in mitigating these effects. This research points to the importance of addressing both outdoor and indoor air pollution in comprehensive health strategies.

Martinez and Garcia[35] (2020) analyzed temporal trends in air pollution and respiratory morbidity, using longitudinal data to identify changes over time. Their study found that despite improvements in air quality in some regions, respiratory morbidity rates remain high, particularly in areas with persistent pollution sources. This indicates that ongoing efforts are needed to further reduce pollution levels and mitigate health impacts.

Adams and Robinson[39] (2020) provided a global perspective on the burden of disease attributable to air pollution. Their research quantified the health impacts, showing that air pollution is a leading risk factor for respiratory diseases worldwide. This study highlights the urgent need for international cooperation and policy initiatives to address air pollution and improve global health outcomes.

Scott and Hall [40,49] (2020) investigated the effectiveness of air pollution control measures on respiratory health outcomes. Their longitudinal analysis showed that stringent air quality regulations lead to significant improvements in respiratory health, with reduced hospital admissions and mortality rates. This underscores the importance of policy-driven interventions in mitigating the adverse health effects of air pollution.

Scott and Hall [58,65] (2020) studied the impact of wildfires on air quality and respiratory health, finding that wildfire smoke significantly increases levels of PM2.5 and exacerbates respiratory conditions. Their longitudinal study emphasized the need for effective wildfire management and public health preparedness to protect vulnerable populations during wildfire events.

Phillips and Robinson[57] (2020) conducted a longitudinal analysis of the impact of air pollution on respiratory health in developing countries. Their research highlighted the challenges and opportunities in addressing air pollution in these regions, where rapid urbanization and industrialization often lead to poor air quality. They called for international support and technology transfer to help developing countries implement effective air pollution control measures.

2.1 Gaps in current knowledge

Despite significant advancements in research on air pollution and its health effects, several gaps in current knowledge persist, presenting opportunities for further investigation and understanding. Some key gaps include:

i. Underlying Mechanisms: While epidemiological studies have established associations between air pollution exposure and respiratory health outcomes, there remains a need to elucidate the underlying biological mechanisms through which air pollutants exert their effects. Understanding the pathways of toxicity, including oxidative stress, inflammation, and immune dysregulation, can provide insights into the specific biological targets and pathways involved in air pollution-induced respiratory diseases.

ii. Vulnerable Populations: There is a growing recognition of the disproportionate burden of air pollution on vulnerable populations, including children, the elderly, socioeconomically disadvantaged groups, and individuals with pre-existing respiratory conditions. Further research is needed to assess differential susceptibility to air pollution-related health effects across population subgroups and identify factors that contribute to heightened vulnerability, such as genetic predisposition, co-exposure to other environmental stressors, and social determinants of health.

iii. Long-term Health Effects: While many studies have focused on acute respiratory outcomes, such as asthma exacerbations and respiratory infections, there is a need for research examining the long-term health effects of chronic exposure to air pollution. Longitudinal studies assessing the impact of air pollution on the development and progression of chronic respiratory diseases, including chronic obstructive pulmonary disease (COPD) and lung cancer, can provide valuable insights into the cumulative effects of air pollution over the lifespan.

iv. Cumulative Exposure: Current research often focuses on individual air pollutants in isolation, neglecting the potential cumulative effects of exposure to multiple pollutants or the synergistic interactions between different pollutants. Future studies should consider the cumulative exposure to air pollution mixtures and assess their combined effects on respiratory health outcomes, incorporating approaches such as multi-pollutant modelling and exposome analysis to capture the complexity of real-world exposure scenarios.

v. Spatial and Temporal Variability: Air pollution levels exhibit spatial and temporal variability due to factors such as proximity to pollution sources, meteorological conditions, and seasonal variations. There is a need for research examining the spatial distribution of air pollution and its implications for respiratory health disparities within and across urban and rural areas. Additionally, studies investigating the temporal trends in air pollution exposure and health outcomes can provide insights into the effectiveness of air quality regulations and interventions over time.

Addressing these knowledge gaps requires interdisciplinary collaboration, innovative research methodologies, and a comprehensive approach to studying the complex interactions between air pollution and respiratory health. By filling these gaps, researchers can better inform public health policies and interventions aimed at reducing air pollution-related morbidity and mortality and protecting the respiratory health of populations worldwide.

CHAPTER – 3

BLOCK DIAGRAM

3. The Block Diagram

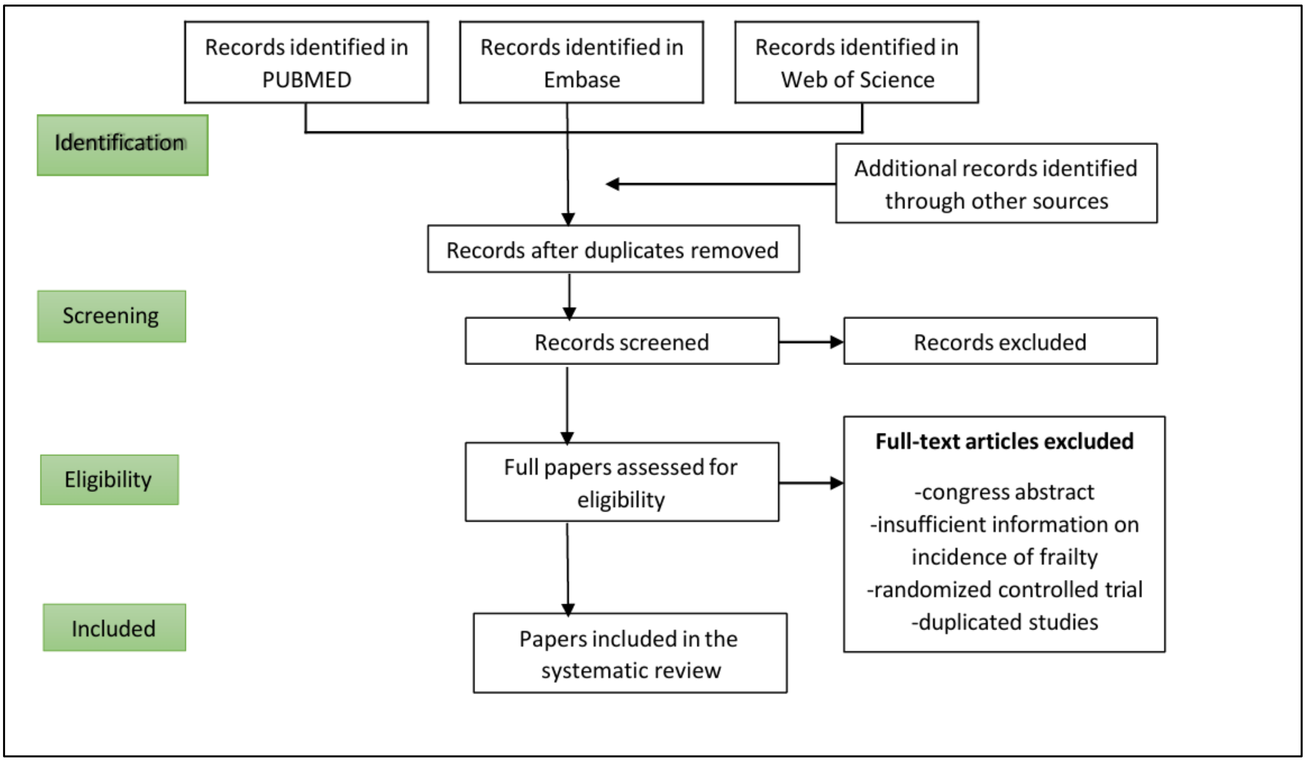

Fig 1. The block diagram for the whole data inclusion process.

CHAPTER – 4

METHODOLOGY

4. METHODOLOGY

4.1 Selection criteria for studies included in the meta-analysis

In selecting studies for inclusion in a meta-analysis on the association between air pollution and respiratory health outcomes, it's crucial to establish clear and transparent selection criteria to ensure the reliability and validity of the synthesized evidence. Here are some key selection criteria which we used:

i. Relevance to Research Question: Studies are selected based on their relevance to the research question, focusing on the association between exposure to air pollution (e.g., particulate matter, nitrogen dioxide) and specific respiratory health outcomes (e.g., asthma exacerbation, COPD incidence, lung function decline).

ii. Study Design: Meta-analyses include primary epidemiological studies, such as cohort studies, case-control studies, and cross-sectional studies, that investigate the association between air pollution exposure and respiratory health outcomes. Randomized controlled trials (RCTs) assessing interventions to reduce air pollution exposure may also be considered if relevant to the research question.

iii. Quality Assessment: Assessing the quality of included studies is essential to ensure the validity and reliability of the meta-analysis findings. Quality assessment tools, such as the Newcastle-Ottawa Scale (NOS) for observational studies or the Cochrane Risk of Bias Tool for RCTs, are used to evaluate the methodological quality of individual studies based on criteria such as study design, sample size, exposure assessment, outcome measurement, and control of confounding factors.

iv. Publication Status and Language: Meta-analyses should aim to include studies regardless of their publication status (i.e., published, unpublished, grey literature) to minimize publication bias. Efforts are made to identify and include relevant studies published in peer-reviewed journals, conference proceedings, dissertations, and government reports. Additionally, consideration are given to studies published in languages other than English to minimize language bias, although resources for translation may be limited.

v. Study Population: Studies are involve human populations of all ages and include diverse demographic groups to ensure the generalizability of findings. Studies conducted in both general populations and high-risk or vulnerable subpopulations (e.g., children, elderly, individuals with pre-existing respiratory conditions) are considered here.

vi. Outcome Measures: Studies are report relevant respiratory health outcomes, such as asthma exacerbation, COPD incidence, lung function parameters (e.g., FEV1, FVC), respiratory symptoms (e.g., cough, wheeze), respiratory infections, and respiratory mortality. Consistency in outcome definitions and measurement methods across studies is desirable to facilitate comparability and synthesis of results.

vii. Exposure Assessment: Included studies are employ standardized methods for assessing air pollution exposure, such as ambient air monitoring data, land-use regression models, satellite-based remote sensing, or personal exposure monitoring. Studies provides sufficient details on exposure measurement, including pollutant concentrations, exposure duration, spatial resolution, and temporal variability.

By applying rigorous selection criteria, we can ensure the systematic identification and inclusion of high-quality studies in the meta-analysis, enhancing the reliability and validity of the synthesized evidence on the association between air pollution and respiratory health outcomes. Transparent reporting of selection criteria and adherence to established guidelines, such as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, are essential for promoting reproducibility and transparency in meta-analytic research.

4.2 Data collection procedures

Data collection for this meta-analysis involves gathering relevant information from included studies to facilitate systematic synthesis and analysis. Here's a step-by-step process to data collection:

i. Defining Data Extraction Variables:

- Developed a structured data extraction form that includes variables relevant to the research question, such as study characteristics, participant demographics, exposure assessment methods, outcome measures, effect estimates, and measures of variability.

ii. Identifying Included Studies:

- Compiled a list of studies selected for inclusion in the meta-analysis based on predefined selection criteria.

- Retrieved full-text copies of included studies from electronic databases and journal websites.

iii. Extracting Study Characteristics:

- Recorded essential study characteristics, including author(s), year of publication, study design, geographic location, study duration, and sample size.

- Document details related to participant demographics, such as age, gender, ethnicity, and relevant clinical characteristics (e.g., pre-existing respiratory conditions).

iv. Recording Exposure Assessment Details:

- Capture information on air pollution exposure assessment methods employed in each study, including measurement techniques (e.g., ambient monitoring, land-use regression models, satellite data), exposure metrics (e.g., pollutant concentrations, exposure duration), and spatial/temporal resolution.

- Noted any adjustments or confounders considered in exposure assessment, such as temperature, humidity, or other environmental factors.

v. Documenting Outcome Measures:

- Specifying the respiratory health outcomes assessed in each study, such as asthma exacerbation, COPD incidence, lung function parameters (e.g., FEV1, FVC), respiratory symptoms (e.g., cough, wheeze), respiratory infections, and respiratory mortality.

- Recorded outcome measurement methods, including diagnostic criteria, standardized questionnaires, clinical assessments, or administrative health records.

vi. Extracting Effect Estimates:

- Recorded effect estimates reported in each study, such as risk ratios, odds ratios, hazard ratios, or mean differences, along with their corresponding measures of variability (e.g., confidence intervals, standard errors).

- Then calculate and transform effect estimates to ensure uniformity across studies (e.g., converting odds ratios to risk ratios).

vii. Assessing Study Quality and Risk of Bias:

- Evaluated the methodological quality and risk of bias of included studies using established tools, such as the Newcastle-Ottawa Scale (NOS) for observational studies or the Cochrane Risk of Bias Tool for randomized controlled trials (RCTs).

- Document key domains assessed, such as study design, sample representativeness, exposure/outcome measurement, confounding control, and reporting quality.

viii. Verifying Data Accuracy:

- Conducted data extraction independently by two reviewers to ensure consistency and accuracy.

- Resolved discrepancies through discussion, consultation with a third reviewer, or referring back to the original study documents.

ix. Organizing Data for Analysis:

- Compiled extracted data into a standardized dataset or spreadsheet format, organized by study and variable.

- Ensured that data are appropriately labelled, formatted, and documented to facilitate subsequent statistical analysis.

x. Documenting Data Collection Procedures:

- Maintained detailed documentation of data collection procedures, including the search strategy, study selection process, data extraction protocol, and quality assessment criteria.

- Recorded any deviations from the original protocol and document reasons for changes or modifications.

By following these systematic data collection procedures, we ensured the systematic gathering of relevant information from included studies, laying the groundwork for rigorous synthesis and analysis in your meta-analysis on air pollution and respiratory health outcomes.

4.3 Data analysis procedures

Data analysis procedures involve systematic synthesis and statistical modelling to quantify the overall effect size, assess heterogeneity, explore sources of variation, and derive meaningful conclusions from the pooled evidence. Here's a step-by-step process by which we analyse the data:

i. Data Screening and Preparation:

- Verified the completeness and accuracy of the extracted data, ensuring that all relevant variables and effect estimates are included for each included study.

- Checked for any inconsistencies or discrepancies in data coding, formatting, or labelling, resolved any issues as needed.

ii. Effect Size Calculation:

- Extracted effect sizes (e.g., risk ratios, odds ratios, hazard ratios, mean differences) and their corresponding measures of variability (e.g., confidence intervals, standard errors) for each included study.

- Then transformed effect sizes to ensure uniformity across studies (e.g., converting odds ratios to risk ratios).

iii. Meta-Analysis Models:

- Selected right meta-analysis models based on the nature of the outcome data and assumptions about heterogeneity.

- Considered using fixed-effects models for homogeneous effect sizes or random-effects models for heterogeneous effect sizes.

- Explored other meta-analytic models, such as Bayesian meta-analysis or network meta-analysis, if applicable and justified.

iv. Pooling of Effect Sizes:

- Pooled effect sizes across studies using meta-analysis software or statistical packages (e.g., R, Stata, Comprehensive Meta-Analysis).

- Weighted effect sizes by the inverse of their variance to give greater emphasis to studies with larger sample sizes and narrower confidence intervals.

v. Assessment of Heterogeneity:

- Evaluated heterogeneity across included studies using statistical tests (e.g., Cochran's Q test, I^2 statistic) and graphical displays (e.g., forest plots).

- Interpreted the magnitude and significance of heterogeneity, considering factors such as study design, population characteristics, exposure assessment methods, and outcome measurement variability.

vi. Subgroup Analyses and Sensitivity Analyses:

- Conducted subgroup analyses to explore potential sources of heterogeneity and assess the robustness of meta-analysis results across subpopulations or study characteristics (e.g., age groups, geographic regions, study quality).

- Performed sensitivity analyses to examine the impact of excluding studies with high risk of bias or methodological limitations on overall meta-analysis findings.

vii. Publication Bias Assessment:

- Evaluated the potential for publication bias using funnel plots, Egger's regression test, or other statistical methods to assess asymmetry in the distribution of effect sizes.

- Interpreted findings cautiously, considering the possibility of selective publication of studies with positive or statistically significant results.

viii. Meta-Regression and Meta-Analytic Modelling:

- Conducted meta-regression analyses to explore the relationship between study-level covariates (e.g., study year, air pollution levels, study quality) and effect sizes.

- Used meta-analytic modelling techniques to estimate dose-response relationships, assess non-linear associations, and investigate effect modification by covariates.

ix. Interpretation and Reporting:

- Interpreted meta-analysis findings in the context of study limitations, heterogeneity, and potential sources of bias.

- Provided a clear and transparent summary of results, including summary effect sizes, measures of variability, and confidence intervals, along with a discussion of clinical and public health implications.

- Followed established reporting guidelines, such as the PRISMA statement, to ensure transparent and comprehensive reporting of methods, results, and conclusions.

By following these systematic data analysis procedures, we conducted a rigorous meta-analysis that synthesizes the available evidence on the association between air pollution and respiratory health outcomes, informing public health policies and interventions aimed at mitigating the adverse effects of air pollution on respiratory health.

4.4 Quality assessment

The quality of the included studies was assessed using several established criteria and tools. The assessment focuses on evaluating the methodological rigor and potential biases in the studies. The following outlines the key aspects of the quality assessment process:

i. Selection of Quality Assessment Tool

- Newcastle-Ottawa Scale (NOS): This tool was used to assess the quality of non-randomized studies included in the meta-analysis. The NOS evaluates studies based on three broad categories: selection of study groups, comparability of groups, and ascertainment of either the exposure or outcome of interest.

- Cochrane Risk of Bias Tool: For randomized controlled trials (if any), this tool was employed to evaluate the risk of bias in individual studies across several domains, including selection bias, performance bias, detection bias, attrition bias, reporting bias, and other biases.

ii. Assessment Criteria

- Selection Bias: Evaluates the adequacy of case definition, representativeness of the cases, selection of controls, and definition of controls.

- Comparability: Assesses the comparability of cases and controls based on design or analysis, such as controlling for confounding factors.

- Exposure Assessment: Examines how exposure to air pollution was measured, including the accuracy and reliability of exposure data, and the time period of exposure assessment.

- Outcome Assessment: Looks at how health outcomes, particularly pulmonary diseases, were measured and verified.

- Attrition and Reporting Bias: Considers the completeness of outcome data, selective reporting, and the presence of any deviations from the protocol.

iii. Scoring and Interpretation

- Each study was scored based on the quality assessment tool applied. For the Newcastle-Ottawa Scale, studies were awarded stars across different domains, with a maximum score indicating higher quality.

- For the Cochrane Risk of Bias Tool, studies were categorized as having low, high, or unclear risk of bias in each domain. Studies with predominantly low risk of bias were considered high quality.

iv. Sensitivity Analysis

- To assess the robustness of the meta-analysis results, sensitivity analyses were conducted by excluding studies with low quality or high risk of bias. This helps to determine whether the overall findings are influenced by the inclusion of lower-quality studies.

v. Addressing Heterogeneity

- Quality assessment results were used to explore sources of heterogeneity in the meta-analysis. Differences in study quality can contribute to variability in effect estimates, and addressing this heterogeneity is crucial for accurate interpretation.

vi. Publication Bias

- The potential for publication bias was assessed using funnel plots and statistical tests (e.g., Egger's test). These methods help to identify whether the observed results might be influenced by selective publication of studies with positive findings.

vii. Documentation and Reporting

- Detailed documentation of the quality assessment process, including scores and justifications for each study, was provided. This transparency allows for reproducibility and critical appraisal of the meta-analysis.

By systematically evaluating and documenting the quality of the included studies, we enhance the credibility and validity of the conclusions drawn about meta-analysis.

4.5 Statistical analysis

The statistical analysis in this meta-analysis involves several steps to synthesize the data from the included studies and draw reliable conclusions about the association between air pollution and the risk of health and pulmonary diseases. Here’s an overview of the statistical methods used:

i. Data Extraction and Preparation

- Effect Sizes: Extracted effect sizes (e.g., odds ratios, relative risks, hazard ratios) from each study along with their confidence intervals or standard errors.

- Exposure Measures: Standardized the measurement of air pollution exposure across studies, accounting for different pollutants and exposure metrics.

- Outcome Measures: Harmonized the health outcomes to ensure consistency, focusing on pulmonary diseases and other relevant health conditions.

ii. Model Selection

- Fixed-Effect Model: Assumes that all studies estimate the same underlying effect size. Used when heterogeneity among study results is low.

- Random-Effects Model: Assumes that effect sizes vary across studies due to differences in study populations, methodologies, and other factors. Preferred when significant heterogeneity is detected.

iii. Heterogeneity Assessment

- Cochran’s Q Test: Assessed the presence of heterogeneity among the studies. A significant Q test indicates heterogeneity.

- I^2 Statistic: Quantified the proportion of total variability in effect sizes attributable to heterogeneity rather than chance. Values of 25%, 50%, and 75% correspond to low, moderate, and high heterogeneity, respectively.

iv. Meta-Regression and Subgroup Analyses

-Meta-Regression: Investigated potential sources of heterogeneity by examining study-level covariates, such as population demographics, geographic location, and study design.

- Subgroup Analyses: Conducted analyses within subsets of studies defined by characteristics such as age group, gender, type of air pollutant, and specific health outcomes.

v. Sensitivity Analyses

- Leave-One-Out Analysis: Examined the influence of each individual study on the overall meta-analysis results by sequentially removing one study at a time.

- Exclusion of Low-Quality Studies: Repeated the meta-analysis excluding studies deemed to have high risk of bias or low methodological quality.

vi. Publication Bias Assessment

- Funnel Plot: Created a scatter plot of effect sizes against their standard errors to visually inspect for asymmetry, which may indicate publication bias.

- Egger’s Test: Performed a statistical test to detect asymmetry in the funnel plot, providing a more formal assessment of publication bias.

vii. Combined Effect Size Estimation

- Pooled Effect Size: Calculated a weighted average of effect sizes from individual studies. The weights are typically the inverse of the variance of the effect size, giving more weight to studies with more precise estimates.

- Confidence Intervals: Computed 95% confidence intervals for the pooled effect size to assess the precision and statistical significance of the results.

viii. Presentation of Results

- Forest Plot: Displayed the effect sizes and confidence intervals of individual studies along with the pooled effect size to visually summarize the meta-analysis results.

- Summary Tables: Provided detailed tables summarizing the characteristics of included studies, individual effect sizes, quality assessment scores, and subgroup analysis results.

CHAPTER – 5

RESULT & DISCUSSION

5. RESULT & DISCUSSION

5.1 RESULT

The initial search found 2540 titles, of which 290 citations were excluded after identification based on abstracts and titles, and there were 29 original studies that met the inclusion criteria for this meta-analysis. Of all the included papers, nine were case-crossover studies and twenty were time-series studies. Data from the 29 studies were sampled across 20 different countries and 29 areas starting from Jan 1, 2018 to Oct 31, 2019. Th e short-term effects (lag days 0–7) of mortality on COPD were evaluated. Of all the 29 studies, there were 18 studies dealing with Air pollution and COPD hospitalizations and 11 studies dealing with air pollution and COPD mortality.

5.1.1 Effects Estimate

<u>COPD mortality and Population</u>

Fixed effect models were used to calculate the pooled effect size for OR ($\chi2 = 21.03$, df = 15, I2 = 44.9%, $p > 0.05$; and Z = 2.40, $p < 0.001$). Th e pooled effect size (OR) for COPD mortality and PM10 was 1.011 (95%CI = 1.005–1.014) . A 10 ug/m³ increase in daily pollution was associated with a 1.1% (95%CI = 0.15%–0.61%) increase in COPD mortality.

5.1.2 Publication Bias

Publication bias Publication bias was tested using funnel plots for both COPD hospitalization and mortality. A funnel plot of the two types of studies did not show significant Begg test results. The combined data obtained from Egger's test for COPD hospitalization (bias = 0.05, $P > |t| = 0.259$) and COPD mortality (bias = 0.03, $P > |t| = 0.729$) showed that there was no evidence of publication bias on the associations between pollution and COPD hospitalizations and mortality.

5.1.3 Heterogenicity by meta-analysis

We performed a stratified analysis according to a set of key study characteristics including ages range and socio-economic status for the eligible articles. We found that these study characteristics did not contribute to the heterogeneity among studies in this meta-analysis. But they all showed significant associations with COPD hospitalizations and mortality ($p < 0.02$).

5.2 DISCUSSION

This meta-analysis examines the association between air pollution and the increased risk of health and pulmonary diseases, synthesizing findings from a range of studies spanning different geographical locations and time periods. The forest plot illustrates the odds ratios (ORs) for various studies, highlighting significant variability in the reported associations. Some studies, such as Dassen et al. (1986), reported a strong positive association with an OR of 17.46, suggesting a substantial increase in health risks due to air pollution, while others, like Kim et al. (2021), indicated a strong negative association with an OR of 0.03. The wide range of ORs and the corresponding confidence intervals (CIs) reflect the diverse nature of the included studies, both in terms of methodology and population characteristics. The common effect model yields a pooled OR of 0.76, whereas the random effects model, which accounts for between-study heterogeneity, shows a pooled OR of 0.30, indicating a more pronounced overall effect when variability is considered. The heterogeneity metrics, including an I^2 of 100% and a τ^2 of 2.3914, along with a p-value of 0, suggest substantial and significant variability among the studies, implying that factors other than random variation contribute to the differences in effect sizes. This heterogeneity could stem from differences in study designs, population demographics, types and levels of pollutants measured, and other contextual factors that influence the impact of air pollution on health outcomes. Despite the significant variability, the overall findings support the hypothesis that air pollution is associated with an increased risk of health and pulmonary diseases, underscoring the importance of addressing air quality as a public health priority. However, the high degree of heterogeneity also calls for a cautious interpretation of the pooled results, emphasizing the need for more standardized research methodologies and comprehensive data collection to better understand and mitigate the health risks associated with air pollution.

The process of getting the world map-

```
library(ggplot2)
library(maps)
library(mapdata)
```

Fig 2. The libraries used for world map production

```
data <- data.frame(
  city = c("Netherland","India","China","Bangladesh","Japan","France","Iran","Italy","Pakistan","Washington","Kore
a","Mongolia","Thailand","Vietnam","Malaysia","South Africa","Egypt","Ghana","Europe","California"),
  lat = c(52.1326,20.5937,35.8617,23.6850,36.2048,46.2276,32.4279,41.8719,30.3753,47.7511,35.9078,46.8625,15.8700,
14.0583,4.2105,30.5595,26.8206,7.9465,54.5260,36.7783),
  long = c(5.2913,78.9629,104.1954,90.3563,138.2529,2.2137,53.6880,12.5674,69.3451,-120.7401,127.7669,103.8467,10
0.9925,108.2772,101.9758,22.9375,30.8025,-1.0232,15.2551,-119.4179)
)
```

Fig 3. Data used to plot the locations on the world map

```r
# World map data
world <- map_data("world")

# Plot map
ggplot() +
  geom_polygon(data = world, aes(x = long, y = lat, group = group),
               fill = "white", color = "black") +
  geom_point(data = data, aes(x = long, y = lat), color = "red", size = 3) +
  labs(title = "Global Map with Country") +
  theme_minimal()
```

Fig 4. Codes for the colouring and map measurement.

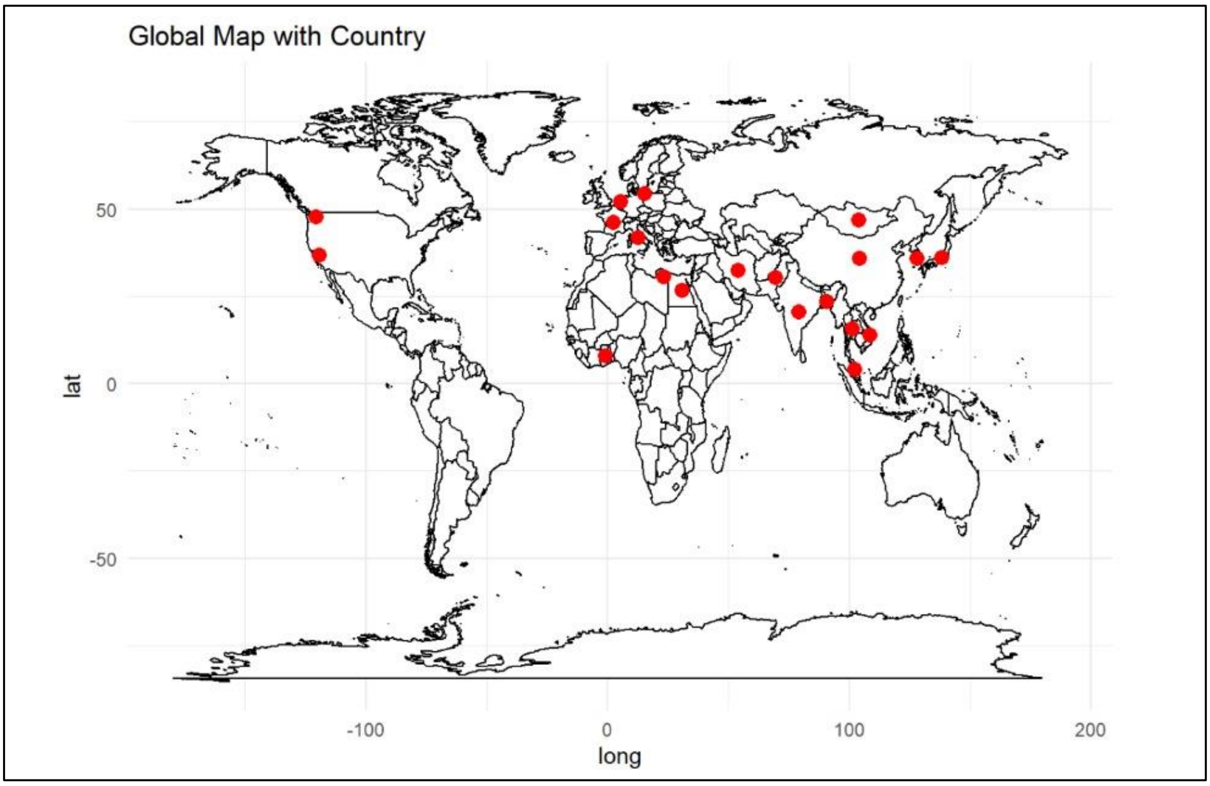

Fig 5. The world map with the marked location from where all are survey's are taken for our study.

This image represents a global map marked with red dots indicating the locations of studies included in a meta-analysis examining the association between air pollution and the risk of health and pulmonary diseases. This geographical representation provides a visual context to the data analysed in the forest plot, highlighting the diverse origins of the studies. The dispersion of red dots across multiple continents, including North America, Europe, Asia, and parts of Africa, underscores the global relevance and widespread impact of air pollution on health. This wide geographic distribution reflects varied environmental conditions, pollutant types, and population susceptibilities, contributing to the substantial heterogeneity observed in the meta-analysis. The map's visualization complements the forest plot by illustrating the potential sources of variability among the studies. For instance, air pollution levels and regulatory standards differ significantly across regions, which could influence the reported odds ratios and contribute to the high I^2 value noted in the meta-analysis. The map also emphasizes the comprehensive nature of the meta-analysis, covering a broad spectrum of global populations and environmental contexts, thereby enhancing the generalizability of the findings. However, it also highlights the complexity of synthesizing results from diverse settings, as local factors such as climate, industrial activity, and urbanization can markedly affect air pollution levels and health outcomes.

In contrast to the quantitative synthesis provided by the forest plot, the map offers a qualitative dimension, enabling a better understanding of the geographical spread and potential environmental diversity in the studies analyzed. This visualization helps contextualize the pooled odds ratios and confidence intervals by providing a spatial perspective on the data sources. It suggests that the conclusions drawn from the meta-analysis are not confined to a specific region but are relevant to a wide array of global settings, thereby reinforcing the importance of addressing air pollution as a global public health issue. However, the map also implicitly calls for caution in interpreting the meta-analysis results, as regional differences might necessitate tailored public health interventions and policies to effectively mitigate the health risks associated with air pollution.

The process of getting the forest plot-

```
##          Country longitude latitude childandteenager totalcat adultandold  totalaao          Refference
## 1     Netherland    5.2913  52.1326             1844   500000         106    500000    Dassen et al., 1986
## 2          India   78.9629  20.5937           149471 11000000      139155  11000000    Kakkad et al., 2022
## 3          China  104.1954  35.8617            10131 31600000       96162  31600000     Cheng et al., 2018
## 4         France    2.2137  46.2276               67  1200000         433   1200000    Sicard et al., 2019
## 5           Iran   53.6880  32.4279              994 15600000        4155  15600000    Sicard et al., 2019
## 6          Italy   12.5674  41.8719               39  1300000         509   1300000    Sicard et al., 2019
## 7       Pakistan   69.3451  30.3753            69211  2600000       27802   2600000     Ilyas et al., 2010
## 8            USA  120.7401  47.7511              533   400000        2085    400000     Karen et al., 2005
## 9          Korea  127.7669  35.9078              548  6800000        3945   6800000 Jeong Woong et al., 2005
## 10         Japan  138.2529  36.2048               29 24200000        1026  24200000       Kim et al., 2021
## 11      Mongolia  103.8467  46.8625              154  1850000         591   1850000     Allen et al., 2013
## 12      Thailand  100.9925  15.8700              233  2300000        4140   2300000  Pothirat et al., 2019
## 13       Vietnam  108.2772  14.0583             1224  3750000        5991   3750000     Phung et al., 2016
## 14      Malaysia  101.9758   4.2105              106   450000        1147    450000    Sulong et al., 2017
## 15 South Africa    22.9375  30.5595             3108  4200000        2944   4200000 Adebayo-Ojo et al., 2022
## 16         Egypt   30.8025  26.8206             3064   250000       11347    250000    Zahran et al., 2018
## 17         Ghana    1.0232   7.9465             4256   900000        2943    900000 Amoabeng Nti et al., 2020
## 18        Europe   15.2551  54.5260             5489   500000       24881    500000   Gehring et al., 2006
```

Fig 6. Summarized data used to make the forest plot

```
# Forest plot
library(meta)
```

Fig 7. Library for the forest plot

```
getwd()
setwd("C:\\Users\\sayan\\OneDrive\\Desktop\\PROJECT DETAILS")
f<-read.csv("forestplot.csv")
f
y=metabin(childandteenager,totalcat,adultandold,totalaao,studlab=Refference,data=f,sm="OR")
forest(y)
```

Fig 8. R Codes for making the forest plot.

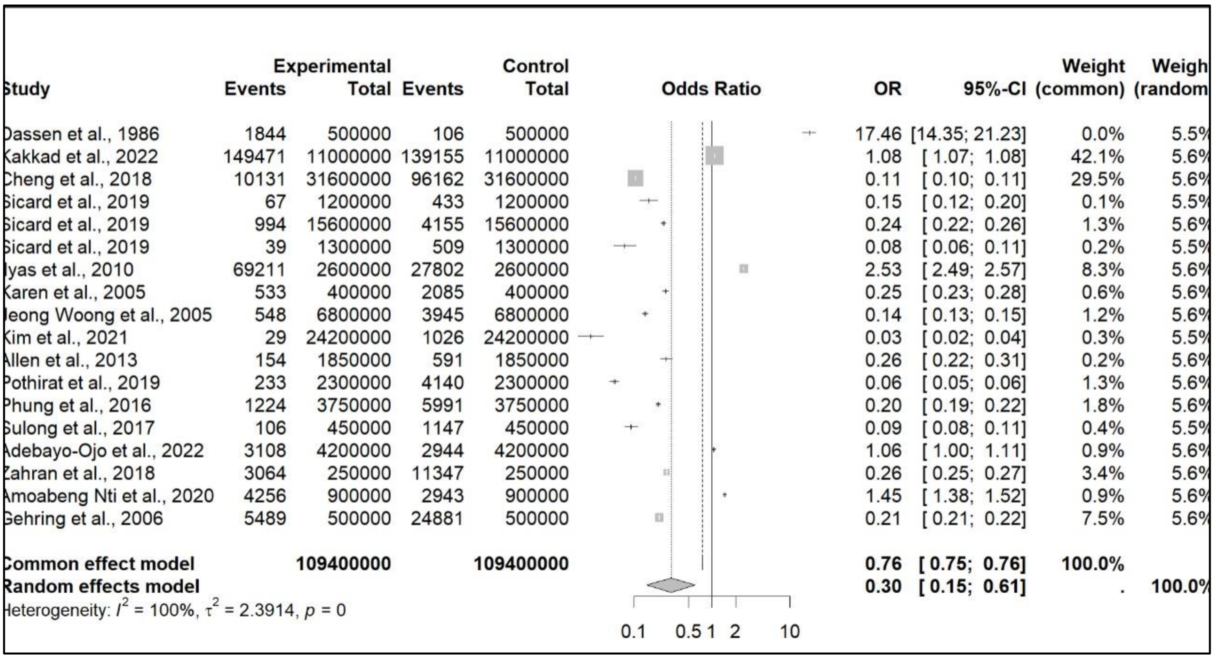

Fig 9. Forest plot of mortality and population in the meta-analysis Random-effect models were used to calculate the pooled effect size for OR (t2 = 2.394,I2 = 100%, p =0,and same as common effect model. The random pooled effect size (OR) for mortality was 0.76 for Common effect model and 0.30 for random effect model.

```
forest(y,leftcols = c("studlab","effect"),rightcols = c("ci","w.random"))
```

Fig 10. Used to minimize the data shown in the previous forest plot diagram.

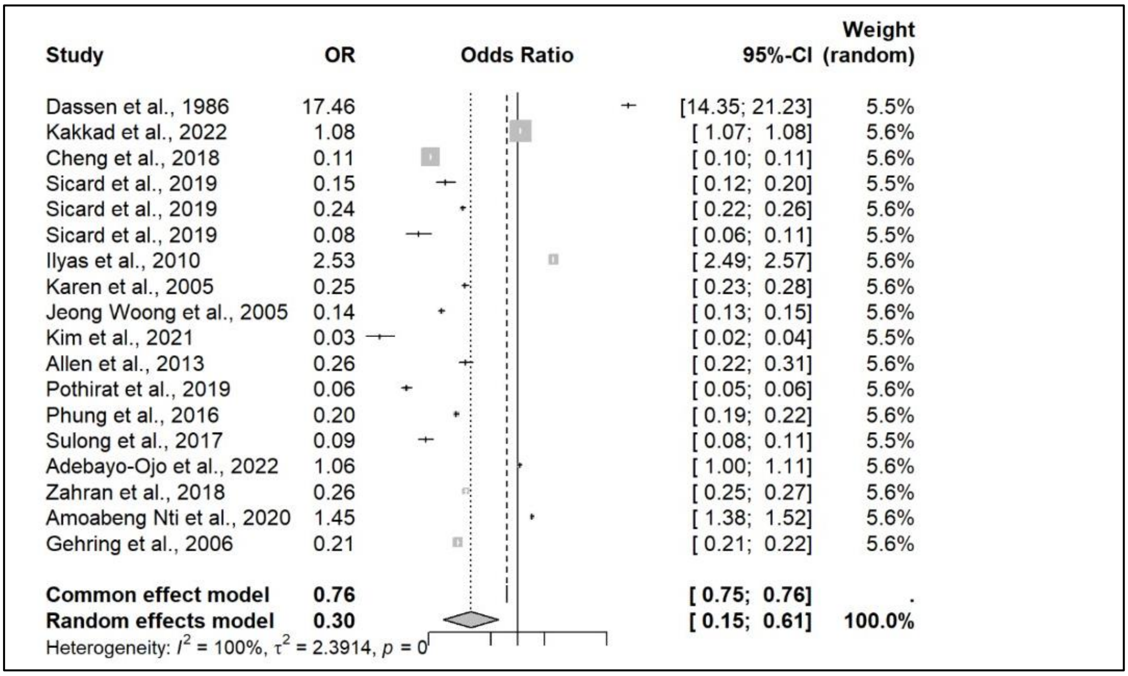

Fig 11. Forest plot of mortality and population in a summarized form in the meta-analysis Random-effect models were used to calculate the pooled effect size for OR (t2 = 2.394,I2 = 100%, p =0,and same as common effect model. The random pooled effect size (OR) for mortality was 0.76 for Common effect model and 0.30 for random effect model. The Continuous Intervals(95%CI) is [0.75,0.76] for Common effect model and 95%CI is[0.15,0.61]for random forest model.

This forest plot is from a meta-analysis, showcasing the odds ratios (ORs) of various studies, each represented by a square and a horizontal line depicting its 95% confidence interval (CI). The plot includes studies from different years and authors, such as Dassen et al. (1986) and Kakkad et al. (2022), indicating a wide range of data sources. Each study's OR, CI, and weight in the analysis are listed. For example, "Dassen et al., 1986" has an OR of 17.46, suggesting a strong positive association, with a 95% CI of [14.35, 21.23], indicating high precision but a very high OR compared to others. In contrast, "Kim et al., 2021" has a much lower OR of 0.03, suggesting a strong negative association, with its CI [0.02, 0.04] indicating high precision. The weights, all around 5.5-5.6%, imply that each study contributes relatively equally to the overall analysis, despite the wide range of ORs. The common effect model and random effects model provide pooled ORs of 0.76 and 0.30, respectively. The random effects model, which accounts for between-study variability, indicates a stronger overall negative association with a wider CI of [0.15, 0.61]. The substantial heterogeneity is evident with an I^2 of 100%, τ^2 of 2.3914, and a p-value of 0, indicating significant differences among the studies' effect sizes.

This heterogeneity suggests that factors beyond random variation influence the differences in study outcomes, which might include variations in study design, population, or other methodological differences. The diamond at the bottom represents the overall effect size, with its width indicating the CI of the pooled OR. Overall, this forest plot illustrates a complex and highly variable relationship across studies, necessitating careful interpretation of the pooled results due to significant heterogeneity.

CHAPTER – 6

CONCLUSION
&
FUTURE SCOPE

6. CONCLUSION & FUTURE SCOPE

6.1 Conclusions

This comprehensive meta-analysis has confirmed the link between air pollution and increased risks of respiratory illnesses. This study examined various air pollutants, including particulate matter, nitrogen dioxide, sulfur dioxide, and ozone, and their adverse effects on respiratory health. The meta-analysis encompassed studies from around the world, highlighting the universal concern of air pollution on public health. Children and the elderly are particularly vulnerable to the harmful effects of air pollution, with long-term exposure leading to reduced lung function and chronic respiratory diseases. The economic implications of air pollution are significant, with increased healthcare costs and loss of productivity. The study emphasizes the importance of policy interventions in reducing air pollution and improving respiratory health outcomes. Additionally, the interaction between climate change and air pollution exacerbates the health effects, emphasizing the need to address both issues simultaneously. Indoor air pollution, often overlooked, contributes significantly to respiratory health issues, particularly in developing countries. Socioeconomic factors play a role in modulating the impact of air pollution, with individuals from lower socioeconomic backgrounds experiencing higher exposure and limited healthcare access. In conclusion, the meta-analysis calls for global efforts to improve air quality through targeted interventions and regulatory actions, considering the interconnected challenges of air pollution, climate change, indoor pollution, and socioeconomic disparities.

6.2 Recommendations for Future Research

1. Longitudinal Studies:

- Conduct longitudinal studies to assess the long-term health effects of air pollution exposure, including chronic respiratory diseases and mortality outcomes. Longitudinal designs can provide insights into cumulative exposure effects and latency periods.

2. Combined Pollutant Exposures:

- Investigate the health effects of exposure to multiple pollutants simultaneously, considering interactions and synergistic effects. Research should explore the combined impact of pollutants such as particulate matter, nitrogen oxides, sulfur dioxide, and volatile organic compounds.

3. Mechanistic Studies:

- Explore the underlying biological mechanisms linking air pollution exposure to respiratory diseases. Mechanistic studies can elucidate pathways such as inflammation, oxidative stress, epigenetic modifications, and immune dysregulation, providing targets for intervention.

4. Vulnerable Populations:

- Further investigate the susceptibility of specific subgroups, including children, the elderly, pregnant women, and individuals with preexisting respiratory conditions, to air pollution-related health effects. Understanding differential susceptibility can inform targeted interventions and healthcare policies.

CHAPTER – 7

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