EVALUATING THE IMPACT OF LONG-TERM EXPOSURE TO AMBIENT $PM_{2.5}$ ON LUNG CANCER INCIDENCE AND MORTALITY: A COMPREHENSIVE META-ANALYSIS

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INTRODUCTION

LUNG CANCER is recognised as one of **the most common causes of cancer morbidity and mortality** worldwide[1], and it is the **second leading cause of death, with the highest number of years of life lost** in highly developed regions[2]. It is widely recognized that ambient **exposure to particulate matter** with a diameter below 2.5 µm ($PM_{2.5}$) represents the **foremost global environmental risk factor**[1,2], being **associated with several health outcomes**, including **lung cancer**, ischemic heart disease, and chronic obstructive pulmonary disease[3].

AIM

To **derive exposure-response** relationships reflecting the **relationship between lung cancer incidence and mortality** cases as function of exposure to **ambient $PM_{2.5}$**.

Is exposure to **$PM_{2.5}$ associated** with an **increased risk of developing lung cancer**?

METHODS

A **comprehensive search** was performed across multiple literature databases for studies published between January 2010 and July 2023.

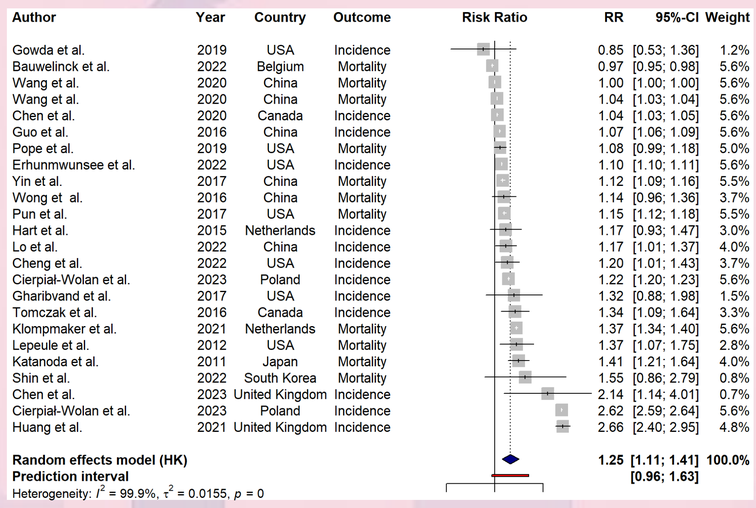
Based on predefined eligibility criteria, a total of **27 studies were included in the final analysis**.

META-ANALYSIS

- A **random-effects meta-analysis,** standardizing effect sizes to a 10 µg/m³ increase in $PM_{2.5,}$ **beta-coefficients** were used.
- **Heterogeneity** was estimated using restricted maximum likelihood. Between-study **heterogeneity** was assessed with the **I^2 statistic and tau², with I^2 > 80% indicating substantial heterogeneity**.
- **Subgroup and sensitivity analyses** were conducted to explore sources of variability and assess the robustness of findings.
- **Publication bias** was evaluated using **funnel plots and Egger's regression test**, provided enough studies was available.
- Analyses were conducted using the 'meta' package in R (v 4.3.2).

RESULTS AND CONCLUSIONS

The **random-effects meta-analysis** revealed that a 10 µg/m³ increase in **long-term $PM_{2.5}$ exposure** was associated with an **increase of 25% in the combined risk of lung cancer incidence and mortality** (pooled risk estimate: RR = 1.25 (95% CI: [1.11; 1.41])).



When analysed separately, $PM_{2.5}$ exposure was associated with

11% increase in lung cancer incidence risk (RR = 1.11; 95% CI: [1.04; 1.18])

14% increase in lung cancer mortality risk (RR = 1.14; 95% CI: [1.04; 1.25]).

Substantial heterogeneity was observed across all meta-analyses (I^2 > 80%), suggesting considerable variability between studies.

Egger's test indicated no statistically significant evidence of publication bias for incidence.

Long-term exposure to $PM_{2.5}$ is significantly associated with an increased risk of lung cancer.

Nevertheless, given the considerable heterogeneity observed, in addition to the potential impact of small-study effects, a cautious interpretation of these results is imperative. It is recommended that future research endeavours focus on the identification of sources of variability and the conduct of comprehensive analyses. This will facilitate **more precise estimation of the long-term health and economic impacts**. The dissemination of findings from such research will **inform the development of targeted prevention strategies and policy support.**

REFERENCES

[1]IARC (2025) Global lung cancer incidence according to subtype: new study highlights rising adenocarcinoma rates linked to air pollution [2]Global Burden of Disease Collaborative Network. (2023) Global Burden of Disease Study 2023 (GBD 2023); [3]WHO. (2024) Fact sheet: Ambient (outdoor) air pollution.

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