

The Association Between County-Level Air Pollution and Advanced-Stage Lung Cancer at Initial Diagnosis in the United States

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Background

Ambient air pollution is an established lung-cancer carcinogen. Whether it shifts the stage of disease at primary diagnosis at the population level remains unclear.

We examined county-level pollution exposure and advanced-stage lung-cancer presentation across the continental U.S., accounting for socioeconomic and lifestyle confounders.

Key Findings

Among 2,538,856 lung-cancer cases analyzed

+0.4%

NO₂: higher advanced-stage rate per SD increase.
RR 1.004 (95% CI 1.001 to 1.007)

n.s.

PM_{2.5}: no independent association with stage.
RR 1.001 (95% CI 0.997 to 1.006)

+1.4–1.7%

Smoking prevalence: strongest predictor of late-stage disease, per SD.
 $p < 0.001$

Histology & Equity

NO₂ associated with squamous cell carcinoma: RR 1.009 (1.005 to 1.012).

PM_{2.5} associated with large cell carcinoma: RR 1.021 (1.001 to 1.042).

No association observed for adenocarcinoma or small cell carcinoma.

Highest-vulnerability counties had a **66.5%** advanced-stage rate, a **14.2 percentage-point** gap versus the lowest-risk stratum.

Methods

Design. Retrospective ecological analysis of the National Cancer Database (NCDB), Jan 2010 to Dec 2023.

Population. Incident lung-cancer cases with known clinical stage across the continental U.S.

Exposure. Satellite-derived county-level PM_{2.5} and NO₂, as standardized 3-year moving averages.

Outcome. Per-county-year rate of advanced-stage (III to IV) diagnosis.

Analysis. Poisson generalized estimating equation (GEE) models

Adjusted Rate Ratios

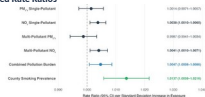


Figure 2. Adjusted rate ratios for advanced-stage lung-cancer diagnosis per standard-deviation increase in exposure (95% CI).

Interpretation

NO₂, a marker of traffic-related pollution, was independently associated with advanced-stage presentation, strongest in squamous-cell carcinoma.

PM_{2.5} showed no independent effect on stage at diagnosis.

Structural factors and smoking remain the dominant drivers of late-stage disease.

Policy: pair tighter traffic-pollution controls with targeted screening outreach in high-vulnerability, low-access communities.

Geographic Distribution of Exposure and Outcome

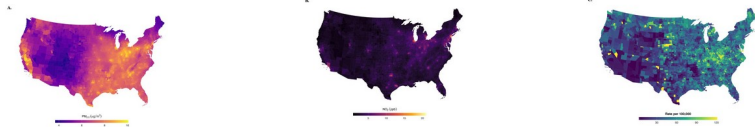


Figure 1. County-level mean PM_{2.5} (A), NO₂ (B), and advanced-stage lung-cancer rate per 100,000 residents (C). Values are county averages over the 2010 to 2023 study period.