Outdoor ambient air pollution and breast cancer survival among Chinese patients: a multi-center analysis of 18553 cases

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Introduction

Ambient fine particulate matter (PM2.5) is a Group 1 carcinogen associated with lung cancer, but evidence on its role in breast cancer prognosis remains limited.Although epidemiological studies suggest associations between PM2.5 exposure and breast cancer incidence, particularly for aggressive subtypes, few studies have evaluated its impact on survival outcomes, including progression-free survival (PFS) and overall survival (OS).

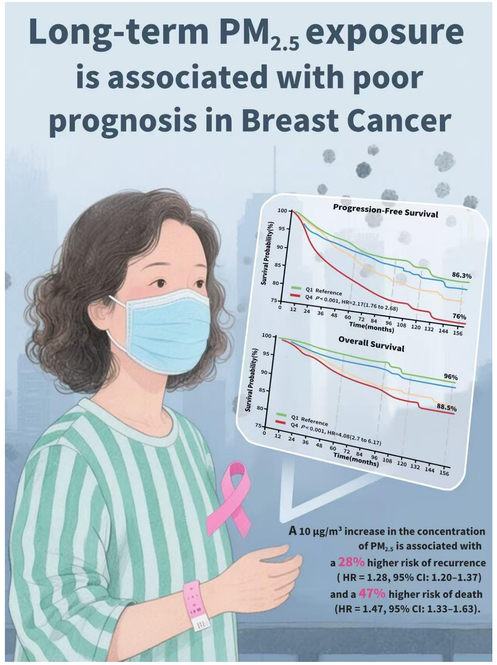


Figure 1. Cover figure

Methods and Materials

In this prospective study we analyzed data from 18,553 breast cancer patients (2000–2019) sourced from two large-scale clinical databases, which included more than 40 medical centers in China. Long-term PM2.5 exposure was assessed using high-resolution spatial-temporal modeling (1 km resolution, R^2=0.92). Cox proportional hazards models were used to evaluate associations between PM2.5 exposure and survival, adjusting for demographic characteristics, Clinical factors, and Socioeconomic status. Stratified analyses were conducted based on Molecular subtype, Age and Tumor characteristics.

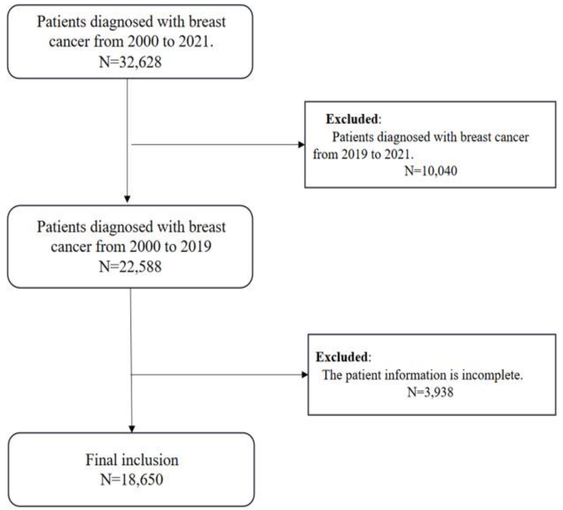


Figure 2. Flow chart of patient enrollment..

Results

Higher PM2.5 exposure was significantly associated with worse PFS and OS in dose-dependent manners. Each 10 μg/m³ increase in PM2.5 was associated with a 28% higher PFS hazard (HR=1.28, 95% CI: 1.20–1.37) and 47% higher OS hazard (HR=1.47, 95% CI: 1.33–1.63) in fully adjusted models. Kaplan-Meier curves showed widening survival gaps over time, with absolute differences in PFS rates between the highest and lowest exposure quartiles increasing from 8.4% at 5 years to 10.3 at 13 years. Subgroup analyses indicated strong associations among HER2-positive (PFS HR=2.13, OS HR=4.03) and triple-negative breast cancer (TNBC; PFS HR=2.53, OS HR=4.03) subtypes, as well as among older patients (>40 years) and those with high Ki-67 expression.

Conclusions

This study is the first to demonstrate that long-term PM2.5 exposure is independently associated with poor prognosis in breast cancer, particularly for HER2-positive and TNBC subtypes. The findings highlight PM2.5 as a modifiable risk factor and emphasize the need to integrate environmental exposure into clinical risk assessment and public health strategies to mitigate breast cancer disparities.

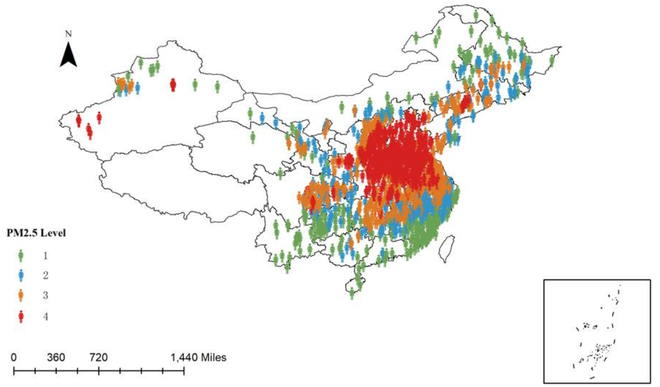


Figure 3. The geographical distribution map of Chinese breast cancer patients diagnosed in the database

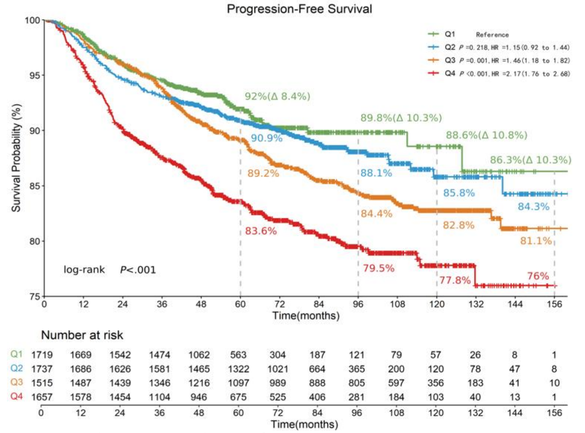


Figure 4. Kaplan-Meier survival curves of PFS

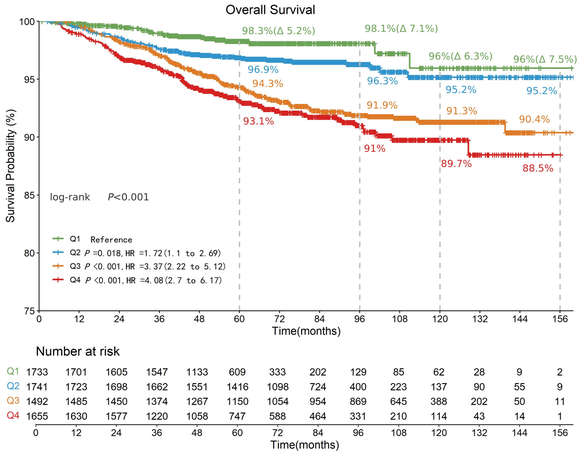


Figure 5. Kaplan-Meier survival curves of OS in breast cancer diagnosed patients exposed to PM2.5.Q1 to Q4 represent different concentration levels of PM2.5, of which Q4 is the highest.

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