

Introduction

- Air pollution is a well-documented public health concern associated with increased morbidity and mortality.¹
- While chronic exposure to fine particulate matter (PM2.5 and PM10) has been extensively studied, the acute effects of air pollution in surgical patients remain underexplored.²
- Given the physiological stress imposed by surgery, anesthesia, and underlying comorbidities, perioperative patients may represent a uniquely vulnerable population to the adverse effects of air pollution.
- Existing studies investigating the effects of air pollution in the surgical context are few in number, geographically limited, and often based in homogeneous populations³, or focus only on one type of surgery or postoperative complication.⁴⁻⁶

Objectives

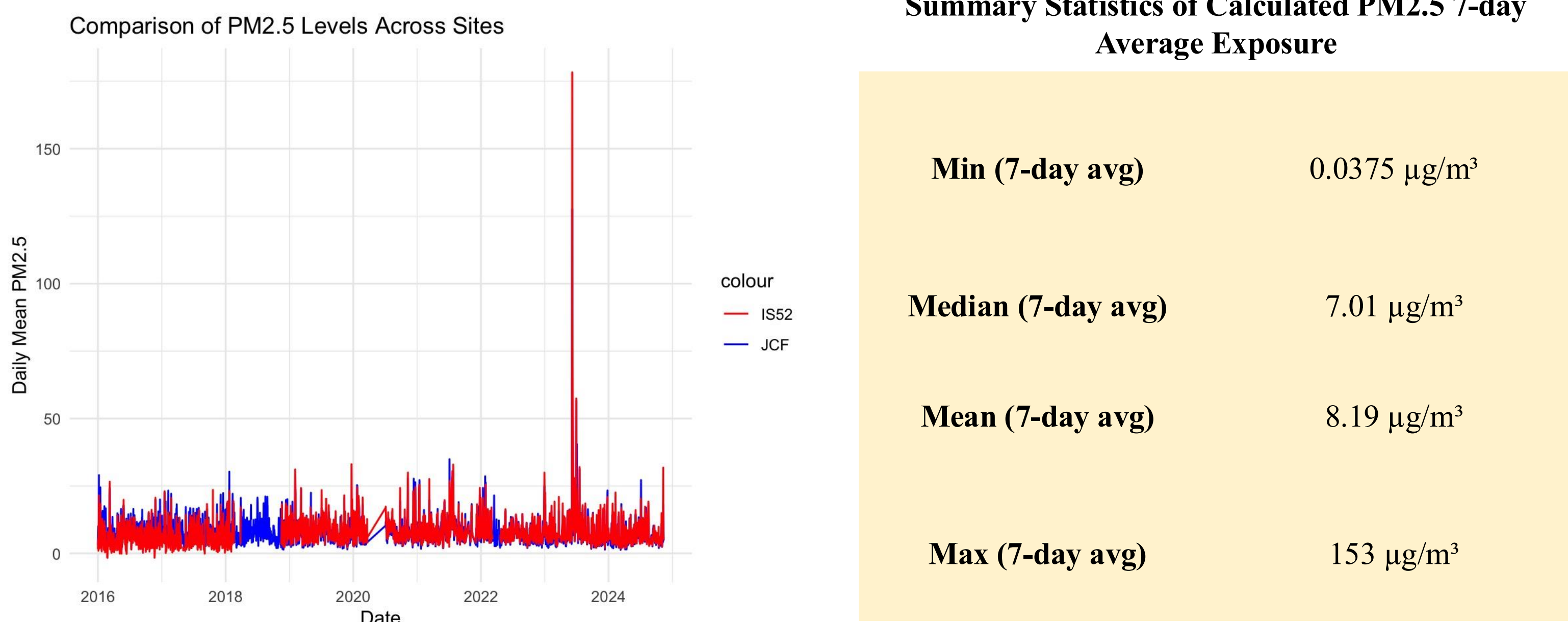
- This study aims to conduct a comprehensive analysis of whether PM2.5 exposure is associated with adverse perioperative outcomes in a diverse cohort of surgical patients.
 - Characterize the degree of short-term perioperative air pollution exposure that leads to adverse outcomes
 - Determine which surgeries are at highest risk

Methods

- Design:** Retrospective cohort study (2016–2024) at a large academic medical center (n = 176,718 surgeries)
- Exposure:** 7-day average PM_{2.5} concentration prior to surgery, averaged across two EPA monitoring sites in the hospital’s catchment area
- Outcomes:** Postoperative complications grouped as:
 - Pulmonary (Composite Measure):** pneumonia, respiratory failure, ARDS, TRALI
 - Renal:** acute kidney injury (AKI)
 - Infectious:** sepsis, UTI, pyelonephritis, fungal infections
 - Cardiovascular/Thrombotic:** NSTEMI, thromboembolic events (PE, DVT)
- Analysis:** Multivariable logistic regression adjusting for age, ASA class, comorbidity burden (Elixhauser index), surgery duration, and CPT-coded surgery type.
- Subgroup analyses:** Stratified by age, comorbidity level (“high/low” based on cumulative Elixhauser index), intubation status, and surgical category (Cardio-Pulm, Digestive, Nervous, Integumentary, MSK, GU).
- Sensitivity analyses:** Assessed 7-day maximum PM2.5 concentration as alternate exposure definition; evaluated outcomes during two wildfire events (June 2023 and July 2021) using calendar-defined exposure windows

Results

Figure 1 & Table 1. Distribution of Preoperative PM2.5 Exposure



- PM2.5 exposure levels remained largely consistent between 2016–2024, with a singular spike in 2023, and a gap in 2020.

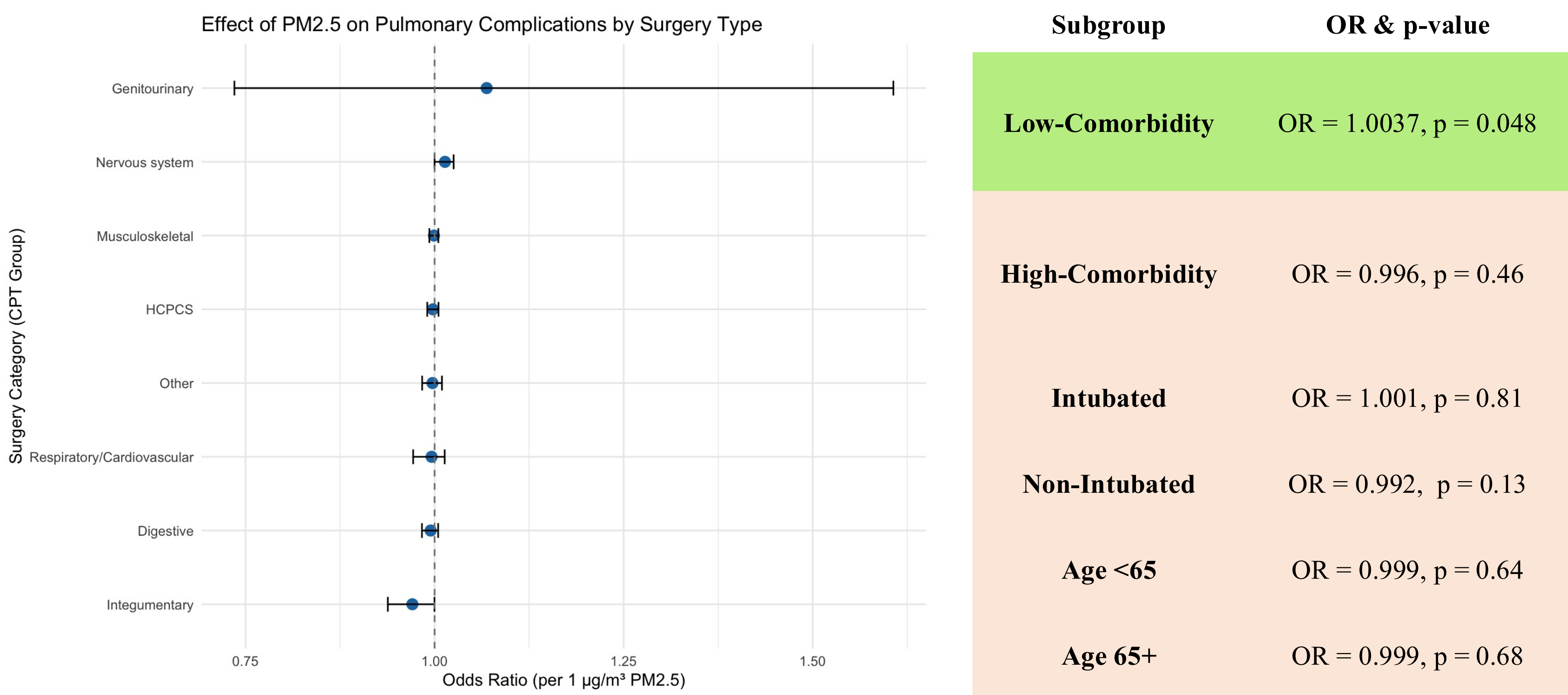
Results

Table 2. Association Between PM2.5 Exposure and Pulmonary Complications

Covariate	OR (95% CI)	p-value	Interpretation
PM2.5 (7-day avg)	1.005 (1.002–1.008)	0.0026	Significant – each 1 µg/m³ ↑ in PM2.5 → 0.5% ↑ odds of pulmonary complication
Age	1.001 (0.999–1.003)	0.073	Not significant at p < 0.05
ASA Class	6.39 (6.17–6.62)	<0.001	Strong predictor higher ASA class = much higher risk
Surgery Duration (per min)	1.001 (1.0009–1.0013)	<0.001	Longer surgeries = small but significant ↑ risk
Comorbidity Index	2.42 (2.29–2.56)	<0.001	Major risk factor – more than doubles the odds

- Each 1 µg/m³ increase in 7-day average PM2.5 was associated with a **0.5% increase** in odds of complications (OR = 1.005, 95% CI: 1.002–1.008, p = 0.0026), but not after including surgery type (p=0.53), suggesting procedure factors may dominate risk.
 - Exposure ranged from 0.04 to 154 micrograms/m³; scaling this OR implies over twice the odds of complications at high exposure (OR≈2.1).**
- ASA class, surgery duration, and comorbidity burden were also significant predictors

Figure 2 & Table 3. Subgroup and Surgery-Type Variation in PM2.5 Effects on Pulmonary Complications



- Stronger effects were seen in nervous system surgeries** (OR 1.014, p=0.028) and **mild associations in low-comorbidity** patients (OR 1.0037, p=0.048).
- No significant associations were seen for AKI, sepsis, UTI, pyelonephritis, fungal infections, NSTEMI, or thromboembolic events, nor were there differences by age or intubation status.

Sensitivity Analyses

- 7-day maximum exposure: No significant association with pulmonary or secondary complications; effect estimates remained near 1.0
- Wildfire windows: Wildfire weeks showed a nonsignificant trend toward higher pulmonary complication rates (aOR ≈1.05–1.08); no differences observed for secondary outcomes

Discussion

Summary of Findings and Conclusions:

- Short-term perioperative PM2.5 exposure was linked to higher odds of pulmonary complications, but this association diminished after adjusting for surgery type → procedural characteristics may play a stronger role in driving risk.
- Importantly, small daily increases in PM2.5, as is common in urban environments with typical functions of 5-15 micrograms/m³, can accumulate and lead to clinically meaningful rises in pulmonary risk.
- No association was found between PM2.5 and AKI, sepsis, UTI, NSTEMI, thromboembolic events, or fungal infections, implying **organ- and procedure-specific effects**.
- Stronger associations were observed among **nervous system surgeries** and **low-comorbidity patients**.
- Using the 7-day maximum PM2.5 level instead of the mean showed no significant associations across outcomes
- During two EPA-documented wildfire events, a nonsignificant trend toward higher pulmonary complication rates was detected.

Limitations:

- Exposure misclassification from use of central monitors rather than individual-level estimates.
- Residual confounding (e.g., socioeconomic factors, practice variation).
- Limited PM_{2.5} variability and missing data for select outcomes may reduce statistical power and model precision.
- Single-center design limits generalizability.

Next steps:

- Expand exposure models:** Test 7-day max vs. average PM2.5 and assess wildfire-related spikes.
- Refine spatial analysis:** compare ZIP-code-based exposure vs. distance from monitors to refine exposure estimates.
- Advance modeling:** explore distributed lag non-linear models to capture time-varying effects.

Conclusions

- These preliminary trends highlight the potential influence of ambient pollution on surgical recovery, especially among higher-risk procedures, such as neurosurgery.
- With air quality increasingly shaped by climate change and large-scale events like wildfires, a better understanding of environmental contributions to perioperative risk could help inform surgical planning and public health efforts.

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