Occupational Exposure by Air Pollution: Evidence from Mortality and Smoke Data

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Abstract

This study investigates the relationship between occupational exposure and wildfire smoke in shaping cause-specific mortality outcomes across U.S. counties from 2020 to 2023. By merging death certificate records from the National Center for Health Statistics (NCHS) with occupation-linked microdata from the Current Population Survey (CPS-IPUMS), we construct a panel data that captures monthly mortality counts by occupation and county. Outdoor exposure levels are derived from O*NET-based task frequency scores and manually labeled occupation categories, while smoke exposure is measured using satellite-based estimates of daily wildfire smoke plume from Hazard Mapping System Fire and Smoke.

We find that the effect of smoke exposure on respiratory and asthma mortality is amplified among outdoor and mixed-exposure occupations, suggesting substantial heterogeneity in environmental vulnerability across the workforce. However, outdoor working environment has negative effect on cardiovascular mortality. These findings have implications for targeted health interventions and adaptive labor protections in the context of climate-related air quality shocks.

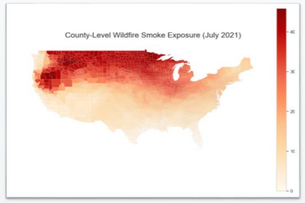
Introduction

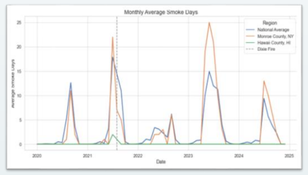
Air pollution has become a global problem since industrialization. Different sources of pollution become more severe as urbanization proceeds. Since the 1950, governments and public institutions have investigated air pollution's impact on different ages, populations, and occupations. Of course, not only the medical researchers are trying to investigate pharmacology and toxicology, social scientists are also interested in conducting empirical studies on air pollution related diseases and its correlation with identity/occupation. Thanks to those environmental scientists and NASA who monitor air pollution and wildfire data (Childs et al. 2024), several articles provide valuable insights in air pollution and healthcare based on existing metrics. Some literatures investigate the causality between air pollution and suicide rate using wild fire rate as an instrumental variable (IV) (Molitor et al. 2023). Since wildfires increase air pollution but are unlikely to directly affect suicide rates through other channels, they serve as a "Instrument" that helps isolate the true impact of air pollution on suicide rates.Others investigate increasing wildfire activity's impact on hospital care utilization, specifically on inpatient admissions and emergency department (ED) visits (Dodier 2024). There are also some articles that categorize the impact of wildfire impact into different diseases and heterogeneous occupations, depending on their working exposure and probability of outdoor activities (Marika et al. 2024). In addition, Multiple government agencies and nonprofit organizations look into occupation exposure from air pollution. In O*NET OnLine database, we can find the time an occupation is exposed to outdoor activities, and the census about how risky an occupation is to have an occupational disease. World Health Organization (WHO) and International Labor Organization (ILO)'s systematic reviews reported evidence of higher risks of ischemic heart disease and stroke amongst people working longer (Frank et al. 2021). In the United States, Occupational Safety and Health Administration (OSHA) provides a dashboard that tracks inspection data, fatality inspection data, and air sampling data, which might be worth investigating in my further research.

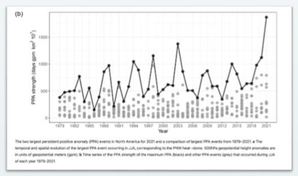
Data Source

Smoke Data

All smoke data are accessed via Harvard Mapping System (HMS). We use TIGER files to form the polygons and approximate the smoke covering area in each FIPS county .

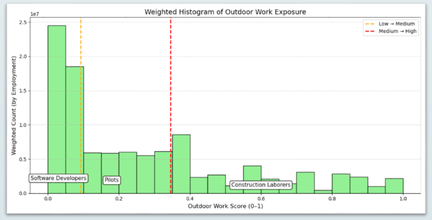






Employment Data

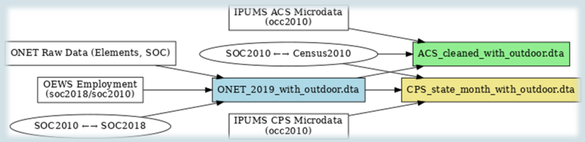
Current Population Survey (CPS) , O*NET 2019 Database
Basic Monthly Files (2020–2023) from IPUMS-CPS: Provides occupation (occ), SOC-coded occupational labels (occ2010), age, region, and employment indicators at the county-month level. O*NET 2019 Database: Occupational attributes including the frequency of outdoor work; merged via soc2010 codes.



Mortality Data

NCHS Multiple Cause-of-Death Files (1999–2023):
Includes individual death records with ICD-10 codes, occupation (occupation), and geographic identifiers (staters FIPS, county FIPSs, death year, death month).

Data Pipeline for O*NET, Occupational Employment and Wage Statistics (OEWS), and CPS



Methodology

$$\text{Mortality}_{coyt} = \beta_1 \cdot \text{OutdoorLow}_{coyt} + \beta_2 \cdot \text{OutdoorMed}_{coyt} + \alpha_{co} + \gamma_{yt} + \varepsilon_{coyt}$$

Mortality$_{coyt}$: Number of deeaths in county c, occupation o, year y, and month t, for a specific ICD 10 cause (e.g., respiratory, cardiovascular, athma)

OutdoorLow$_{coyt}$, OutdoorMed$_{coyt}$: Dummy Variables indicating low and medium occupational outdoor exposure; high exposure is the base group.

α_{co}: County-by-occupation fixed effects

γ_{yt}: Year-by-month fixed effects

ε_{coyt}: Error term, with standard errors clustered at the county level

Results

	(1)	(2)	(3)
	Respiratory	Cardiovascular	Asthma
outdoor_low	-0.072	0.536***	-0.001
	(0.117)	(0.190)	(0.002)
outdoor_med	-0.081	0.454**	-0.002**
	(0.117)	(0.185)	(0.001)
Constant	0.451***	1.299***	0.007***
	(0.079)	(0.125)	(0.001)
Observations	243488	243488	243488

- $p < 0.1^{*}, p < 0.05^{**}, p < 0.01^{***}$
- Standard errors in parentheses

Discussion & Future Work

As we can see in (1) and (3), the outdoor dummies do have a positive effect on respiratory and asthma mortality. In the panel regression, All constant are positive, implying that high outdoor exposure implies higher risk of respiratory diseases, such as COPD, pneumonia, and asthma. In outdoor_low and outdoor_med, each coefficient is negative, which shows that as people become less exposed to outdoor areas, they're less likely to suffer from respiratory mortality. These results are consistent with literature's conclusion (Dodier M, 2024). Yet, The scientific community does not fully understand how long-term, repeated exposures to high concentrations of wildland fire smoke may affect a worker respiratory system. Future work on respiratory mortality can be conducted using lagging variable (t+1, t+2) to reveal the long-term effect of smoke on respiratory-cause mortality. Another potential approach is to use clinical notes or emergency records during heavy smoke months to investigate their correlation, as mortality is usually the extreme case of morbidity, and long-term affect of outdoor exposure may not be directly reflected.

The cardiovascular coefficient is not consistent with intuition: outdoor_low and outdoor_med coefficients are significantly positive, reflecting the negative correlation between outdoor exposure level and cardiovascular mortality. This could be explained through several potential mechanism and bias. According to age distribution, young people are more likely to enroll in outdoor occupations, which results in selection bias, or so called "healthy worker effect". In contrast, cardiovascular diseases cardiovascular risk is often higher in sedentary indoor jobs (e.g., clerical work) due to less physical activity, more stress or poor ergonomic conditions.

We will keep solving the mismatch between soc code in NCHS mortality data and CPS_ONET data. Future work will focus on occupation code merging.

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