Source-specific fine particulate matter and hospitalization due to myocardial infarction

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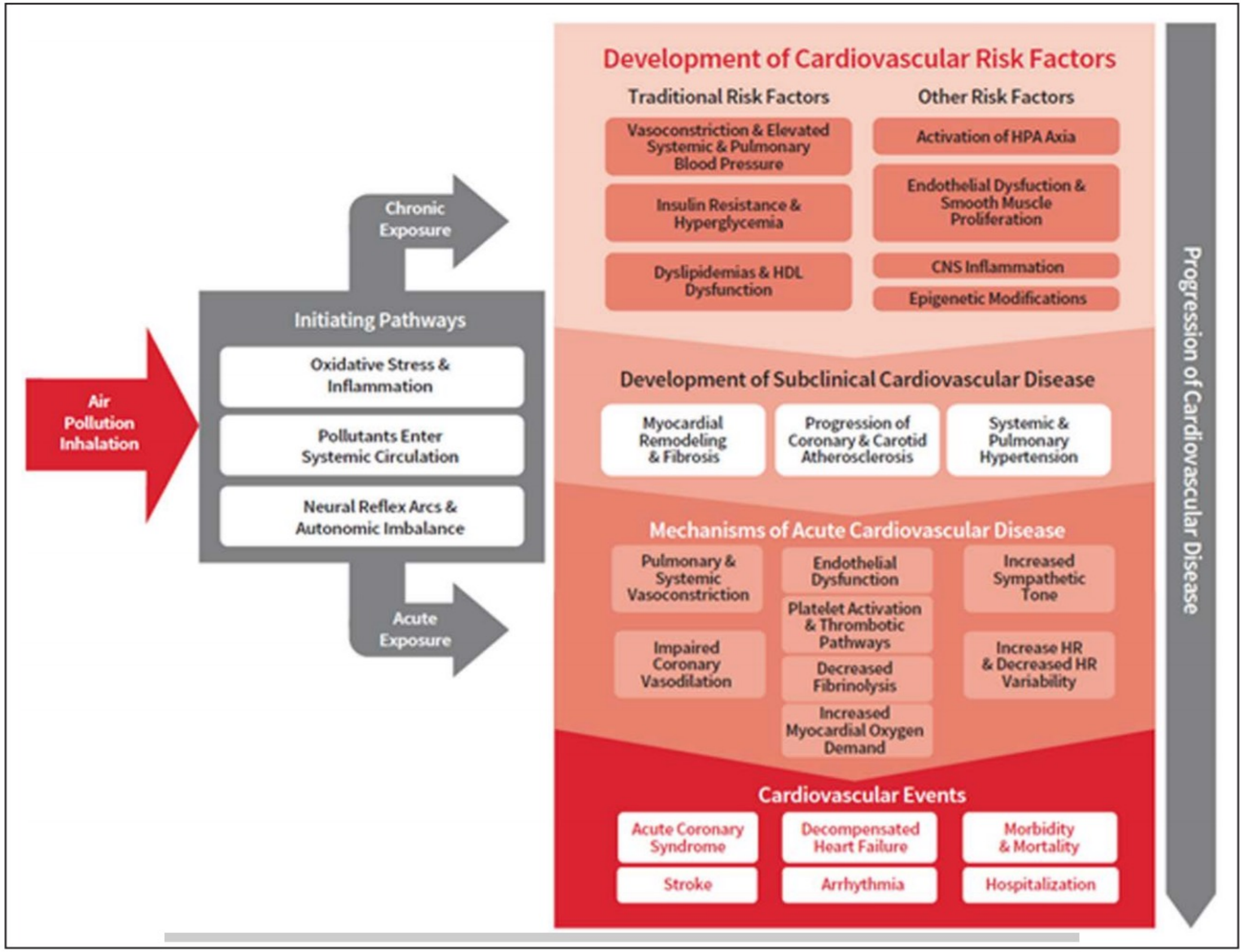
MOTIVATION

- Globally, ischemic heart disease was the leading cause of death in both 2000 and 2019, and is responsible for an increase of more than 2 million deaths over the last two decades[1]
- An estimated 6.67 million deaths worldwide in 2019 were attributable to air pollution, approximately half of which were due to cardiovascular disease[2]
- Identifying particularly toxic sources of $PM_{2.5}$ can maximize efficiency in air pollution policies
- Heat exposure is also associated with MI and could have a synergistic relationship with source-specific $PM_{2.5}$ and MI[3]

1. Global Health Estimates 2020: Deaths by Cause, Age, Sex, by Country and by Region, 2000-2019. Geneva: World Health Organization; 2020.
2. Murray CJL et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019. The Lancet. 2020.
3. Sun Z, Chen C, Xu D, Li T. Effects of ambient temperature on myocardial infarction. Environ Pollut. 2018..

BACKGROUND

- $PM_{2.5}$ inhalation can trigger acute CV events[1]
- Evidence of source-specific differences in CV outcomes[2]
- Temperature is often considered a confounder but could also modify the relationship between source-specific $PM_{2.5}$ and CVD[2]



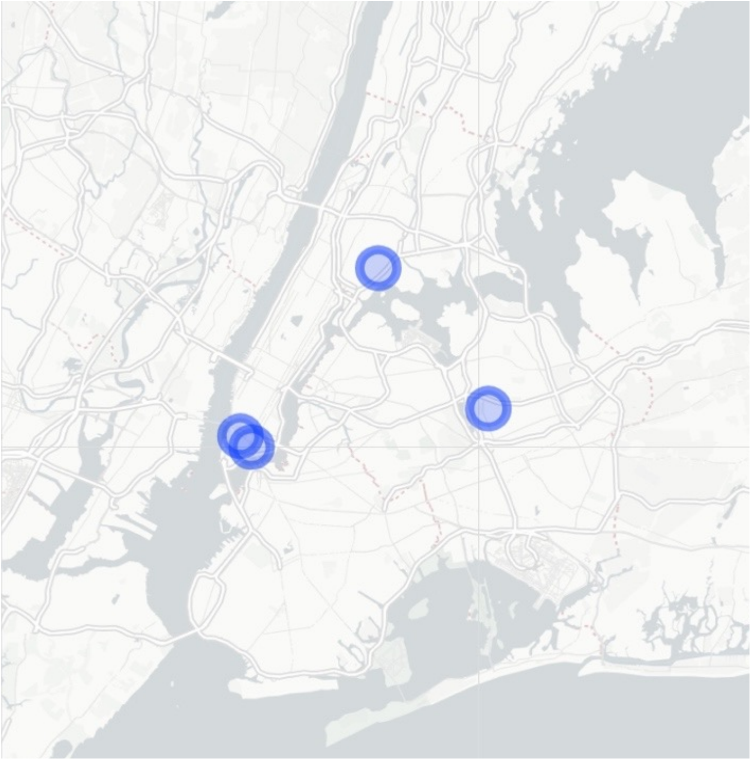
Adapted from Rajesh Vedanthan and Michael Hadley, 2019 in Brauer et al. 2021

1. Newby DE et al. Expert position paper on air pollution and cardiovascular disease. Eur Heart J. 2015.
2. Lall R, Ito K, Thurston GD. Distributed Lag Analyses of Daily Hospital Admissions and Source-Apportioned Fine Particle Air Pollution. Environ Health Perspect. 2011.

AIMS

- To evaluate whether $PM_{2.5}$ from certain sources may be differentially associated with acute myocardial infarction (MI) in NYC
- To evaluate the potential for effect modification by same-day temperature

DATA SOURCES



Map of $PM_{2.5}$ monitor locations in NYC

- Study population: Population of NYC 2007-2015
- Outcome:
  - MI admissions in NYC hospitals
  - SPARCS
- Exposure Assessment
  - Speciated $PM_{2.5}$ from EPA AQS at monitors in 3 locations
  - Taken every 3 or 6 days
  - Daily average of all monitors used in source apportionment
- Covariates
  - Temperature and relative humidity: NLDAS

SOURCE APPORTIONMENT: APCA

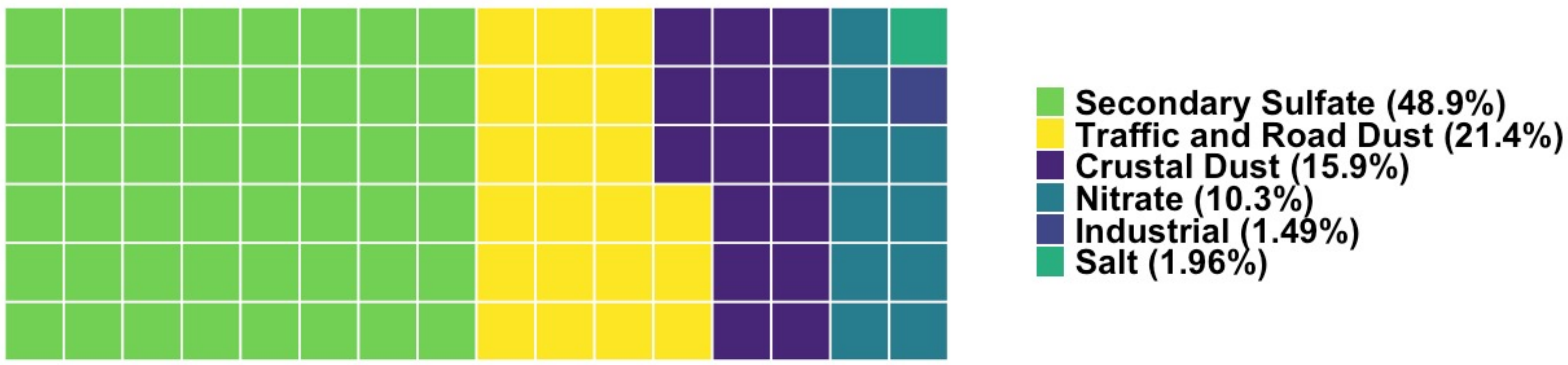
- How do we identify sources of $PM_{2.5}$?
  - Pattern recognition through dimension reduction
- Absolute Principal Components Analysis (APCA) is an extension of PCA
  - $PM_{2.5}$ concentrations are regressed on scaled component scores for final scores
- Main advantage: computation of daily predicted source concentrations in the same units as $PM_{2.5}$ and its chemical constituents
  - Improves interpretability and can be compared with prior studies that use APCA

Image courtesy of Elizabeth Gibson

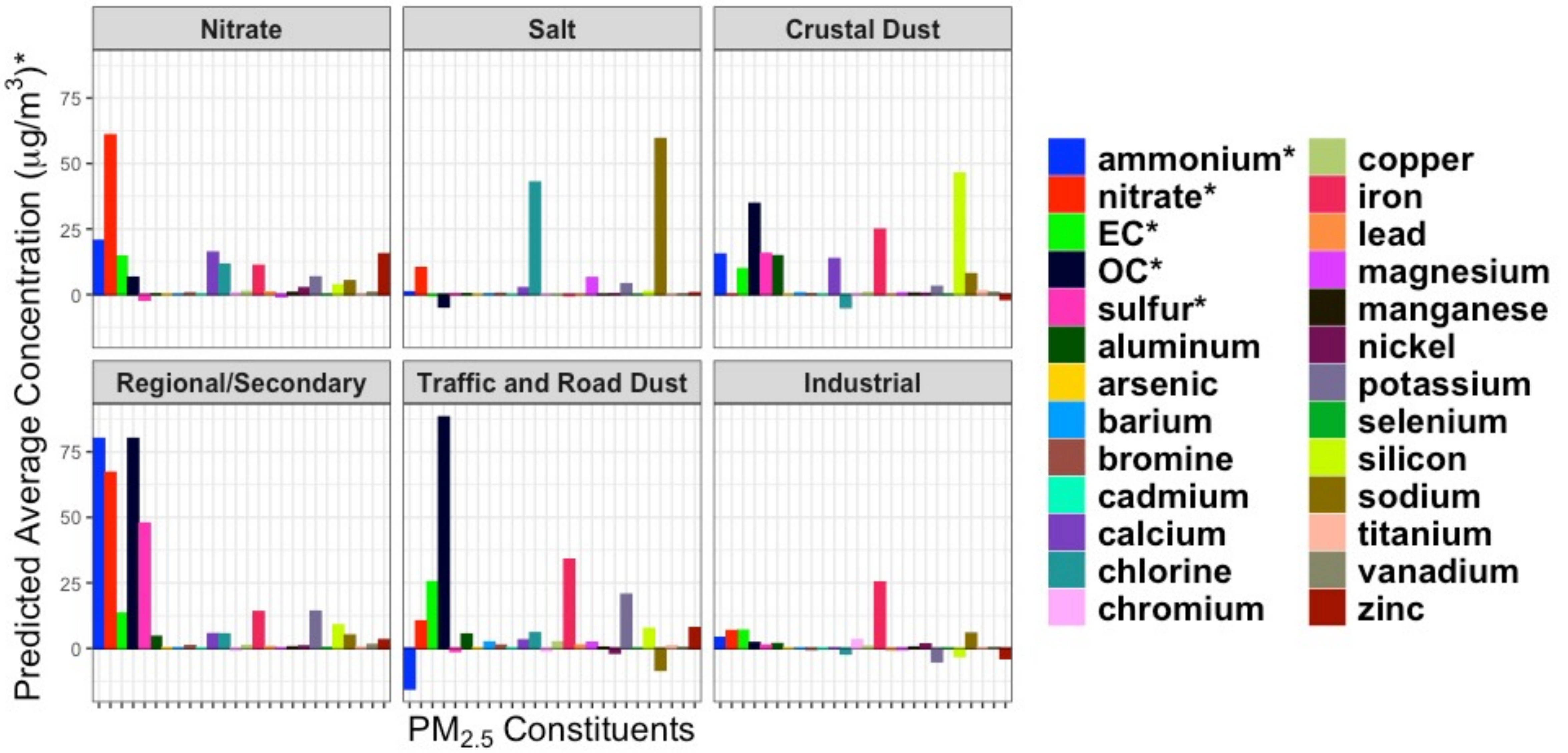
TIME-SERIES ANALYSIS

- Poisson model with quasi-likelihood
- All identified sources included in final model, modeled linearly
- Adjusted for:
  - Same-day and 3-day average ambient temperature and relative humidity included, modeled nonlinearly
  - Day of the week
- Interaction terms with categorical indicators for temperature quartiles

PROPORTION OF TOTAL $PM_{2.5}$ FROM EACH SOURCE

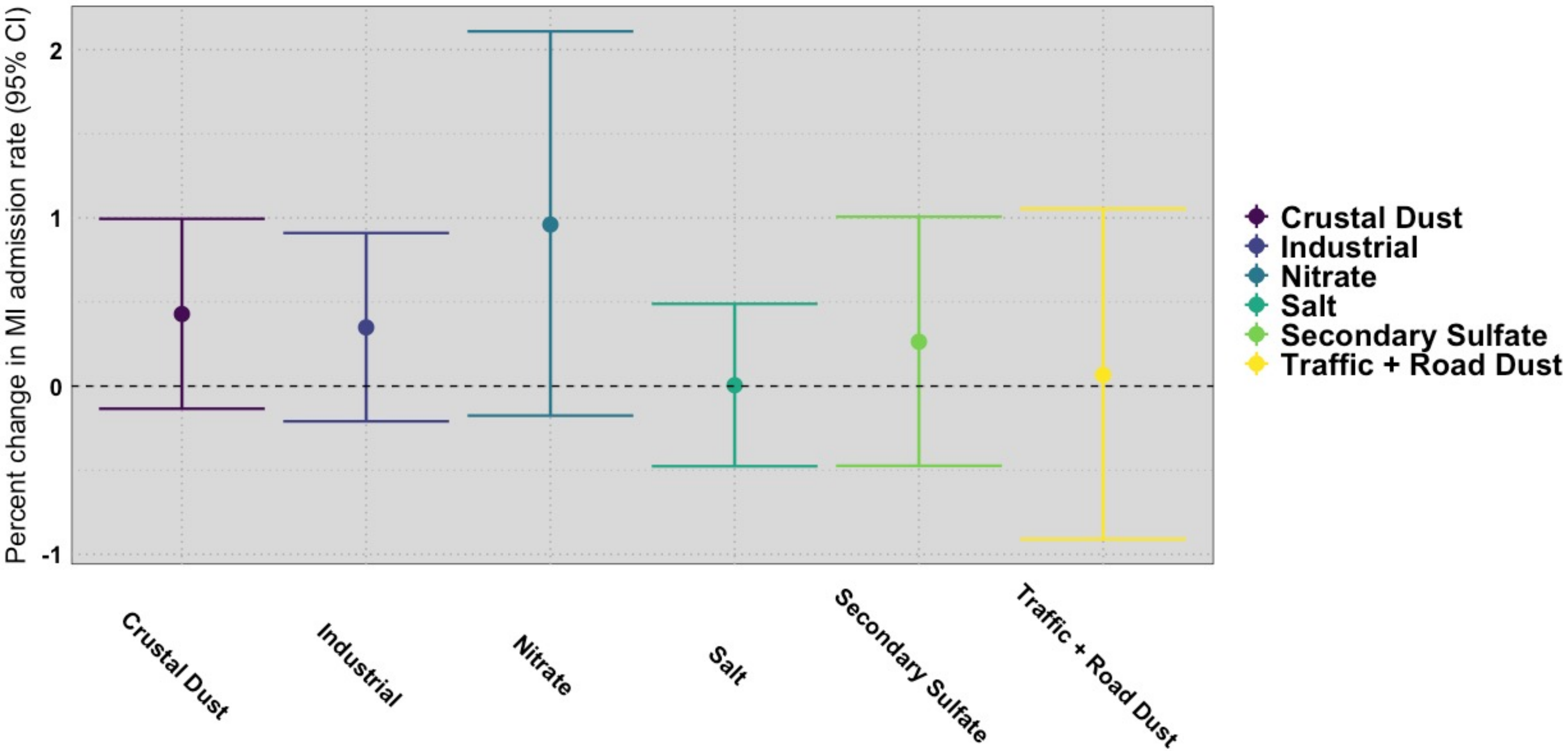


IDENTIFIED $PM_{2.5}$ SOURCES



* Predicted concentrations for ammonium, nitrate, elemental carbon (EC), organic carbon (OC) and sulfur reported in $0.1 \cdot \mu g/m^3$

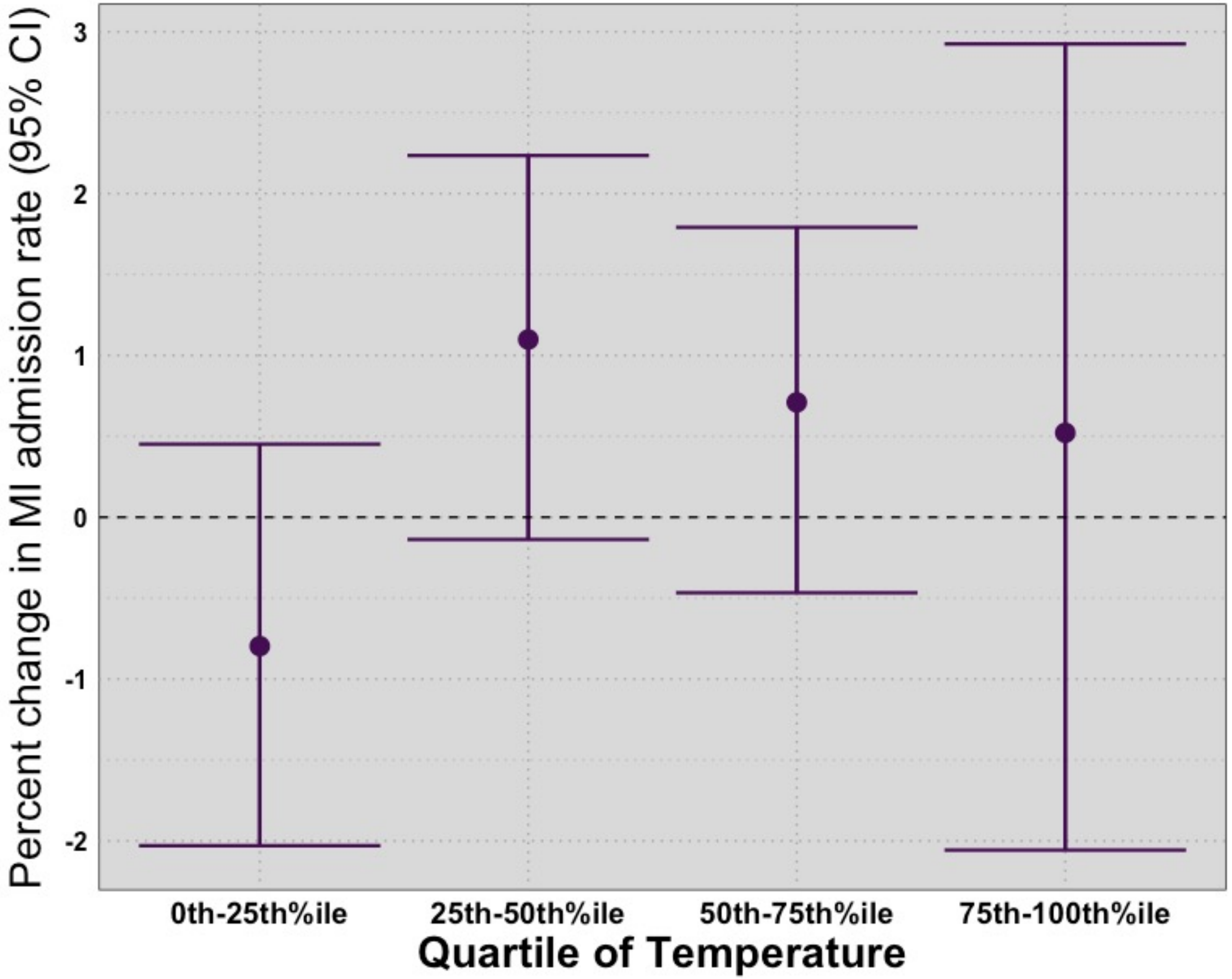
MAIN EFFECTS MODEL



Percent change in MI admission rate for each IQR increase in source-specific $PM_{2.5}$, adjusting for all covariates

EFFECT MODIFICATION BY TEMPERATURE

- Only crustal dust showed borderline evidence of interaction with same-day temperature ($F_3 = 2.0795$, $p = 0.0991$)
- Possible artifact of indoor vs. outdoor exposure and ventilation
- Reduced statistical power for interaction analysis



DISCUSSION AND CONCLUSIONS

- Nitrate, crustal dust, and industrial sources of $PM_{2.5}$ were associated with increased MI admissions rate
- Previous studies have found traffic to be associated with cardiovascular risk, but we did not[1]
- Nitrate may be associated with either local or regional sources, and is likely related to agricultural emissions[2]
- Both crustal dust (silicon and aluminum)[3] and industrial components (nickel, zinc, chromium, lead)[4] contain chemical constituents that have been previously found to be associated with CV risk
- Future studies should consider assessing for potential effect modification by temperature

1. Rich DQ et al. Triggering of cardiovascular hospital admissions by source specific fine particle concentrations in urban centers of New York State. Environ Int. 2019
2. Zhou C et al. Ambient Ammonia Concentrations Across New York State. J Geophys Res Atmospheres. 2019..
3. Becker S et al.. Seasonal variations in air pollution particle-induced inflammatory mediator release and oxidative stress. Environ Health Perspect. 2005.
4. Huang W et al. Seasonal Variation of Chemical Species Associated With Short-Term Mortality Effects of $PM_{2.5}$ in Xi'an. Am J Epidemiol. 2012.. .

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