Long-term $PM_{2.5}$ Components Exposures and Cause-specific Mortality in a U.S. Medicare Cohort

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INTRODUCTION

By the year 2030, an estimated 72 million people (1 out of every 5 Americans) will be over the age of 65 and chronic diseases like heart disease, cancer, stroke and chronic lower respiratory diseases are the leading causes of morbidity and mortality in this group. More than 65% of older Americans have multiple chronic conditions, and treatment for this population accounts for 66% of the country's health care budget.

Environmental exposure to air pollution causes inflammation, oxidative stress, and pulmonary and vascular dysfunction. There is consistent evidence that older people are more vulnerable to air pollution than younger people therefore they have higher risk of developing chronic diseases due to the air pollution exposure. This will increase the cost of health care and risk of death for this population.

Associations have been found between particulate matter (PM) and adverse health effects in many toxicological and epidemiological studies. PM is not a single specific chemical entity and it has different components which could differ regionally. It is not well understood whether some components of PM have greater contribution on adverse health effects than others. Since different components can come from different sources, answering this question can help us to identify the most influential components and control their emission sources.

In this project we examined the association between long-term PM components exposures and all-cause and cause-specific mortality such as cardiovascular, respiratory and cancer mortality in a cohort of more than 8 million Medicare beneficiaries living across the conterminous US between 2000 and 2008, control for confounders, and as modified by region of residence.

METHODS

Study Population

Medicare Enrollees aged between 65 and 120.

Residing in conterminous US between 2000-2008

Mortality Assessment

Mortality from major causes (**Table 1**) using ICD–9 codes from National Death Index

Exposure Assessment

12 month moving average of daily $PM_{2.5}$ components concentrations

$PM_{2.5}$ on 6x6 km grid using spatio-temporal models

Statistical Analysis

Medicare beneficiaries matched based on geographic centroid of their residential ZIP code, which had to be ≤6 mi radius of valid EPA AQS monitor

Association of long-term $PM_{2.5}$ components and cause-specific mortality examined using log-linear regression models (**Figure 1**)

Sensitivity analyses

- Adjusted for (1) $PM_{2.5}$ for components without multicollinearity (**Figure 3 and 4**); (2) Ecologic covariates from the 2000 U.S. Census; (3) monthly county-level prevalence of current smokers, diabetics, heavy drinkers (>two drinks per day), asthma and body mass index from BRFSS
- Modified by (1) region (**Figure 5**)

Table 1. Number of monitors, enrollees, and deaths by cause, US 2000-2008.

Characteristics (ICD–9)	$_{25th}$ Median $_{75th}$	Total Number (%)
Monitoring stations		312
Medicare enrollees	$_{1,759}$ 9,969 $_{48,464}$	8,173,355
All-Cause deaths	$_{185}$ 2,191 $_{7,475}$	1,633,409
Cardiovascular (I00-I99)	$_{83}$ 1,015 $_{2,744}$	652,139 (39.9)
Respiratory (J00-J99	$_{36}$ 302 $_{789}$	175,202 (10.7)
Cancer (C-D)	$_{50}$ 572 $_{1,703}$	367,063 (22.5)

RESULTS

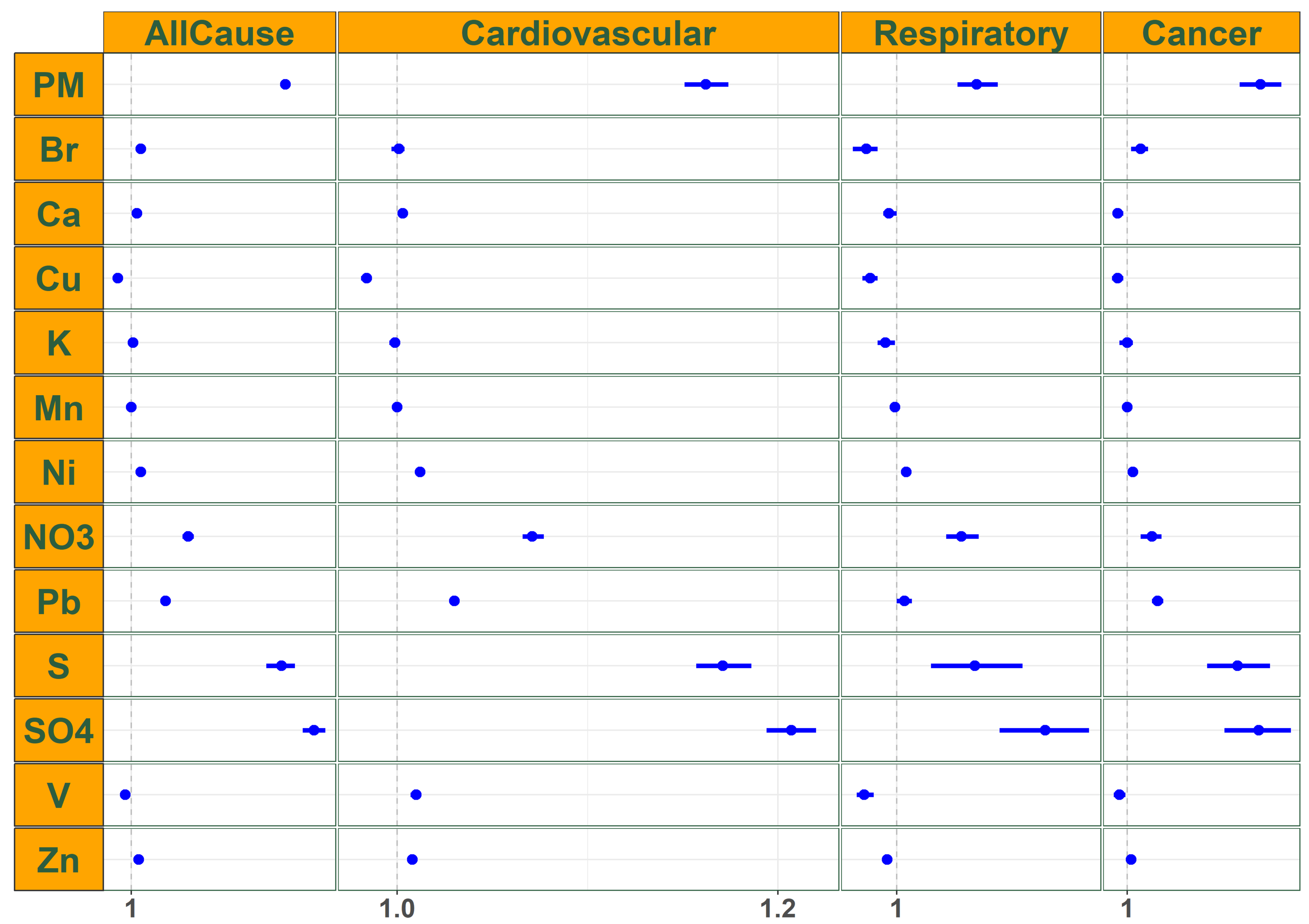

Figure 1. Mortality risk ratios (95% CI) associated with IQR increase in 12-month moving average of $PM_{2.5}$ and each $PM_{2.5}$ components: by cause of death, US 2000 – 2008

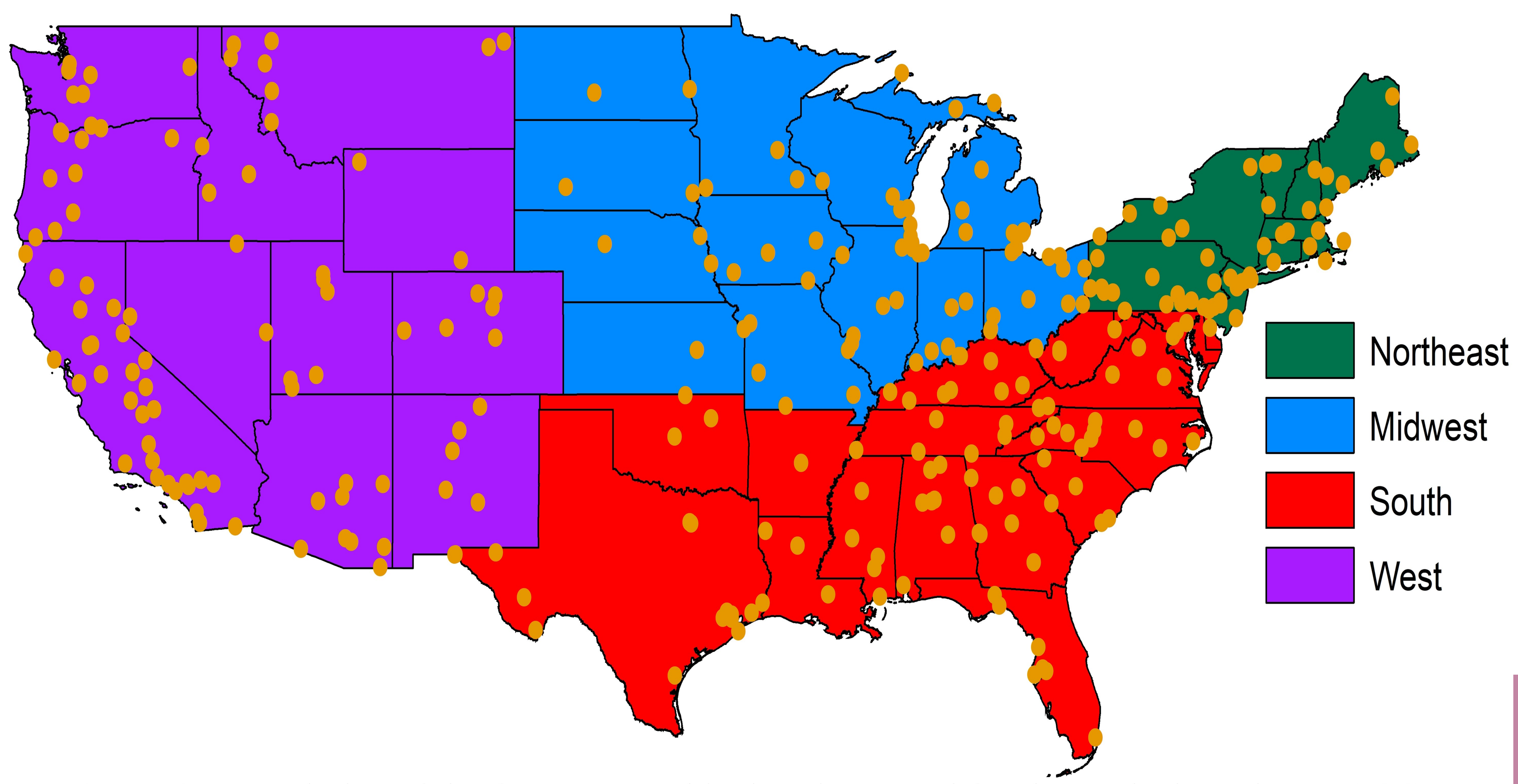

Figure 2. Boundaries of the four geographical regions used for the analysis and EPA AQS $PM_{2.5}$ components monitoring site across the US.

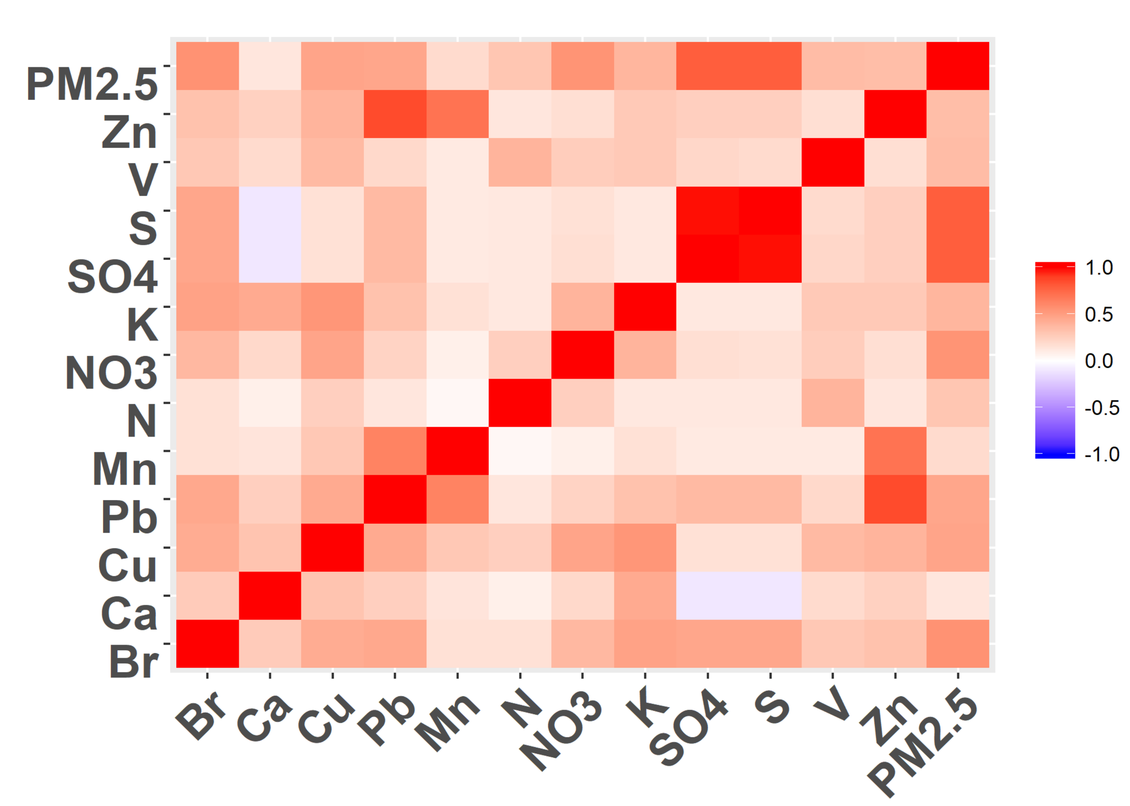

Figure3. Pearson Correlation

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Dec2018, Environmental Data visualization, CEE Department

Data Sources Information:

- USEPA
- BRFSS
- United States Census Bureau
- Centers for Disease Control and Prevention
- Centers for Medicare and Medicaid Services

DATALAB

INNOVATE, ANALYZE, VISUALIZE

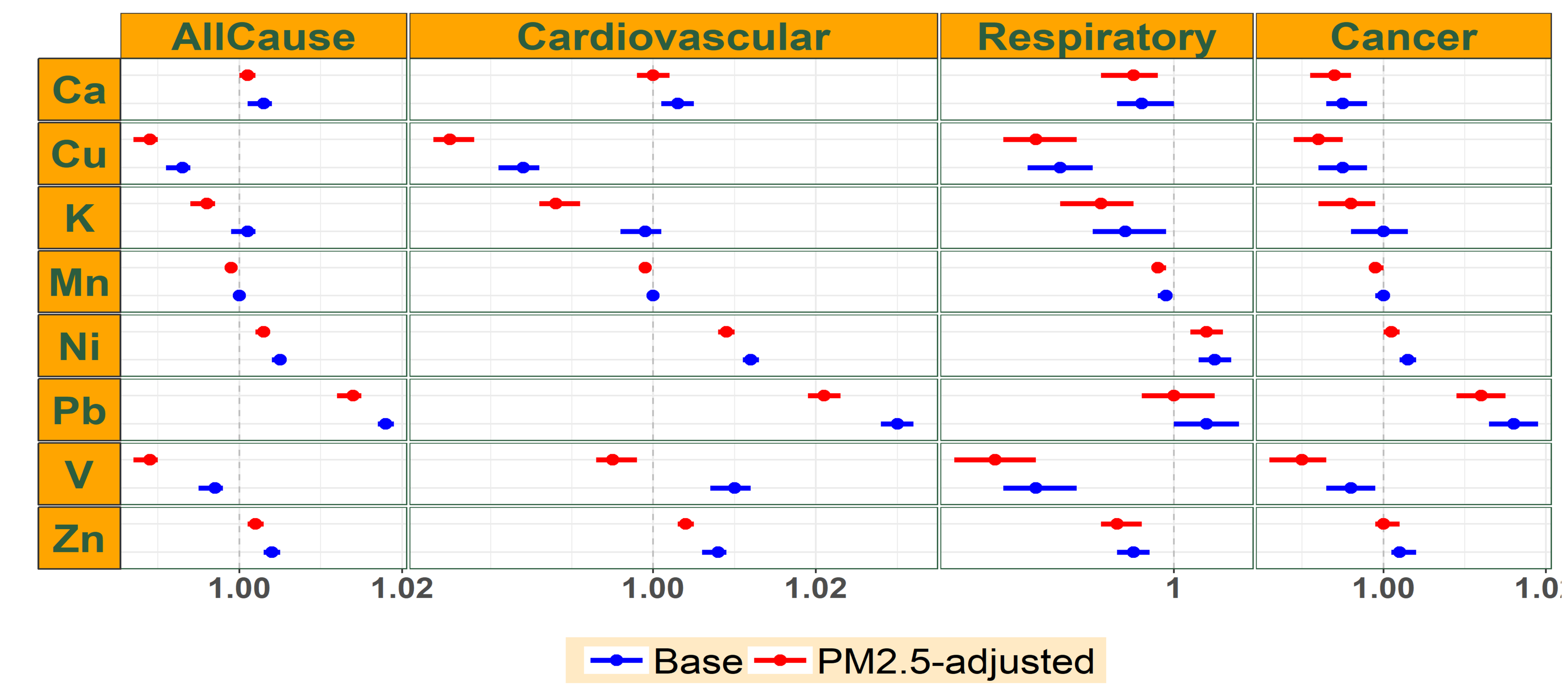

Figure 4.Mortality risk ratios (95% CI) associated with IQR increase in 12-month moving average of $PM_{2.5}$ component: by cause of death, base versus $PM_{2.5}$-adjusted model, US 2000 – 2008.

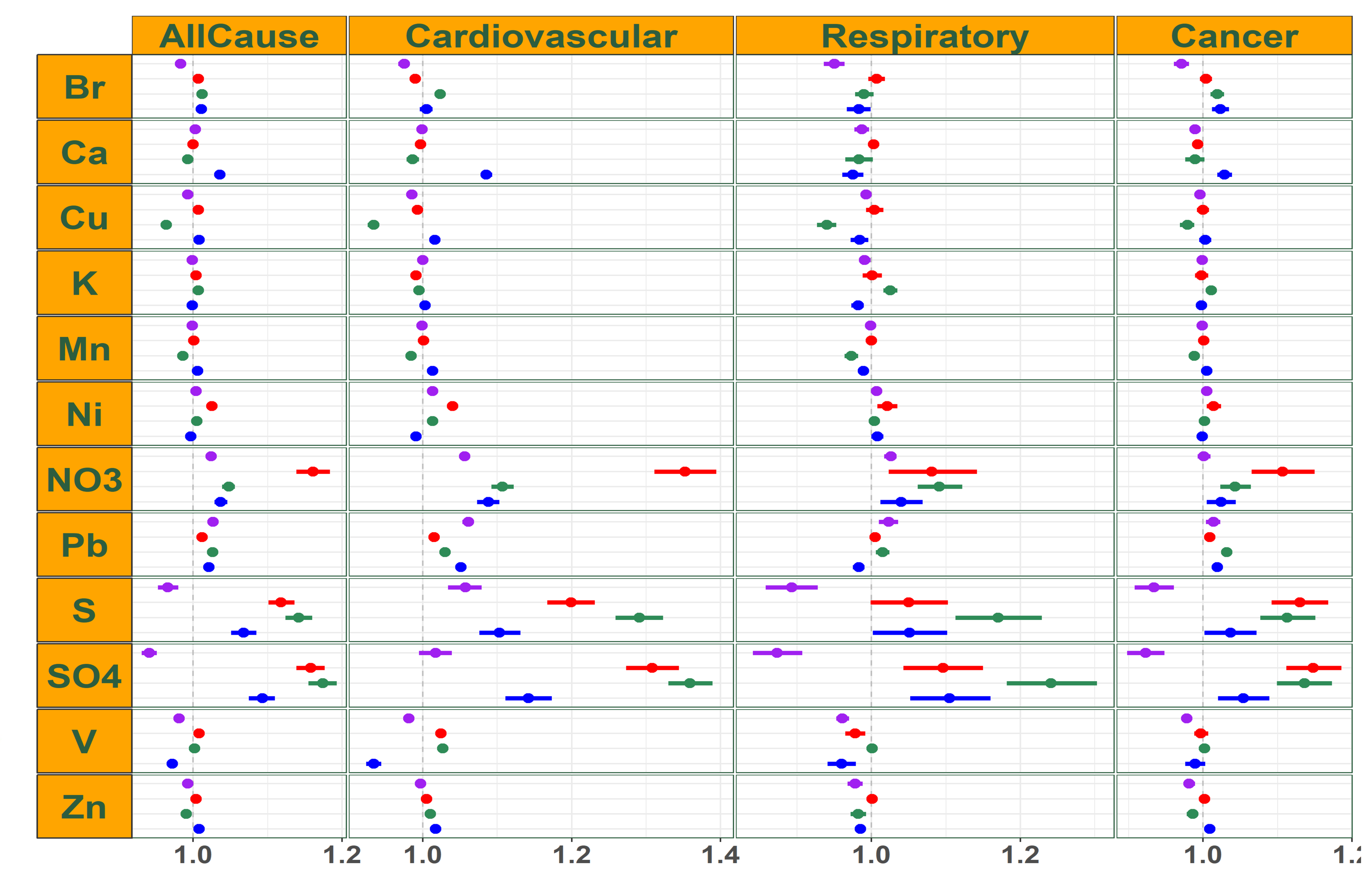

Figure 5. Mortality risk ratios (95% CI) associated with IQR increase in 12-month moving average of $PM_{2.5}$ component: by region and cause of death, US 2000 – 2008.

CONCLUSION

- In a cohort of over 8 million Medicare beneficiaries, we found consistent, significant associations of long-term $PM_{2.5}$ and several of its components exposures and increased mortality.
- Our findings showed that SO_4 had the highest risk ratio compared to other components. We found robust, significant increases in SO_4-associated RRs for mortality from cardiovascular, respiratory and cancer-related diseases, with these associations robust to adjustment by ecological, and behavioral covariates.
- We found that for all causes of death in this study and all components, $PM_{2.5}$-adjusted models had lower risk ratios compared to the single pollutant model of each component.
- We showed that for all causes of death, component-associated mortality risks differed by region with the highest RRs found in the Northeast and South
- We can identify the source of most harmful components (like combustion, fossil fuels, …), limit their usage and replace them with clean energy.
- For future research we could assess the consistency of these associations across different exposure windows (12- to 60-month moving averages) and examine whether associations differed by urbanicity