Impact of ambient fine particulate matter carbon measurement methods on observed associations with acute cardiorespiratory morbidity

Jay Turner; Washington University in St. Louis
Andrea Winquist, Mitchel Klein, and Stefanie Sarnat; Emory University
James Schauer; University of Wisconsin - Madison

From: G. Gordon and W. Keifer (1980) The Delicate Balance: An Energy and the Environment Chemistry Module, Harper & Row, New York.

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Photo: Varun Yadav

Motivation

- **First Study*:** $PM_{2.5}$ components and emergency department visits for cardiovascular and respiratory diseases in St. Louis Missouri-Illinois metropolitan area
- St. Louis – Midwest Supersite measurements, June 2001 – April 2003
- Time series analysis using daily data for air quality and emergency department visits at 36 of 43 acute care hospitals in the area

* S.E. Sarnat, A. Winquist, J.J. Schauer, J.R. Turner and J.A. Sarnat (2015) *Environ. Health Perspec., 123*, 437-444.

Air Quality Parameters

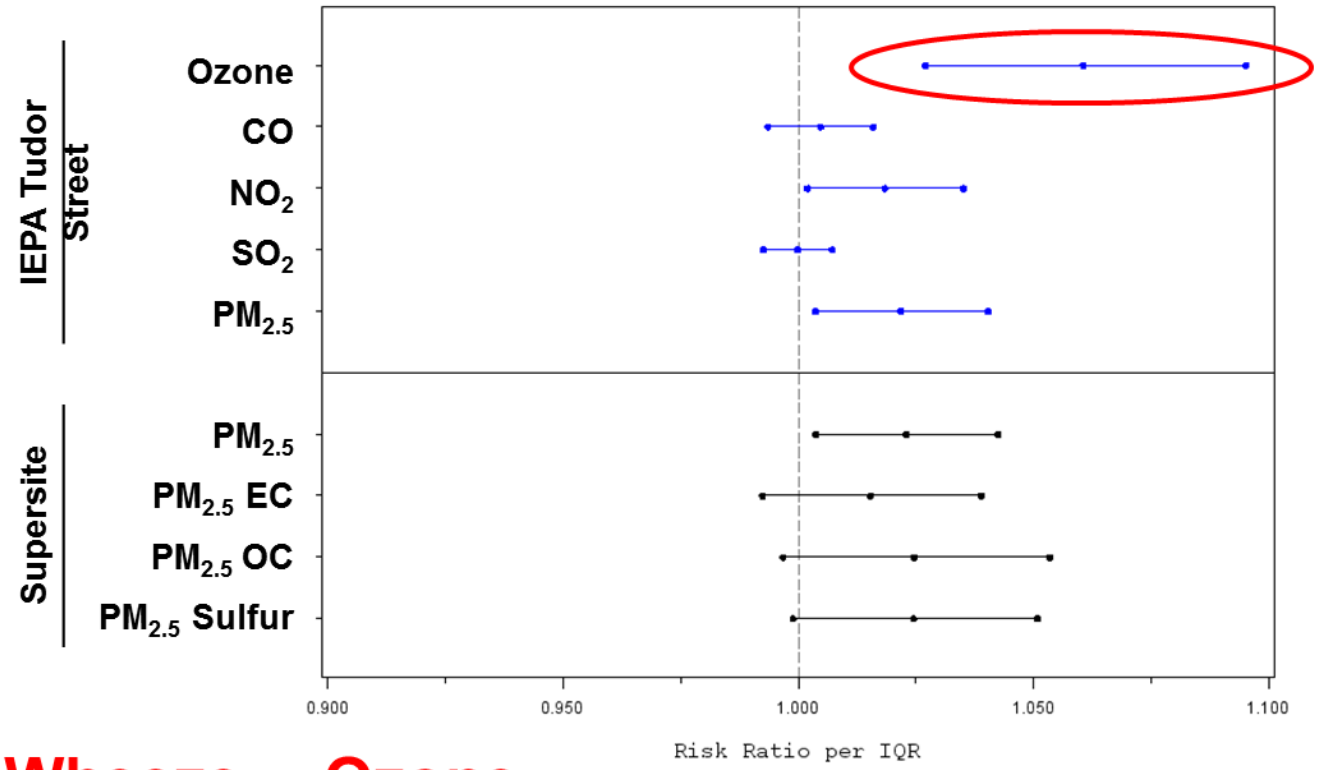
- 24-hour integrated $PM_{2.5}$
  - Gravimetric mass
  - Major ions (SO_4, NO_3)
  - Carbon (EC, OC by NIOSH / ACE-Asia protocol)
  - Organic Speciation: *n*-alkanes (2), hopanes (2), PAHs (4)
  - Metals and metalloids (Si, K, Ca, Fe, Cu, Zn, Pb)
- Criteria Gases (Illinois EPA East St. Louis station)
  - 8-hr max O_3
  - 1-hr max CO, NO_2, SO_2

Hospital Admissions Type

- Cardiovascular Diseases (CVD)
  - Ischemic Heart Disease
  - Dysrhythmia
  - Congestive Heart Failure (CHF)
- Respiratory Diseases (RD)
  - Pneumonia
  - Chronic Obstructive Pulmonary Disease (COPD)
  - Asthma/Wheeze

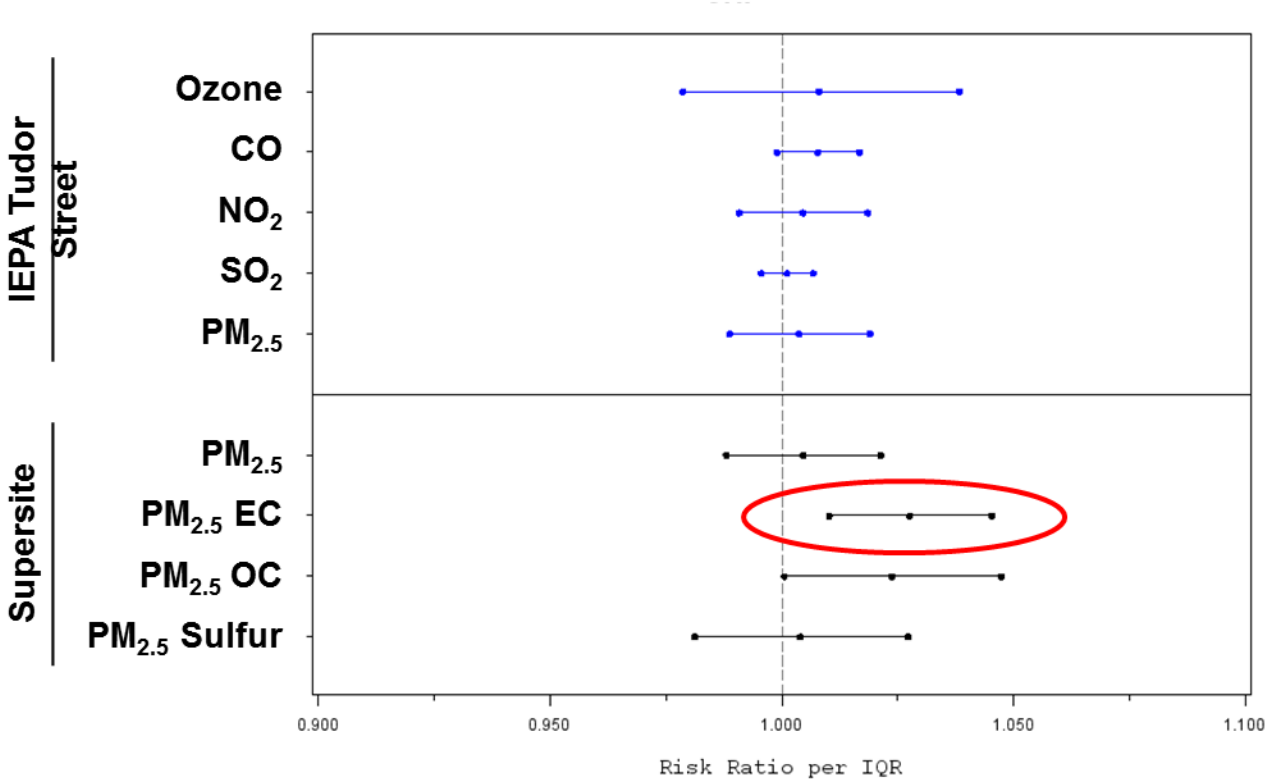
Asthma & Wheeze

Risk Ratio per Interquartile Range of pollutant concentration… if bar is entirely to the right of this arrow then the association is statistically significant (95% C.L.)



Asthma & Wheeze… Ozone

Congestive Heart Failure



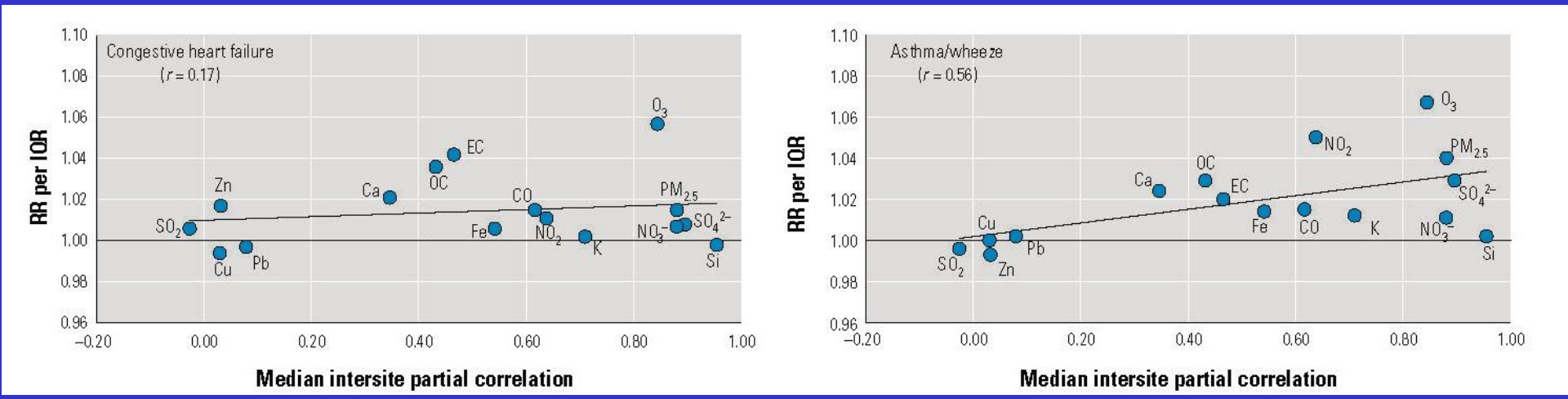
Congestive Heart Failure… Soot (Elemental Carbon)

Key Findings

- Robust associations for:
  - CVD and 17α(H),21β (H)-hopane
  - CHF and Elemental Carbon (EC)
  - RD and O_3
  - Asthma/Wheeze and O_3, NO_2, $PM_{2.5}$

- Used St. Louis area SLAMS data with Supersite data to assess spatial variability
  - Rate ratios for components with high spatial variability may be biased towards the null

Rate Ratios and Partial Correlation

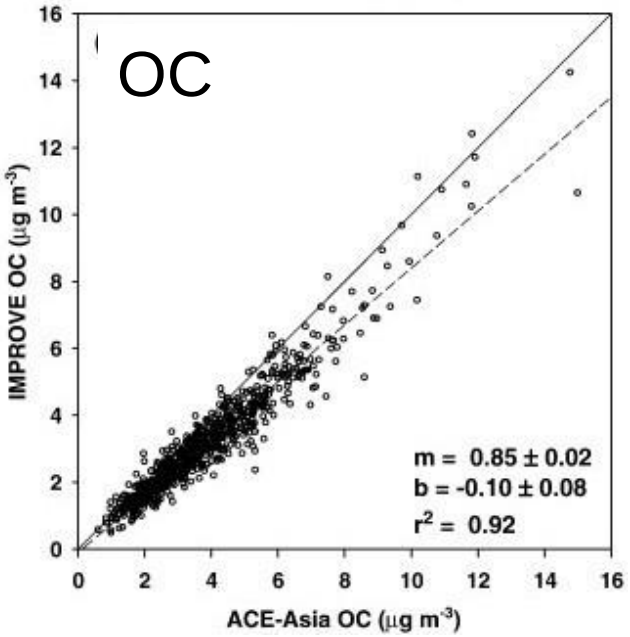


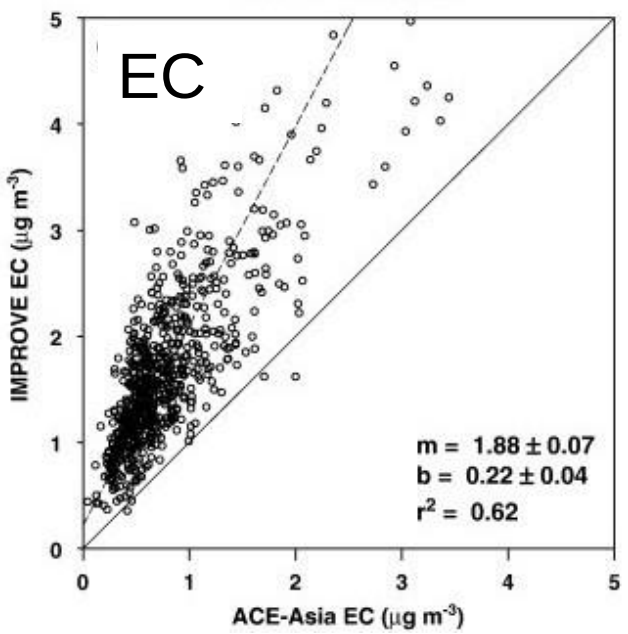
- Asthma/Wheeze
  - Components with highest RR were also most correlated across sites
- Congestive Heart Failure
  - No relationship between strength of association and spatial correlation

St. Louis – Midwest Supersite $PM_{2.5}$ Carbon Measurements

- 5-minute Aethalometer Black Carbon (BC) and UV-absorbing carbon (UV-C)
- Hourly EC and OC (Sunset labs analyzers)
- Daily 24-hour integrated filters (U. Wisconsin sampler)
  - Organics speciation by extraction-GCMS (1-in-6 day)
  - Organics speciation by thermal desorption-GCMS (remaining days)
  - EC/OC using NIOSH analysis protocol
  - EC/OC using IMPROVE analysis protocol

OC and EC by Method





Objective of Second Study*

- Examine associations between PM components and emergency department visits
- Focus on comparison of results using EC and OC from the NIOSH and IMPROVE analysis methods

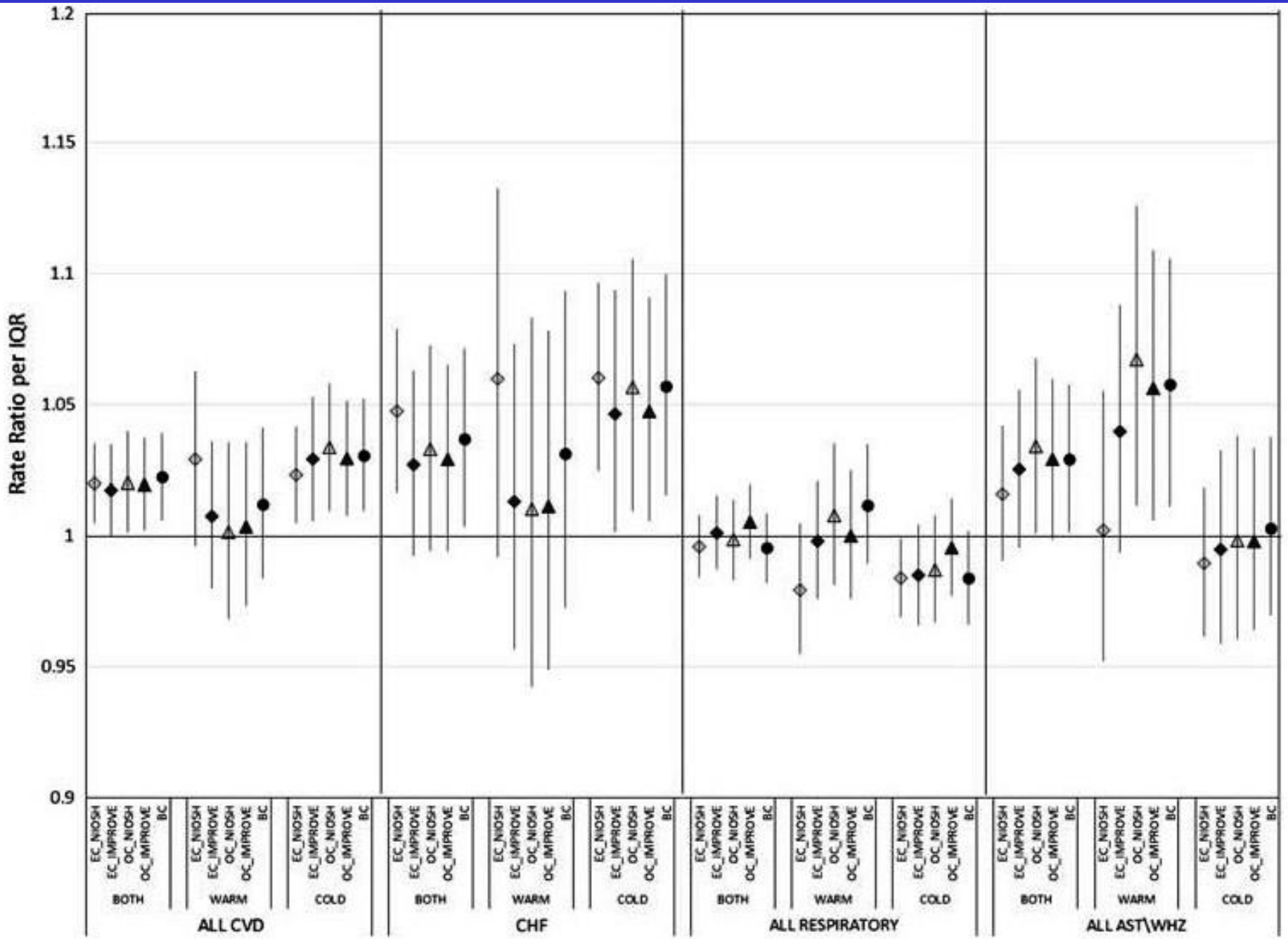
i.e. does the carbon analysis method matter?

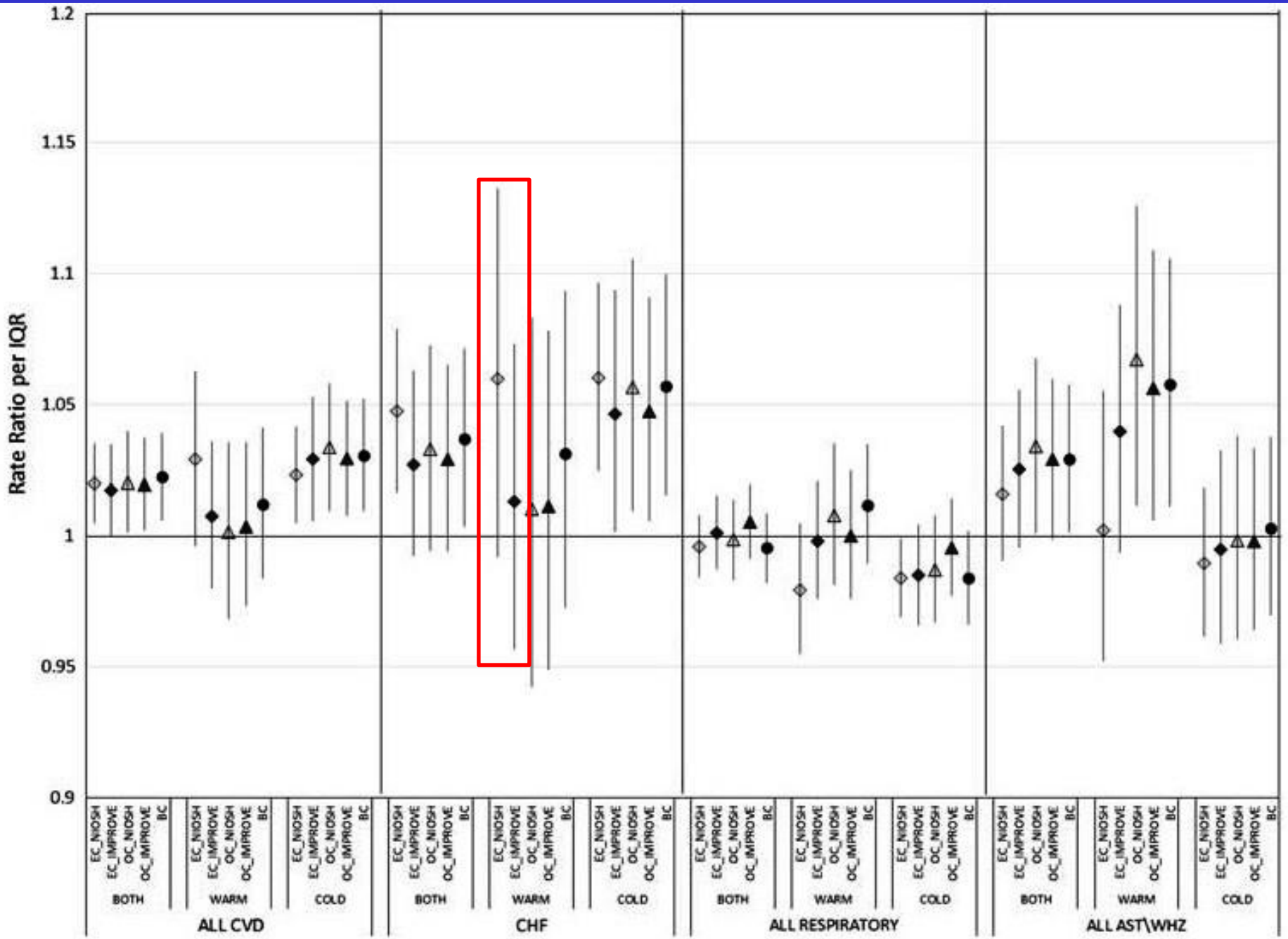
* A. Winquist, J.J. Schauer, J.R. Turner M. Klein and S.E. Sarnat (2015) *J. Exposure Sci. Environ. Epi., 25*, 215-221.

Pearson Correlation Coefficients

Method	EC-N	EC-I	OC-N	OC-I	BC
EC NIOSH (EC-N)	1.00				
EC IMPROVE (EC-I)	0.78	1.00			
OC NIOSH (OC-N)	0.64	0.81	1.00		
OC IMPROVE (OC-I)	0.63	0.78	0.95	1.00	
Aethalometer BC	0.77	0.85	0.81	0.80	1.00

In St. Louis, BC may be an indicator of both EC and OC, and not EC only


Rate Ratio per IQR
1.2
1.15
1.1
1.05
1
0.95
0.9
EC_NIOSH
EC_IMPROVE
OC_NIOSH
OC_IMPROVE
BC
BOTH
WARM
COLD
ALL CVD
CHF
ALL RESPIRATORY
ALL AST\WHZ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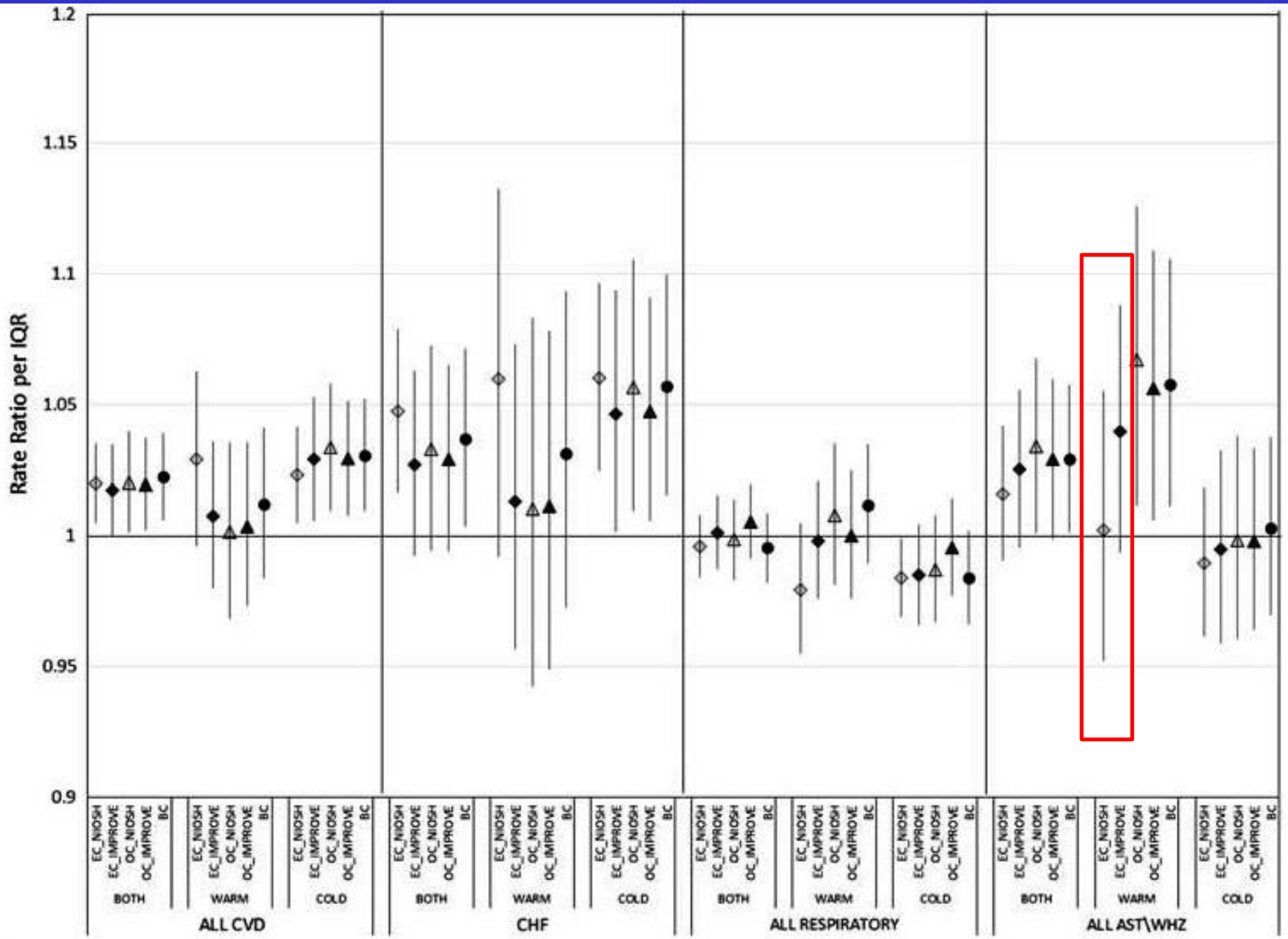
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Key Findings & Summary

- Associations generally concordant when using EC and OC measures from NIOSH and IMPROVE
  - Confidence intervals for the rate ratios overlap
- Some evidence of differences between methods
  - Associations between CHF and EC stronger for NIOSH than for IMPROVE (warm season)
  - Associations between Asthma/Wheeze and EC stronger for IMPROVE than for NIOSH (warm season)
  - Differences in associations could be because of chance, or may arise from differences in the composition of the PM assigned as EC and OC

Acknowledgements

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  - USEPA Supersites Program, USEPA Region VII
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