“State of the Science” of Acute Air Pollution Health Effects Research

George Thurston and Kazuhiko Ito
NYU School of Medicine

For Presentation at:

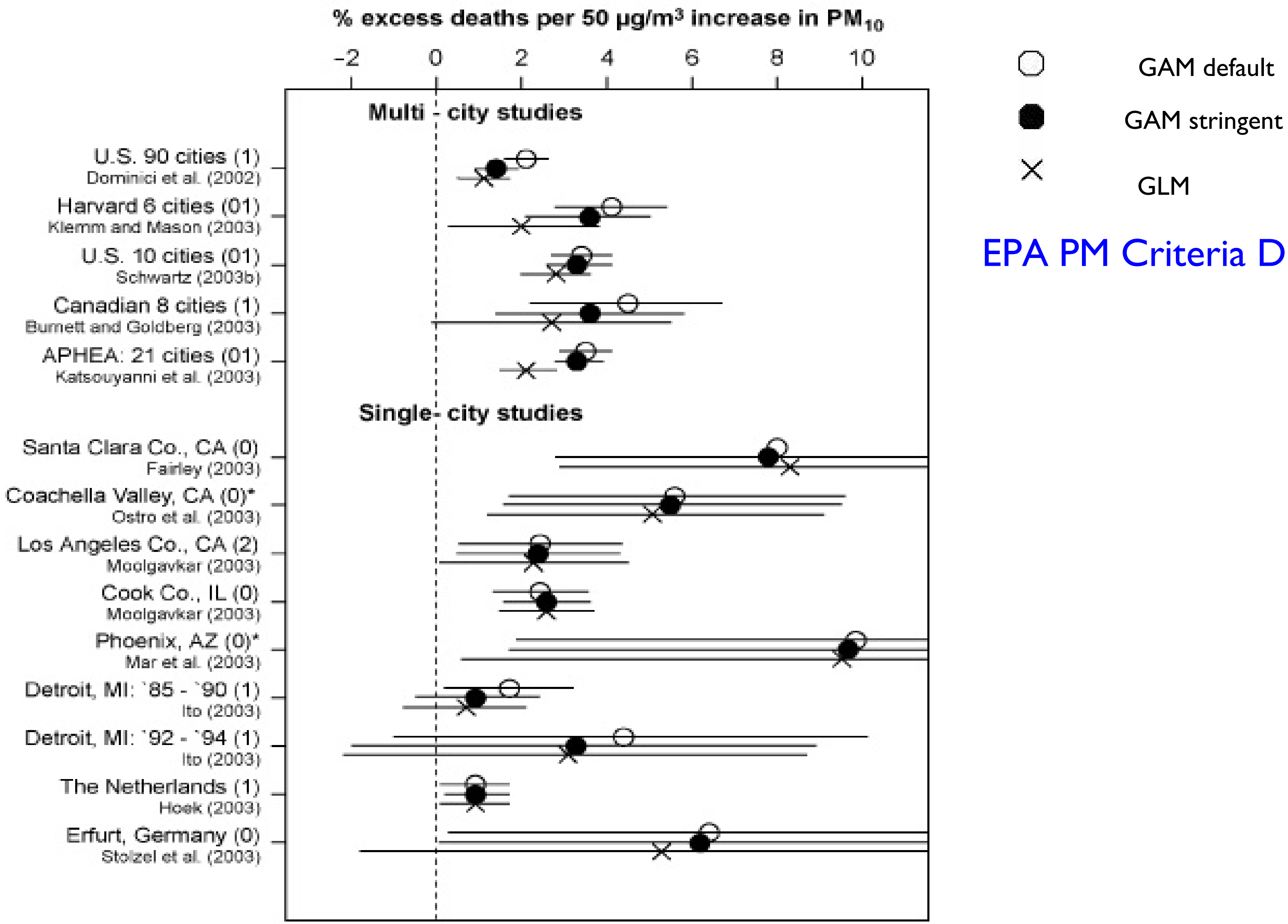
EPA and CDC
Symposium on Air Pollution Exposure and Health

Goals

- 1. What do we know about the acute air pollution health effects relationship?
  - Ozone and PM summary slides
  - Variations in Effect Estimates
- 2. What are the major outstanding data/methodological issues in resolving effect size?
  - a. Modeling Issues (Thurston)
    - -Publication Bias?
    - - Weather?
    - - Effects Lag Structure?
  - b. Exposure (Ito)
    - - PM Source/Composition Variations
    - - Spatial Variability (differential exposure misclassification?)
    - - Personal vs. Population (indoor/outdoor)
- 3. Future directions

There is no Doubt that Acute Exposures to Air Pollution are Associated with Excess Acute Mortality, But there is Still Uncertainty about the Size of the Effect:

Most Multi-City Mortality Studies Give RR Similar to Single City Studies (RR≈ .6% Per 10 *ug*/m³ PM10)

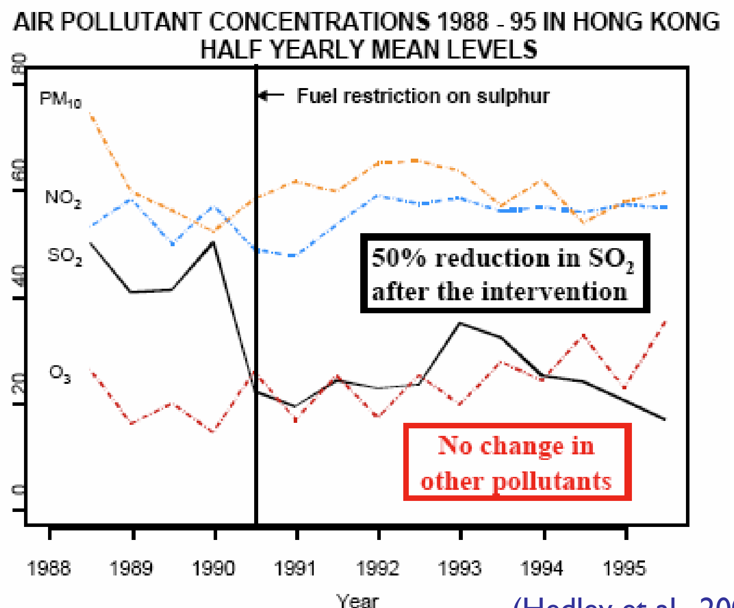


EPA PM Criteria Document, 2004

If You Clean the Air, the Adverse Health Effects Go Down

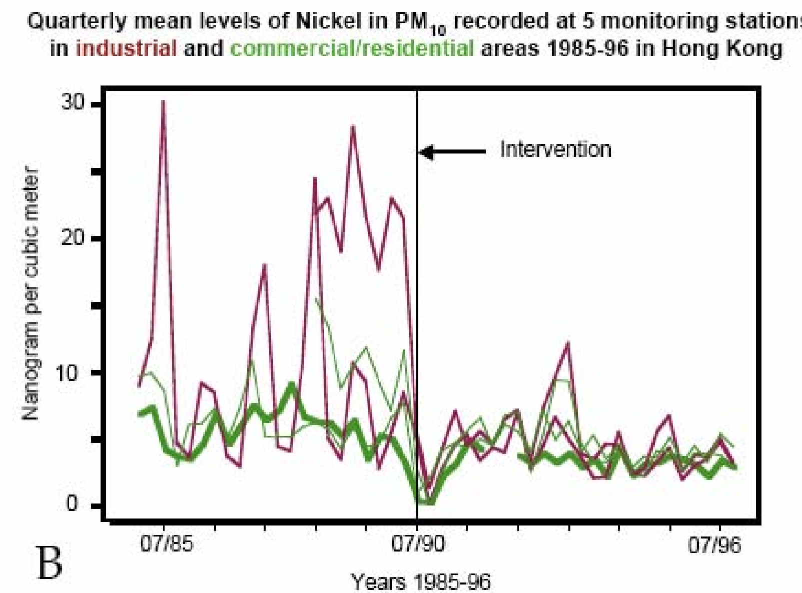
But There is Also Uncertainty As to Which Components Are Causing Greatest Effects

Example: Hong Kong Intervention Suggests Sulfur and Metals Are Important



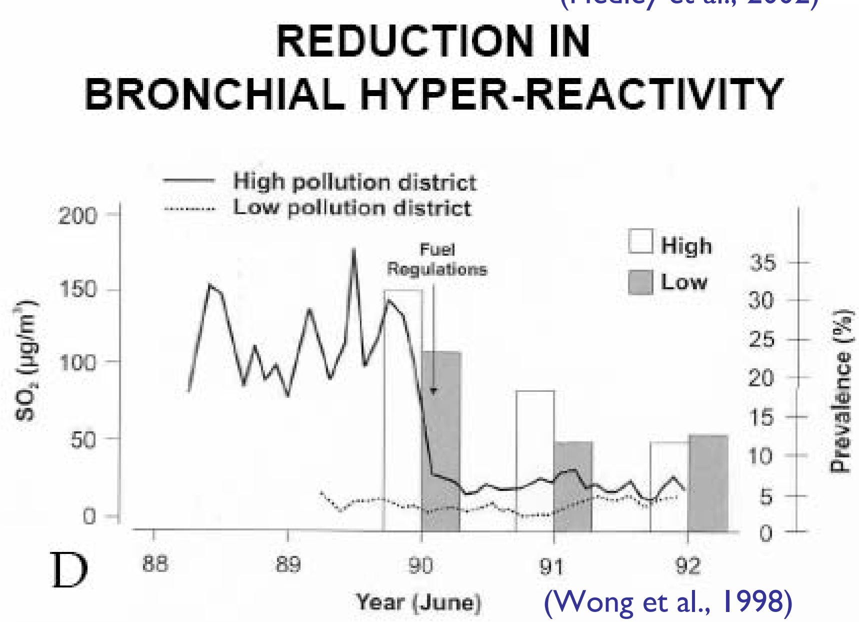
A

(Hedley et al., 2002)



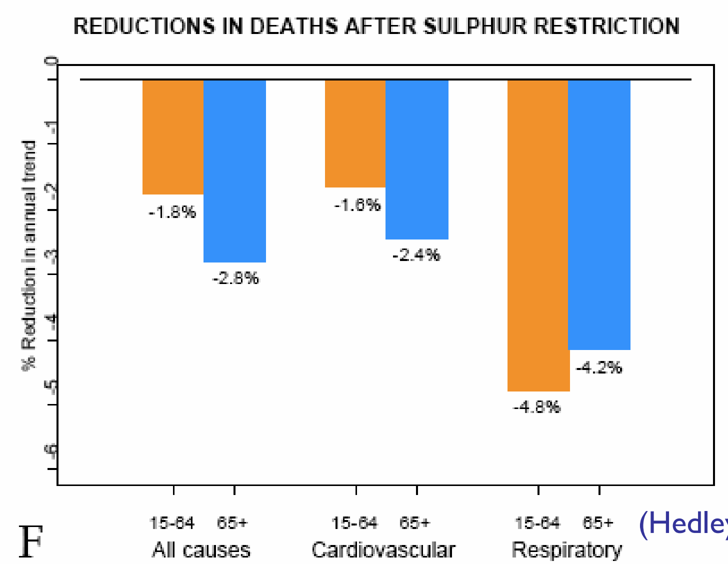
B

(Hedley et al., 2004)



D

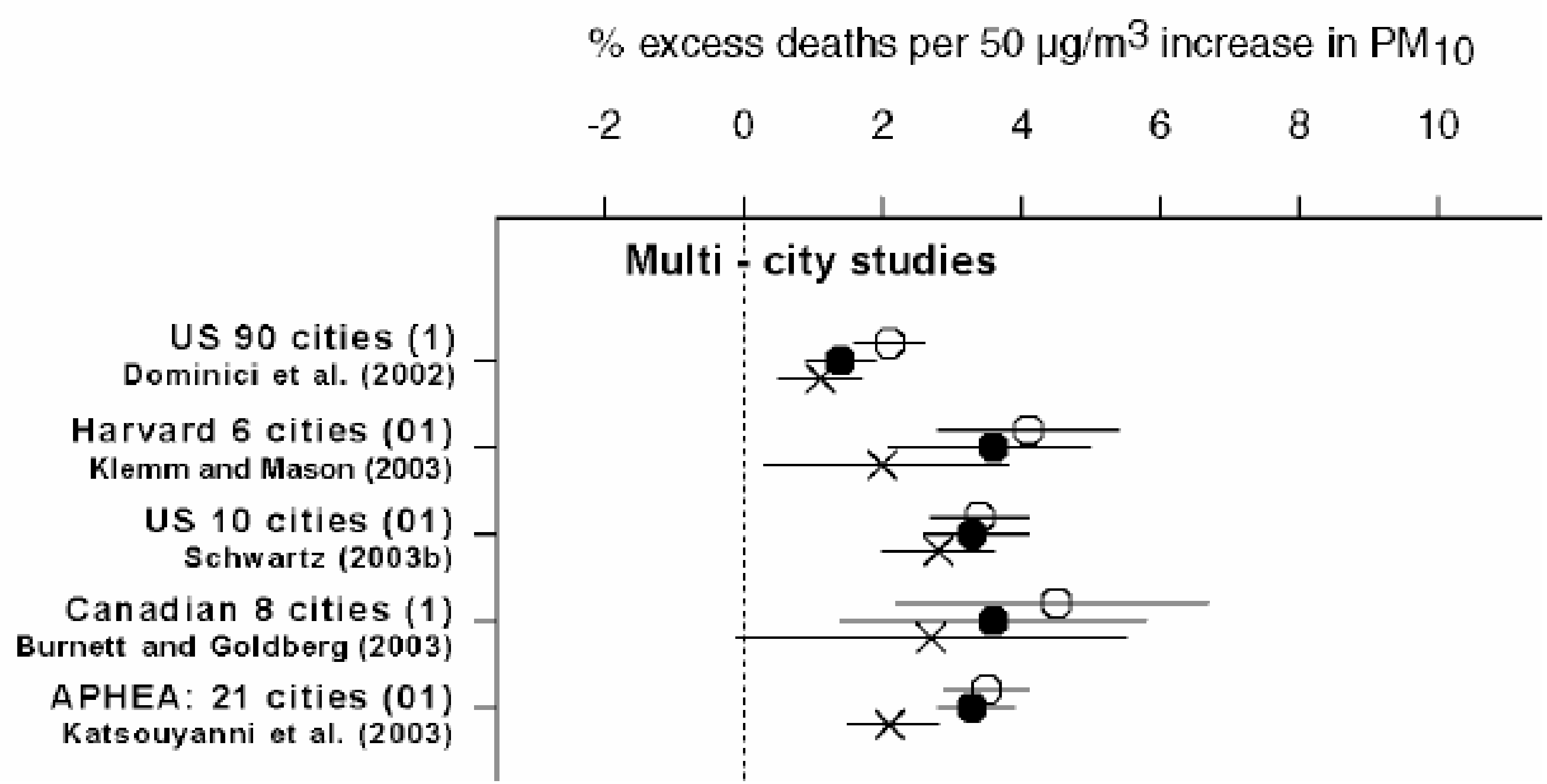
(Wong et al., 1998)



F

(Hedley et al., 2004)

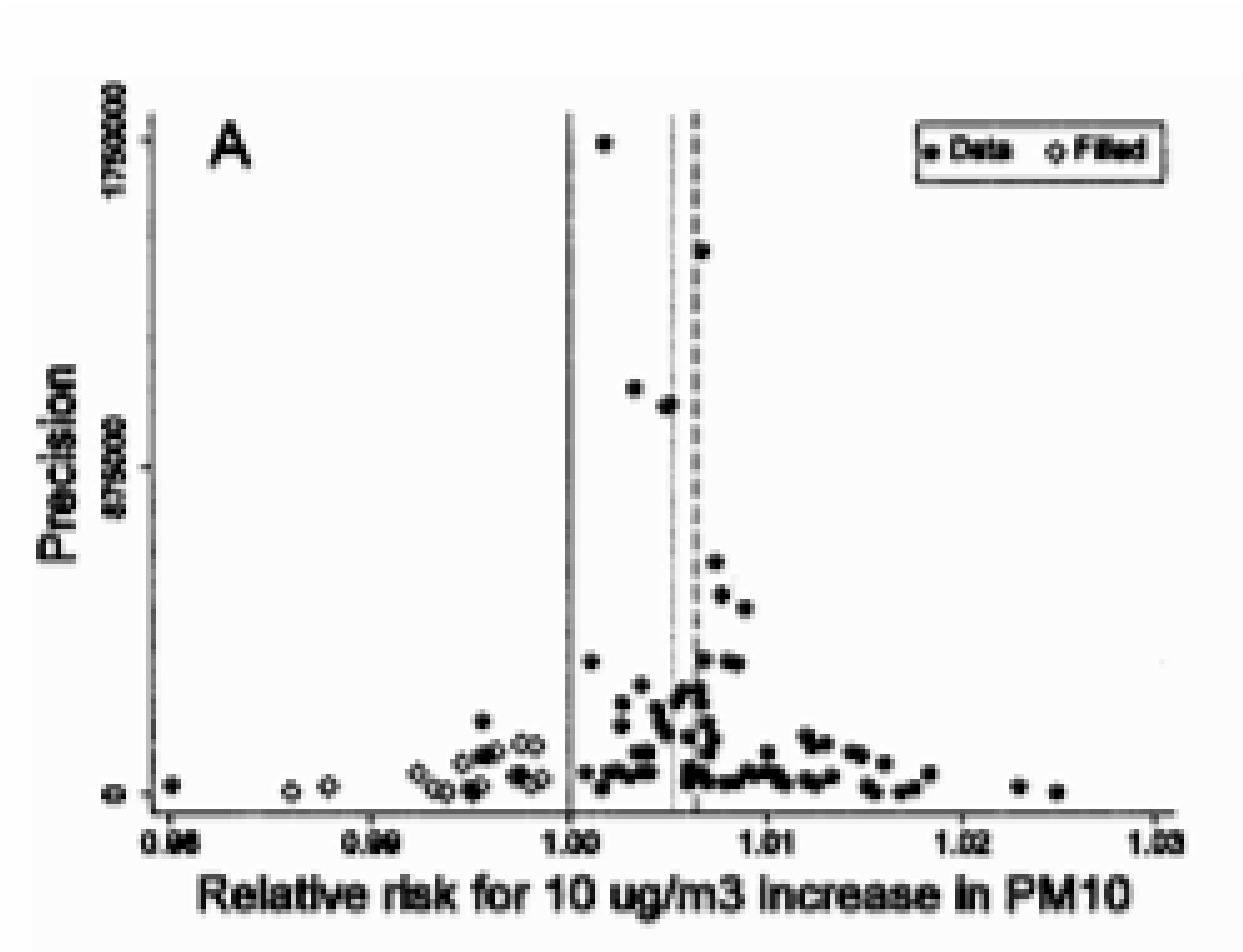
One Effect Size Question:
Why are Other Time Series Studies' RR's Almost Double that of NMMAPS?



from EPA PM Criteria Document, 2004

Is it Publication Bias?:

Anderson et al. Funnel Analyses Suggest that this Accounts for Only 17% of Difference



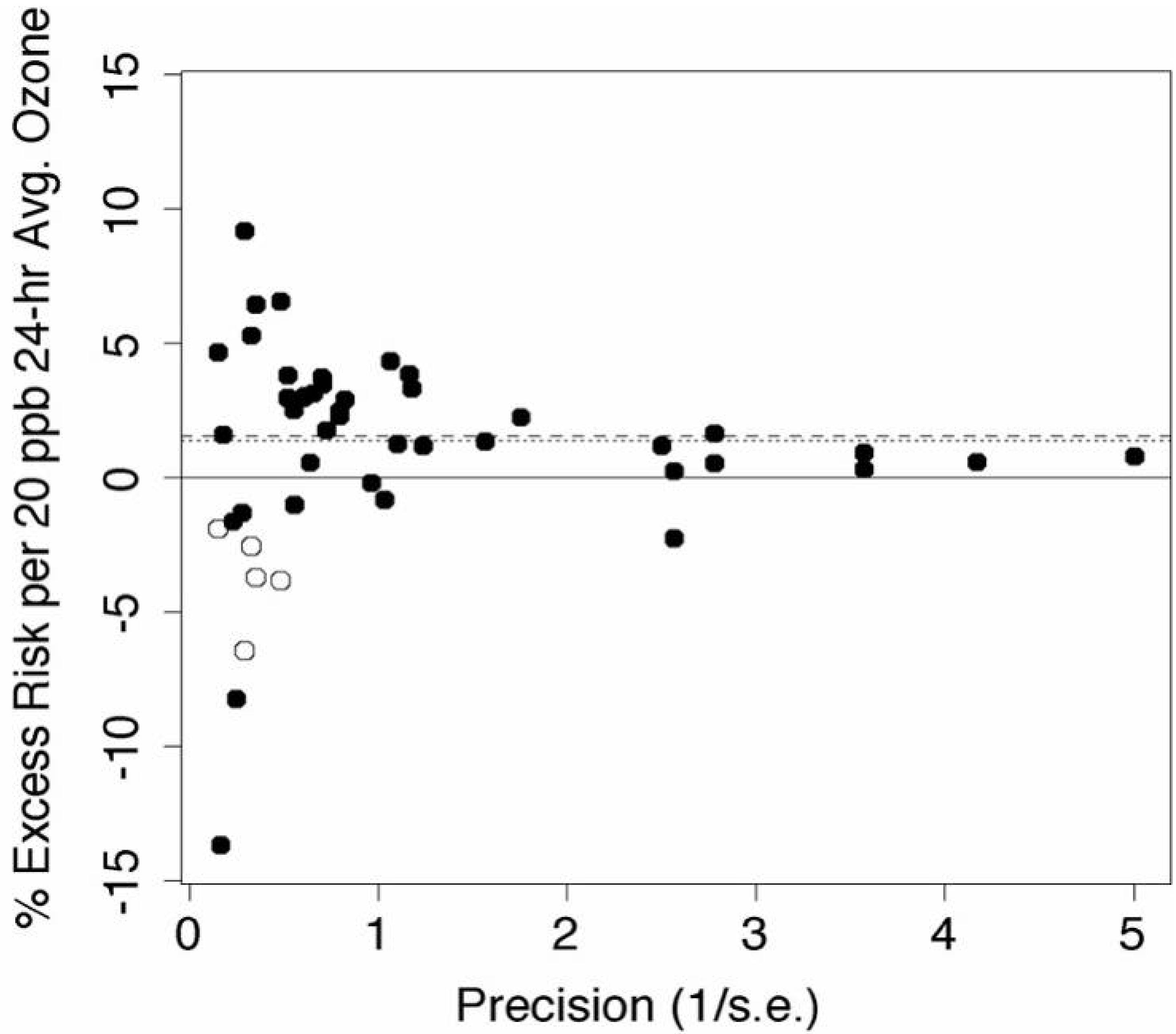
There is Also Consistency Across Recent Ozone-Mortality Meta-Analyses

Bell et al.: 0.83% (0.53% - 1.12%)
Levy et al.: 0.82% (0.62% - 1.00%)
Ito et al.: 0.80% (0.55% - 1.00%)

per 10 ppb 24-avg. ozone

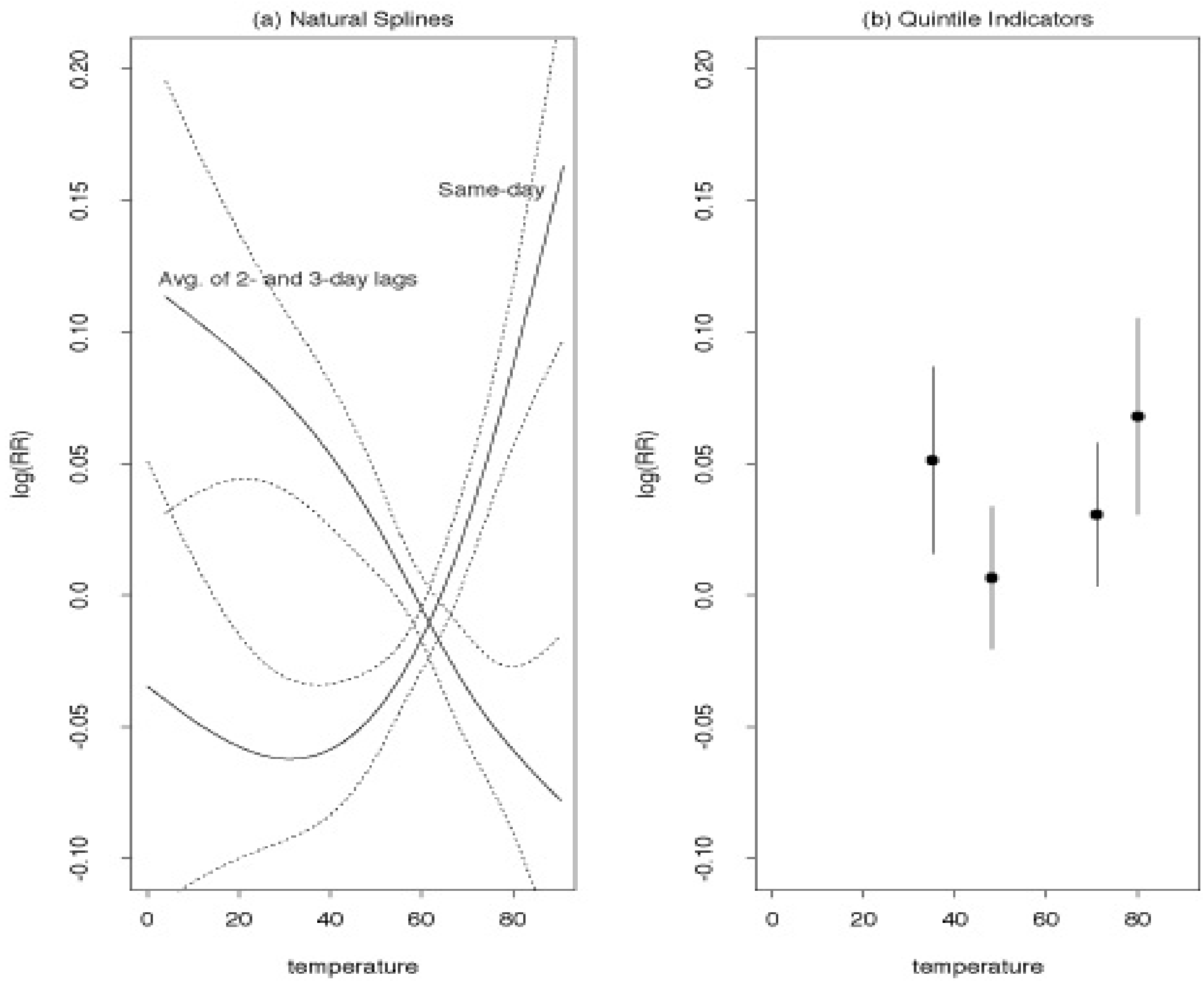
……….…*BUT* these are all larger than the Bell et al. (2004) multi-city estimate from 95 cities. Is <u>this</u> due to publication bias?

Funnel Analyses Indicate that publication bias is small for O_3-mortality studies, as well (Ito, DeLeon, and Lippmann, 2005)



Are we Correctly Adjusting for Weather Effects?

Issue: Conservative vs. Parsimonious Models



Predicted non-accidental mortality from 2 types of weather models: Philadelphia data.

Is it Choice of City-Specific Lags?:

Anderson et al. Reanalyses of NMMAPS Allowing Cities to Have Individualized Lags: Yields NMMAPS Estimates Close to Other Studies

TABLE 2. Analysis of Selective Reporting Biases Using the NMMAPS Data From 90 Cities*

Selection of Estimates	Summary Estimate† (95% CI)	Heterogeneity P Value	Percent Increase Compared With Lags 0, 1, and Lags 0, 1, and 2	Asymmetry P Value	Adjustment
Lag 0 estimates	1.003 (1.001–1.004)	$P = 0.075$	NA	$P = 0.989$	Estimate unaltered
Lag 1 estimates	1.004 (1.003–1.005)	$P = 0.385$	NA	$P = 0.235$	Estimate unaltered
Lag 2 estimates	1.003 (1.002–1.004)	$P = 0.031$	NA	$P = 0.308$	Estimate unaltered
Analysis I: choice of 2 lags (lag 0 and lag 1)					
Most statistically significant (in either direction)	1.005 (1.003–1.007)	$P < 0.001$	67%, 25%	$P = 0.487$	Estimate unaltered
Most statistically significant (in harmful direction)	1.005 (1.004–1.006)	$P = 0.496$	67%, 25%	$P < 0.001$	Estimate adjusted to 1.005 (1.003–1.006)
Analysis II: choice of 3 lags (lag 0, lag 1, and lag 2)					
Most statistically significant (in either direction)	1.006 (1.004–1.008)	$P < 0.001$	100%, 50%, 100%	$P = 0.716$	Estimate adjusted to 1.005 (1.003–1.007)
Most statistically significant (in harmful direction)	1.007 (1.006–1.008)	$P = 0.240$	133%, 75%, 133%	$P < 0.001$	Estimate adjusted to 1.006 (1.005–1.008)

*Unpublished data provided by Dominici et al.
†Estimates are relative risks for a 10 $\mu g/m^3$ change in pollutant.

Does Choosing Best Lag Under or Overestimate Total Effect?

Schwartz (2003) Analyses Indicated the Choosing only the 0-1Day Average Lag Underestimates the Total Distributed Lag RR

Table 2. Association Between PM_{10} (mean of lag 0 and lag1) and Daily Deaths in 10 US Cities: Analyses Stratified by Season (warm vs cold)

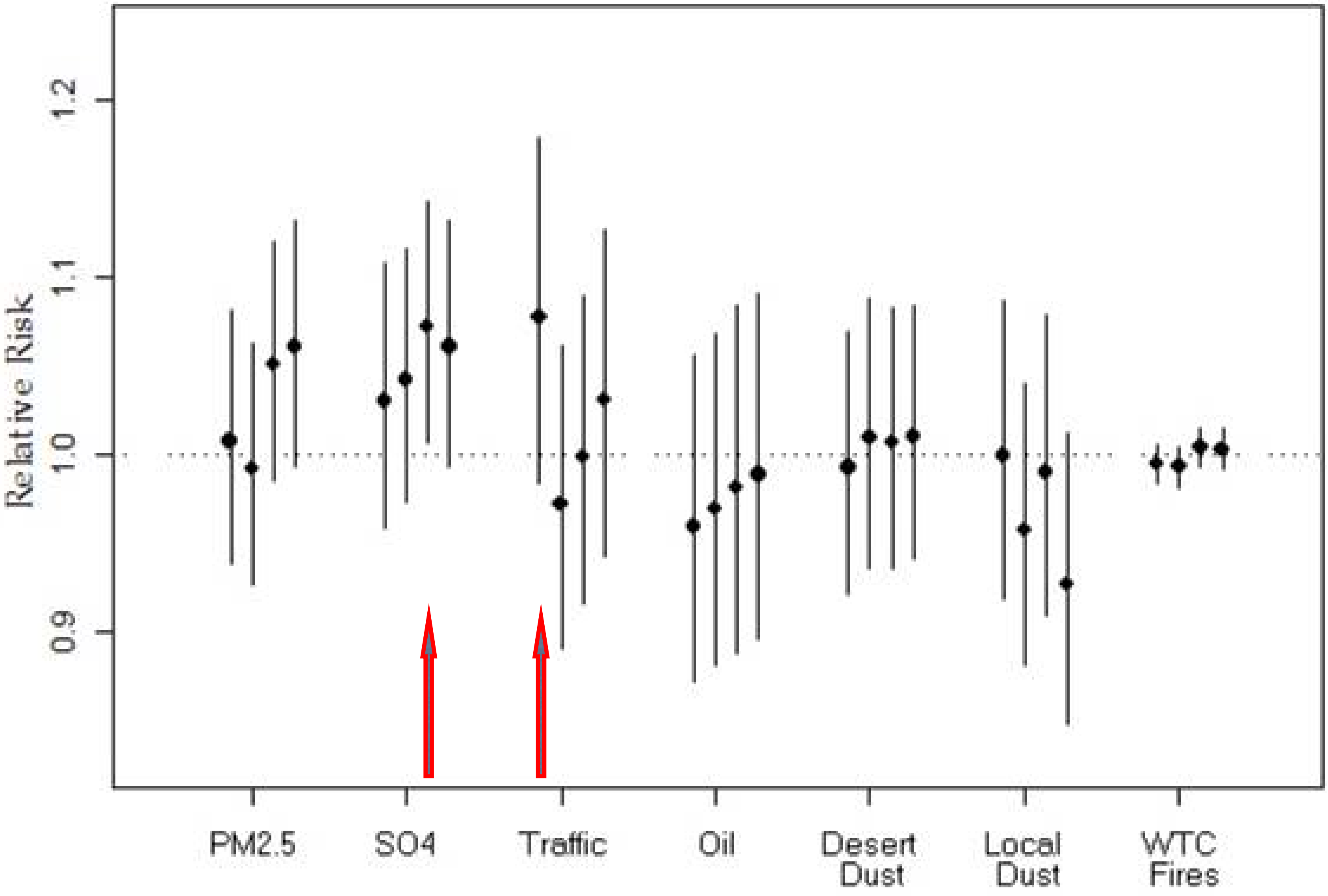
Model	Old GAM		New Convergence		Natural Splines	
	Percentage Increase in Deaths	95% CI	Percentage Increase in Deaths	95% CI	Percentage Increase in Deaths	95% CI
Overall	0.67	0.52, 0.81	0.66	0.52, 0.80	0.55	0.39, 0.70

Table 3. Distributed Lag Between Air Pollution and Daily Deaths in 10 US Cities

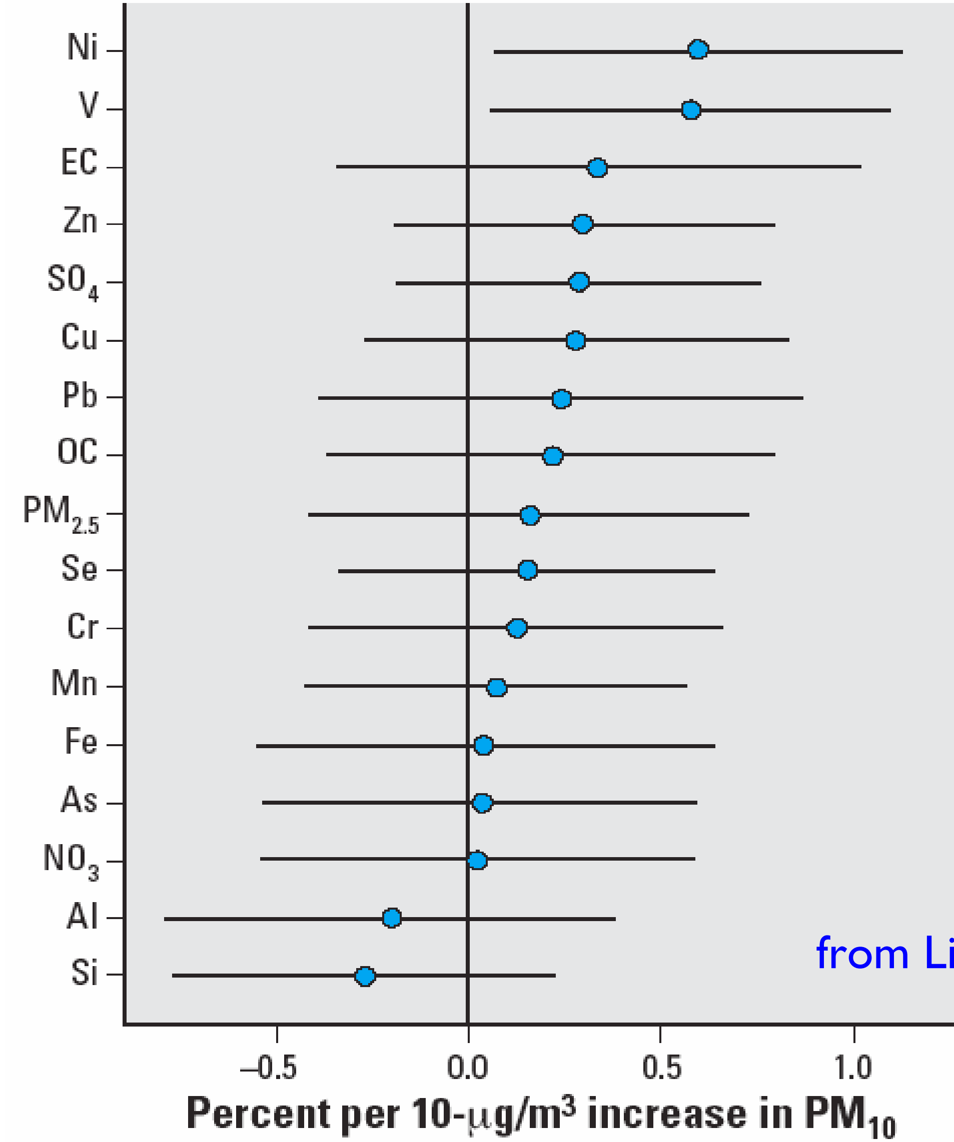
City	Old GAM		New Convergence		Penalized Splines	
	Quadratic Distributed Lag	No Constraint	Quadratic Distributed Lag	No Constraint	Quadratic Distributed Lag	No Constraint
New Haven	1.85 (0.72)	1.80 (0.79)	1.79 (0.58)	1.77 (0.79)	1.88 (0.64)	1.78 (0.85)
Birmingham	0.36 (0.50)	0.34 (0.53)	0.36 (1.16)	0.34 (0.53)	−0.65 (0.52)	−0.65 (0.72)
Pittsburgh	0.89 (1.04)	1.00 (0.31)	0.65 (0.22)	0.62 (0.29)	0.58 (0.24)	0.56 (0.33)
Detroit	1.53 (0.32)	1.75 (0.30)	1.65 (0.22)	1.33 (0.30)	1.15 (0.25)	1.14 (0.35)
Canton	1.61 (1.25)	1.72 (1.36)	1.58 (1.02)	1.70 (1.35)	1.68 (1.12)	1.79 (1.51)
Chicago	0.98 (0.26)	0.91 (0.27)	1.08 (0.22)	1.06 (0.30)	1.01 (0.19)	0.98 (0.26)
Minneapolis	2.08 (0.49)	2.01 (0.53)	2.03 (0.39)	1.97 (0.53)	2.10 (0.40)	2.05 (0.55)
Colorado Springs	1.94 (1.18)	1.75 (1.26)	1.85 (1.04)	1.66 (1.25)	1.79 (1.11)	1.68 (1.40)
Spokane	2.04 (0.34)	0.74 (0.43)	1.10 (0.55)	1.10 (0.59)	0.96 (0.57)	0.94 (0.72)
Seattle	1.46 (0.31)	1.46 (0.34)	1.45 (0.28)	1.45 (0.34)	1.37 (0.30)	1.37 (0.36)
Overall	1.41 (0.13)	1.29 (0.13)	1.23 (0.14)	1.13 (0.14)	1.04 (0.11)	1.03 (0.14)

Do PM Composition Differences Explain City-to-City Variations in PM Lag?:

Recent New York City Analyses Indicates Traffic Particles (EC) to Have Shorter Time Lag (0 day Max) than Sulfate-Related PM (2 day Max) (Lall et al., 2006)



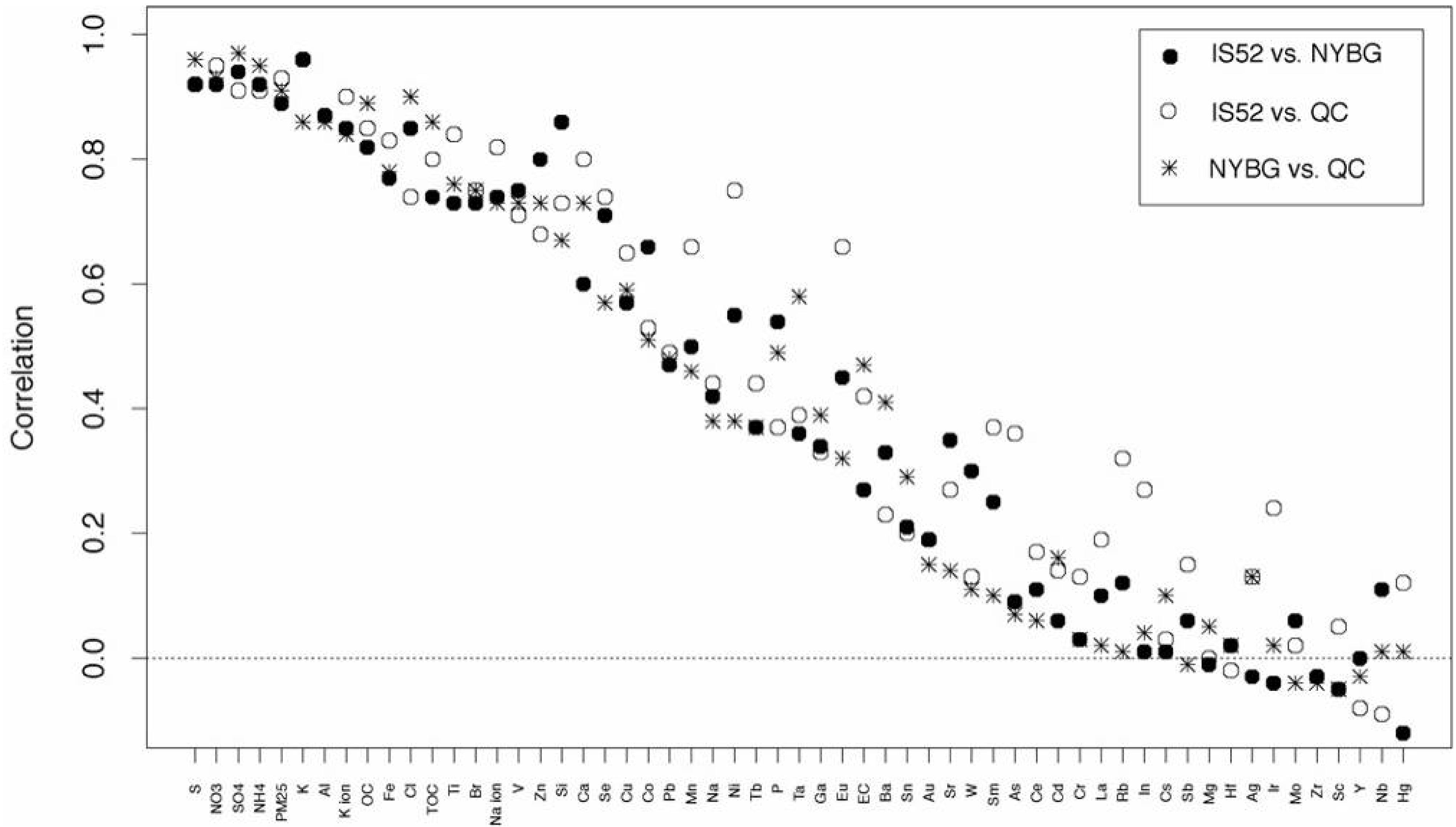
NMMAPS City-Specific Results Also Indicate Composition Is Related to the Size of PM10 mortality RR estimates across the US cities



from Lippmann et al., in press 2006

Differences in mortality risk coefficients shown as the 5th-to- 5th–95th percentile difference in concentrations of FPM and FPM components for the 60 NMMAPS MSAs for which FPM speciation data were available.

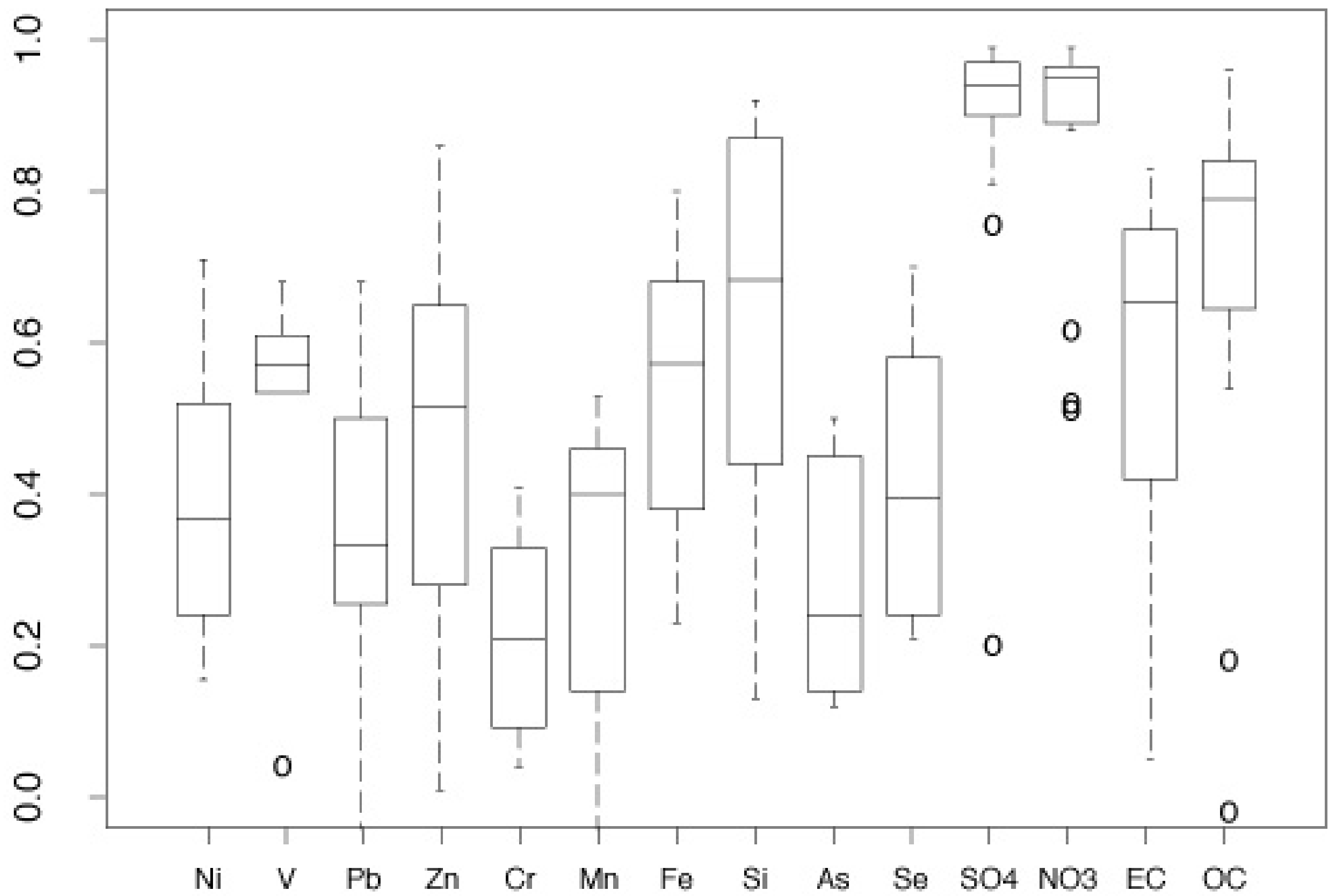
Temporal Correlation of PM components across 3 NYC Monitors: Indicates that Some Components are Less Spatially Homogeneous



from Ito, Xue, and Thurston, 2004

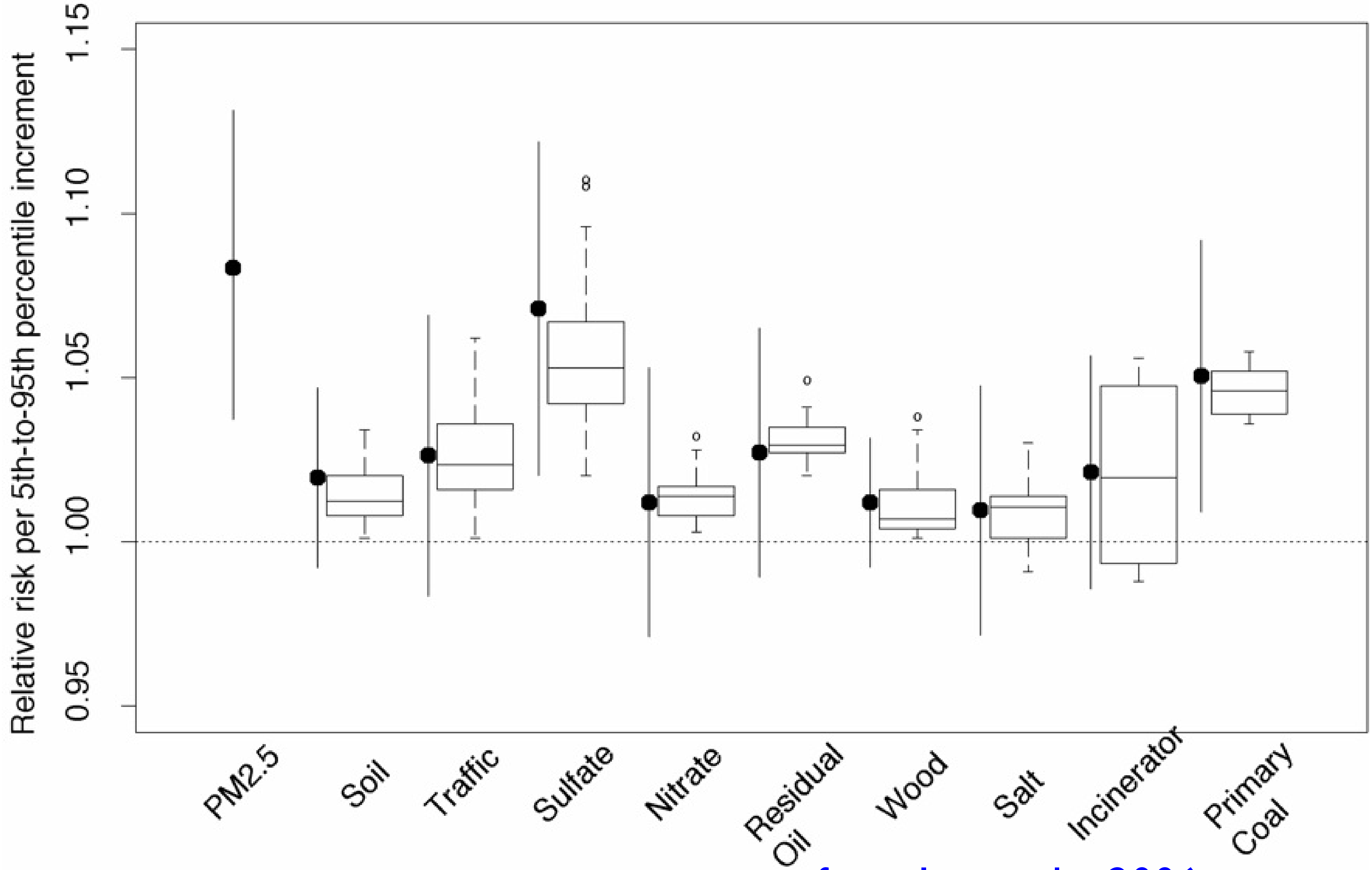
Distribution of median site-to-site correlation from 28 MSA's:

Spatial/temporal correlation of PM components varies across species and across cities



The 2003 EPA Source Apportionment Workshop:

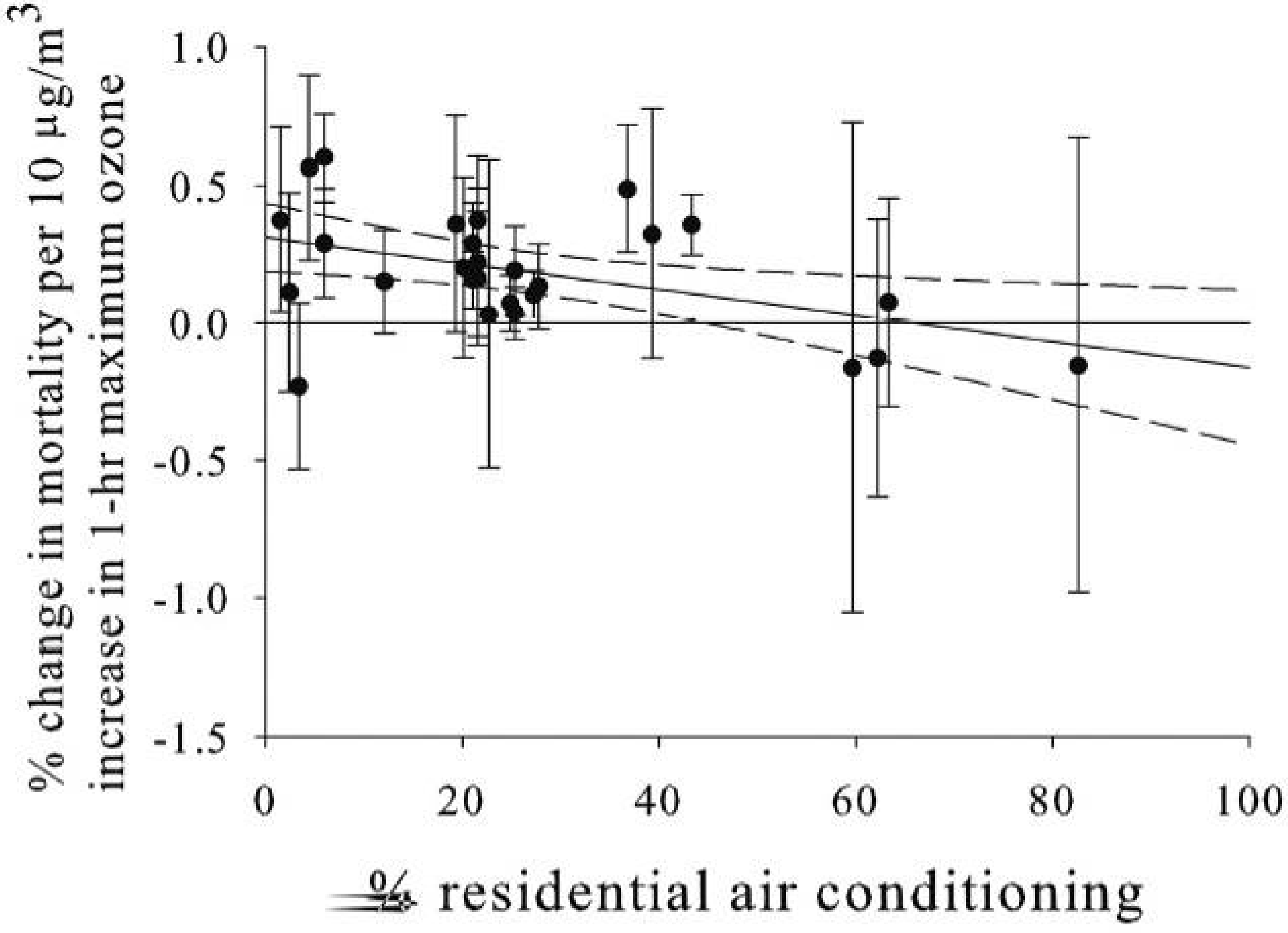
Mortality Relative Risks Vary Across Source Categories



from Ito et al., 2006

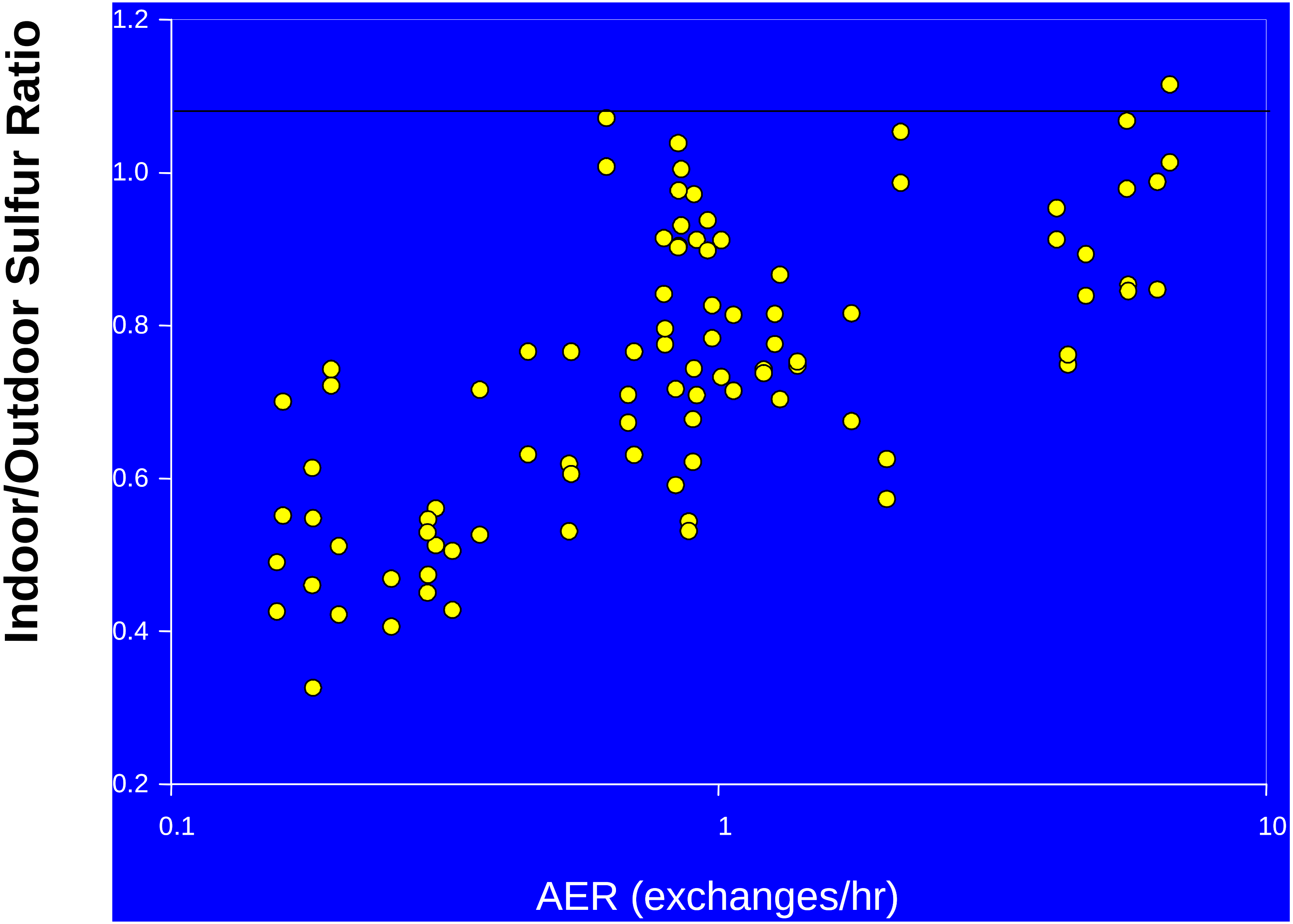
Do Indoor and Outdoor Exposure Variations Explain Regional Differences in PM RR Effect Estimates?

Higher % AC: Lower ozone-mortality RR



From Levy et al., 2005

Indoor/Outdoor Pollution Ratio Decreases With Lower Air Exchange Rate



Sarnat et al., 2002

Suggested Future Directions

- Better Resolve Modeling Uncertainties:
  - Weather...or not?
  - Lag Structure Choices
- Improve Source-Specific Effect Estimates
  - Maintain and expand speciation data collection in key (larger) US cities (e.g., LA, Chicago, NYC) where there is epidemiologic power: operate multiple sites in these key cities. Need one daily sampling site to capture time-distributed health effects.
  - Better address biogenic sources (e.g., wood burning) and separate traffic components. Add OC speciation. Consider Thermal Desorption Mass Spec Analyses (Jamie Schauer).
- Improve Epidemiologic Population Exposure Estimates
  - Improve Spatial Exposure estimates (e.g., vs. home or MSA mean). Consider time-activity patterns..
  - Separate outdoor from indoor contributions to pollution exposure and health effects.