Utility of Different Exposure Metrics used in Epidemiological Studies of Air Pollution

Halûk Özkaynak

US EPA, Office of Research and Development
National Exposure Research Laboratory, RTP, NC

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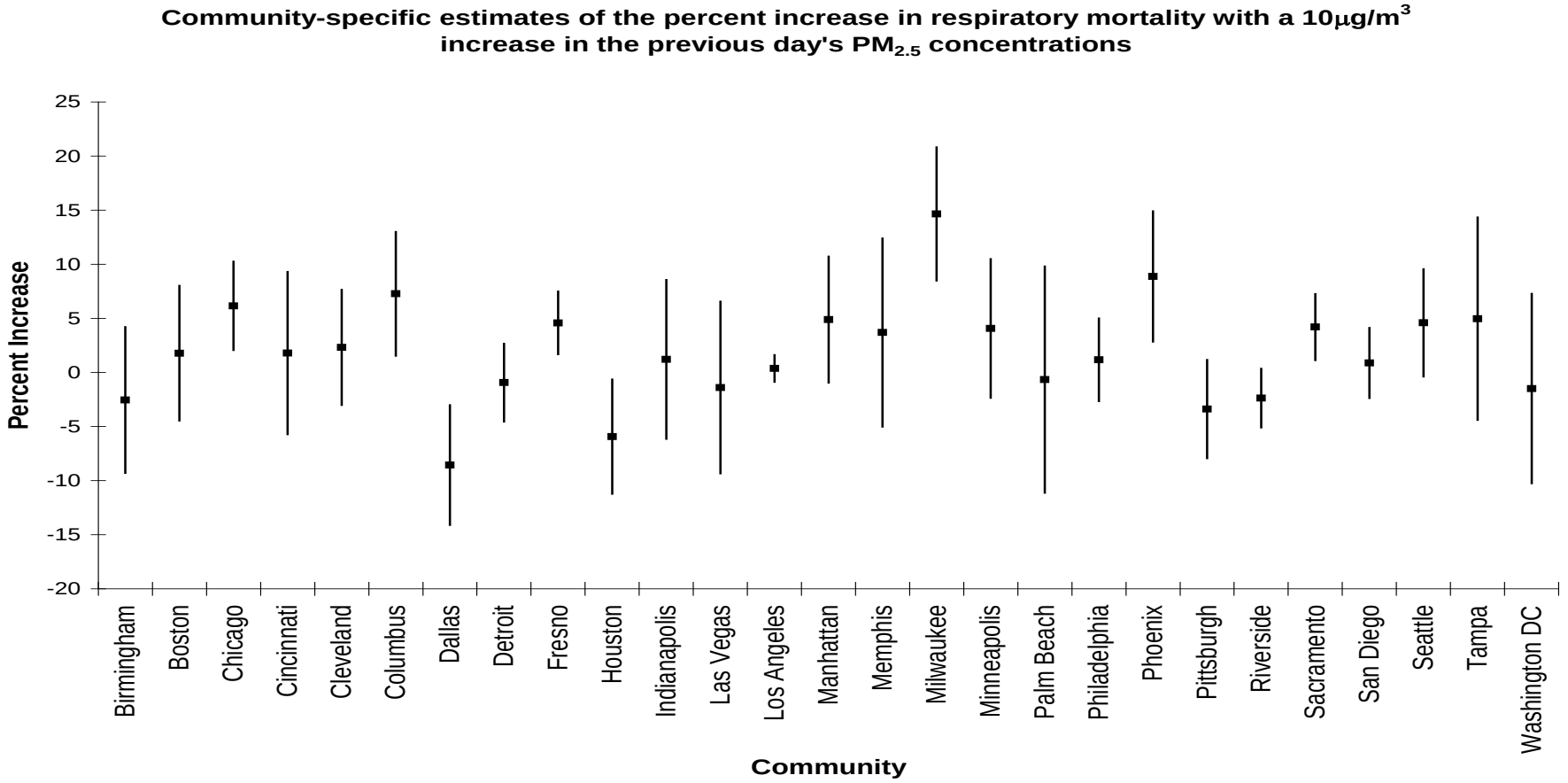
*Estimated Effects of Ambient $PM_{2.5}$ on Acute Mortality in the US **



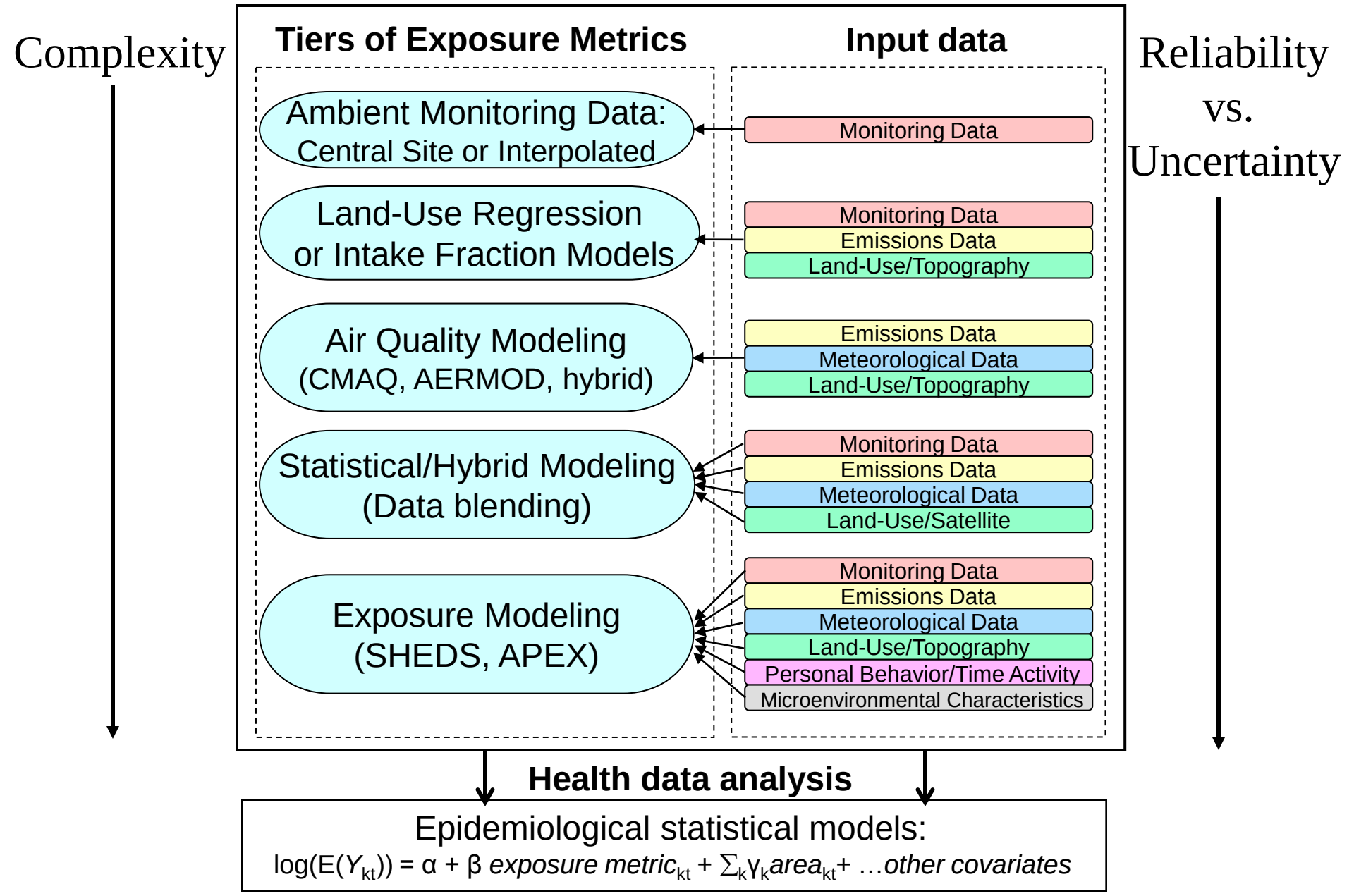
· represents estimates; lines around · are 95% confidence interval

***Source of data**: Franklin et al. 2007)

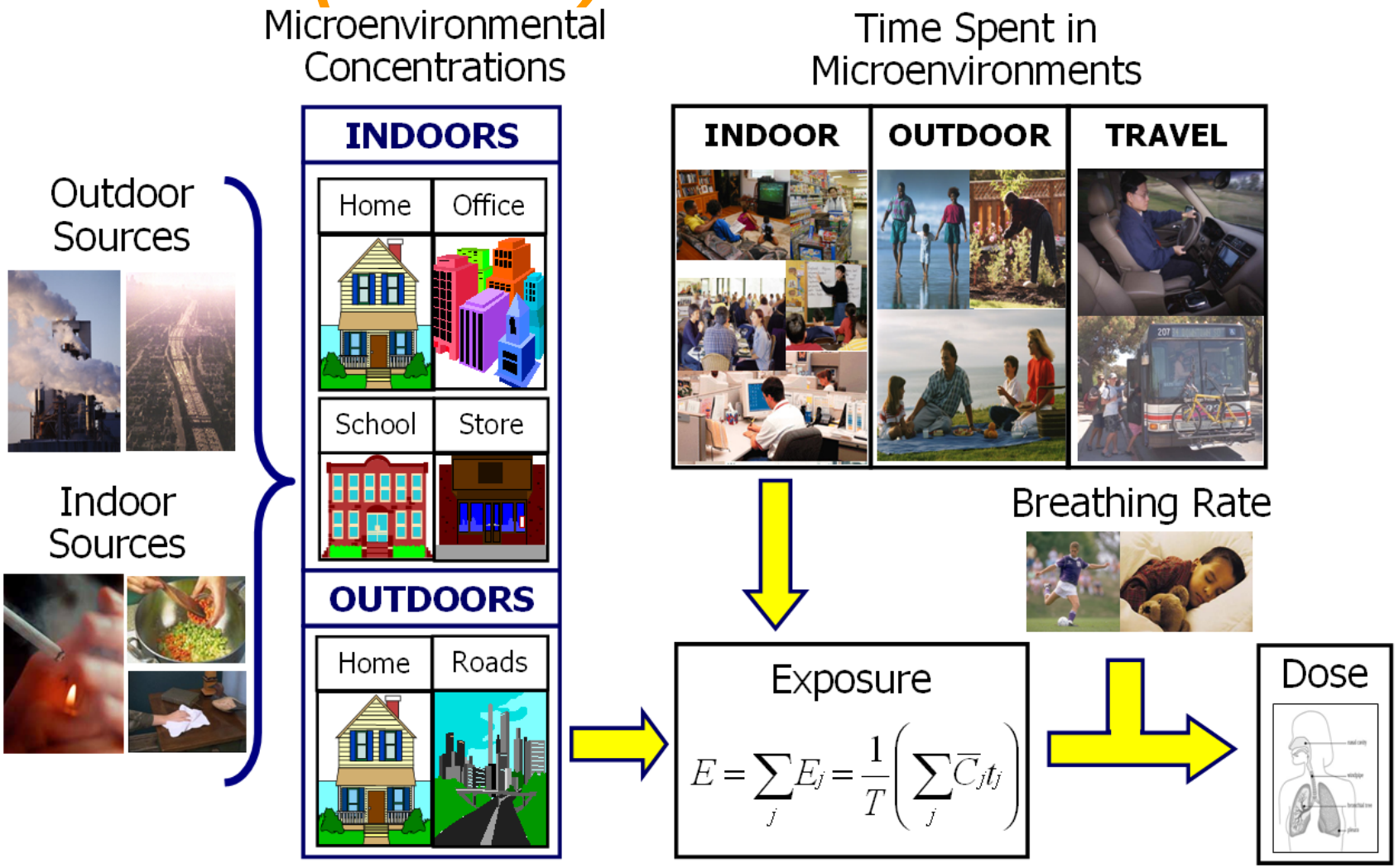
Need for Better Exposure Characterization in Air Pollution Health Studies

- Numerous epidemiologic studies have used measurements from central-site ambient monitors as surrogates of personal exposures to air pollution
- Central-site monitors may *not* account for:
  - spatial and temporal heterogeneity of urban air ambient pollution
  - human activity patterns
  - infiltration of ambient pollutants indoors
  - contributions of indoor sources that may be effect modifiers
- Central-site are especially problematic for certain PM components and species (e.g., EC, OC, coarse, ultrafine) that exhibit significant spatial heterogeneity
- A number of enhanced exposure assessment approaches have recently been developed and applied in the investigation of air pollution health effects by EPA and collaborating academic institutions

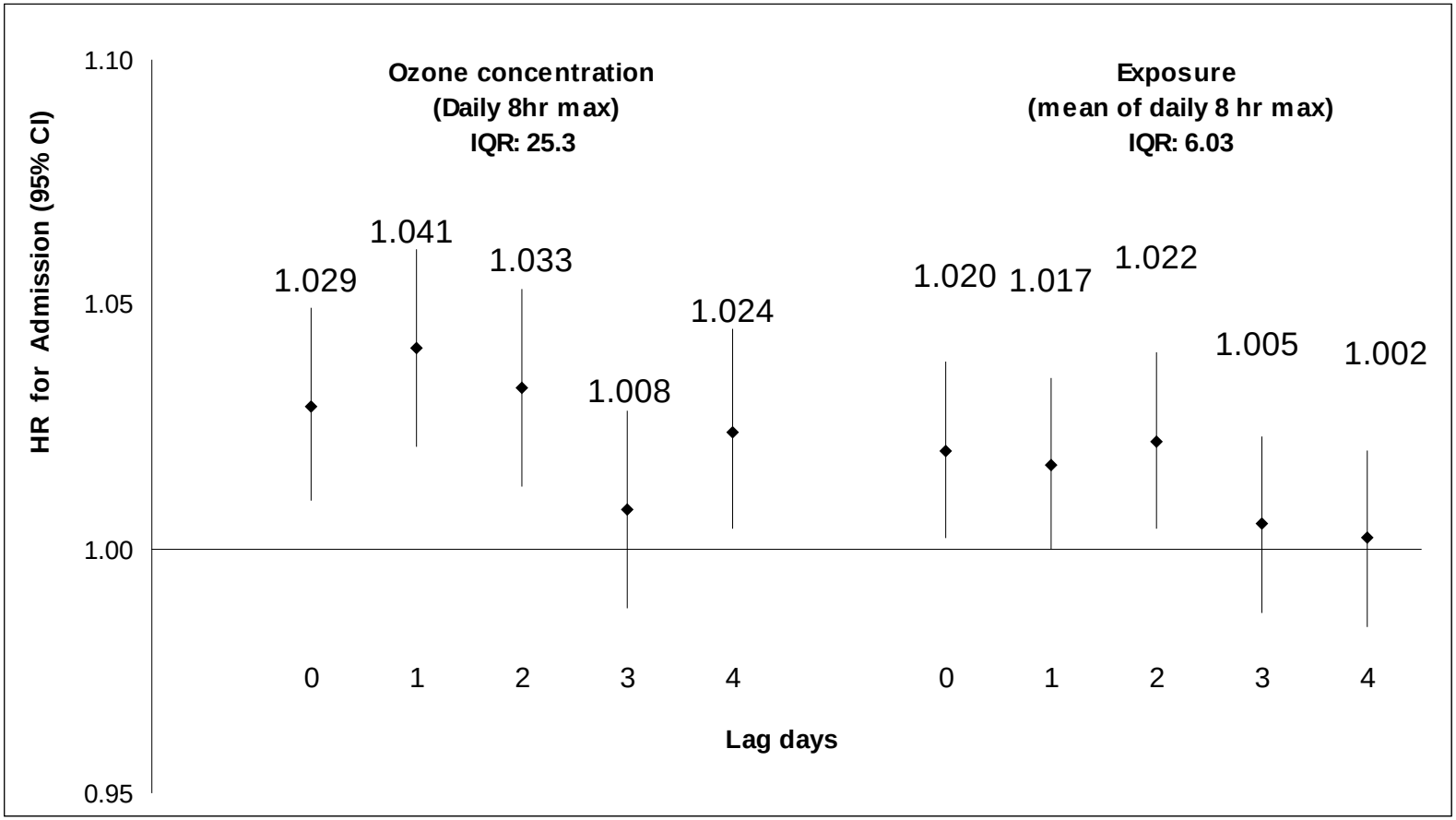
Exposure Metrics Considered by Health Studies



Stochastic Human Exposure and Dose Simulation (SHEDS) Model for Air Pollutants

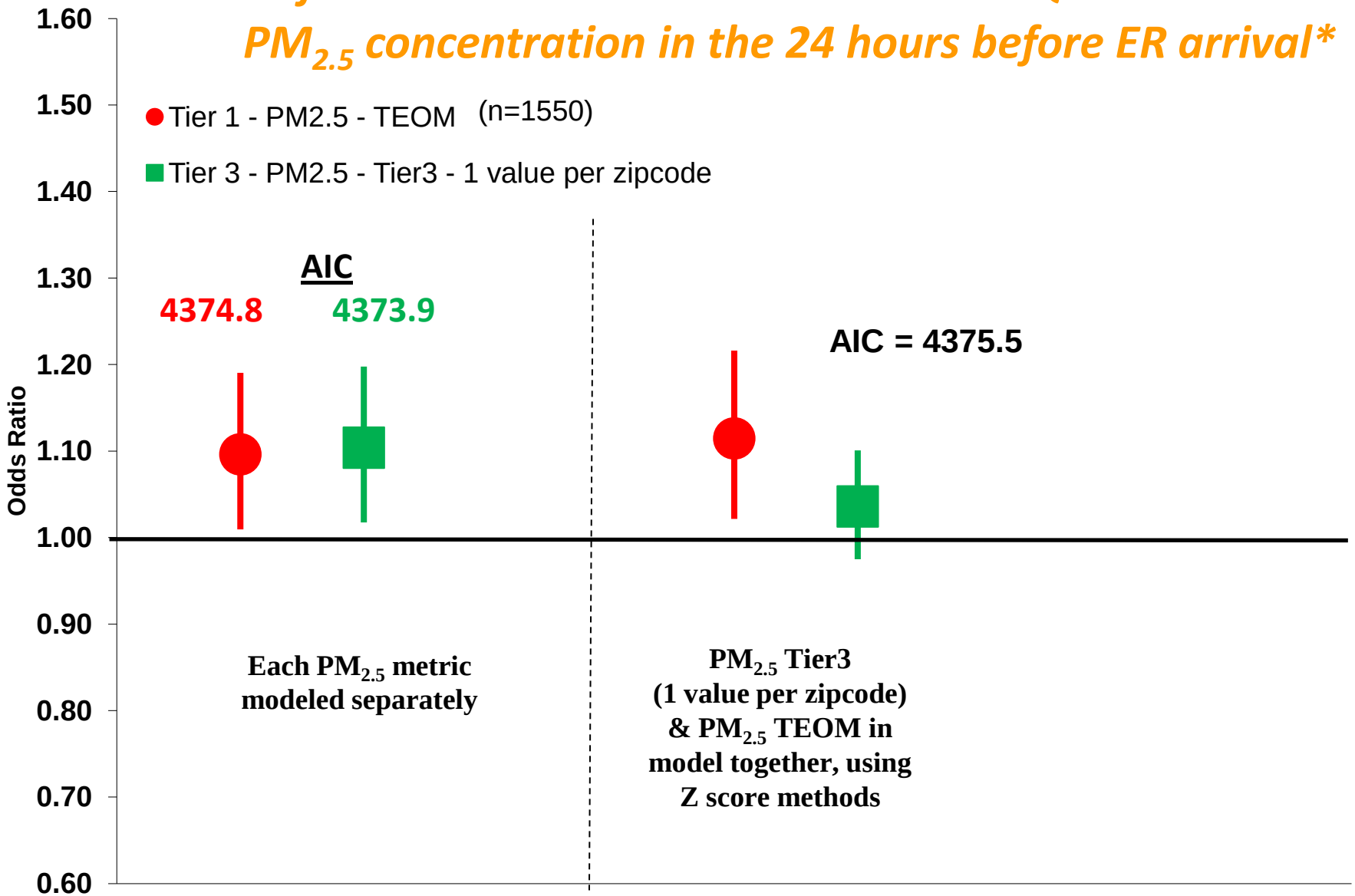


Comparison of Effects per IQR Unit Change in Ozone Concentration vs. Exposure on Respiratory Hospital Admissions in NYC (Jones et al. 2011)



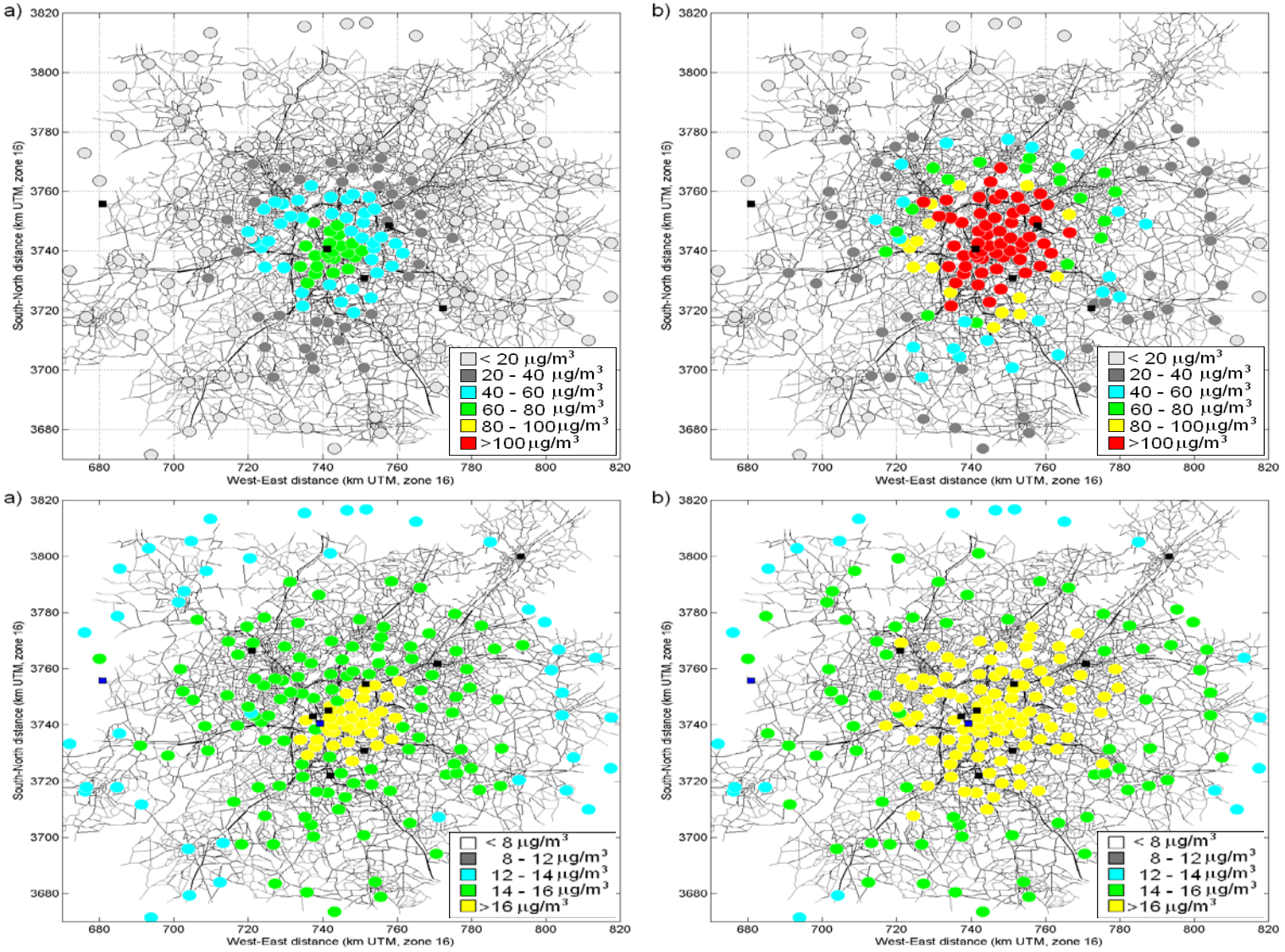
Conditional logistic regression model adjusted for categorical mean UAT.

Tier 3 - SHEDS/APP: Relative odds of a transmural infarction in NJ associated with each IQR increase in $PM_{2.5}$ concentration in the 24 hours before ER arrival*

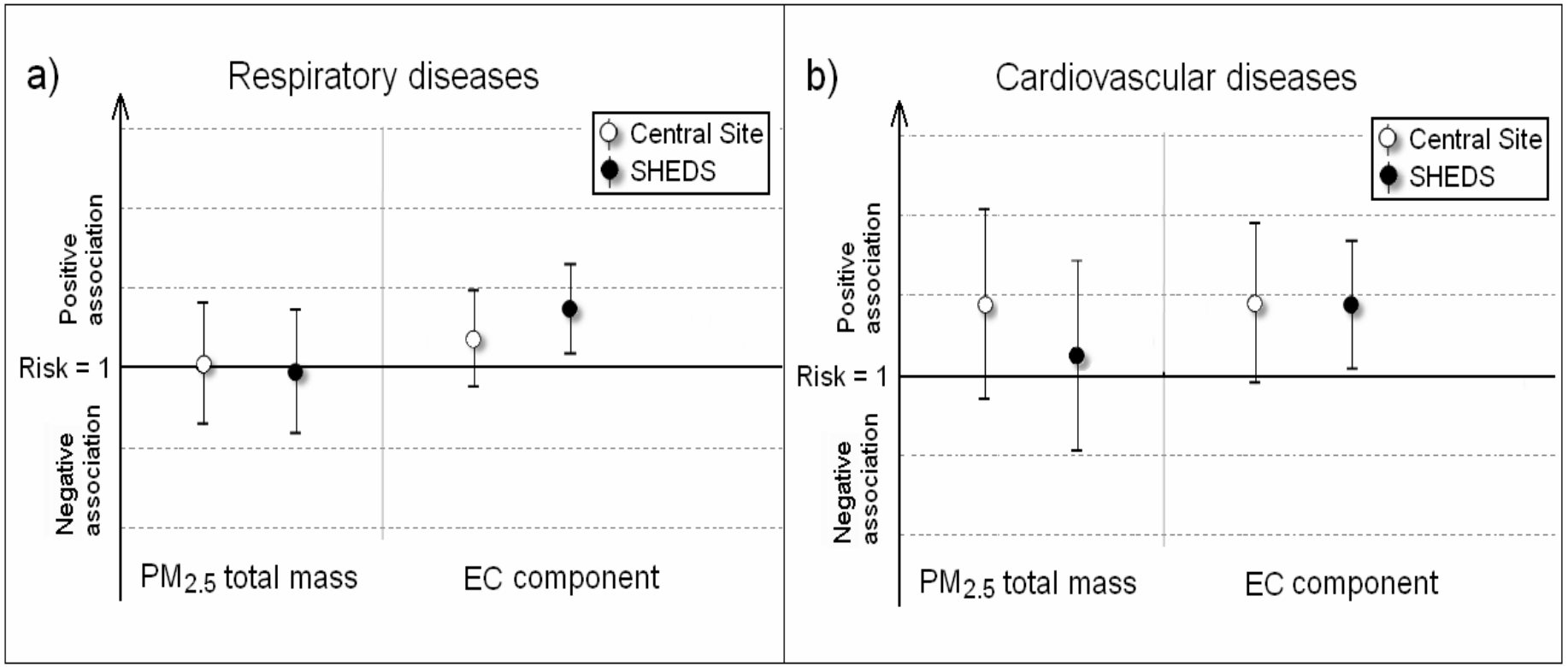


*Source: Turpin et al. 2011

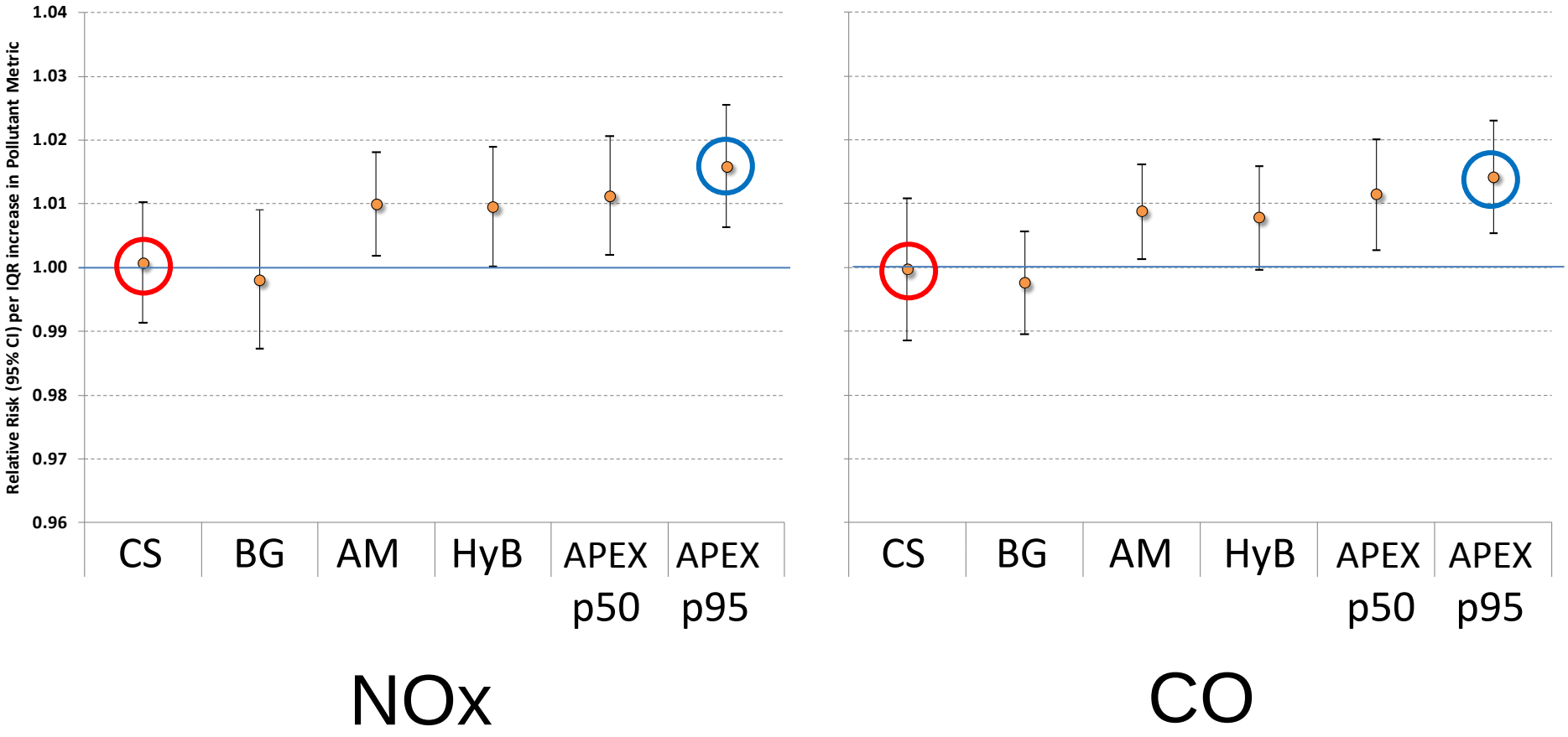
Modeled 4-year average NO_x and $PM_{2.5}$ concentrations in Atlanta: a) regional background and b) hybrid (regional combined with local) !999-2002



Results of the epidemiologic analysis of emergency department data in Atlanta for a) respiratory diseases and b) cardiovascular diseases (Özkaynak et al. 2011)



Associations between 24h NOx/CO and Asthma ED Visits In Atlanta (Sarnat et al. 2011)



Overall Summary of Findings

- Observed RRs differ by metric, pollutant and study design
  - Measurement error is present in every metric
  - Effects of error on risk estimates vary by type of exposure error (Goldman et al 2011)
  - For time-series studies ambient concentrations may serve as an appropriate exposure surrogate
  - For cohort studies or mixed spatio-temporal study designs (as shown in the Atlanta analysis) the use of more refined exposure surrogates than the conventionally used ambient monitoring data may boost study power, reduce exposure prediction errors and strengthen the estimated associations between air pollution and health data

- CO, NOx → Asthma ED Associations Varied by Metric Choice
  - Model-based estimate higher and significant compared to central site estimate
  - Consistent with *a priori* expectations for spatially-heterogeneous pollutants
    - Suggests that accounting for spatiotemporal distribution of pollutants may be important for timeseries studies
    - May indicate reduced measurement error for these pollutants

- Ozone, $PM_{2.5}$ → Magnitudes of Association with Daily Mortality, MI, Respiratory Hospitalization s and Emergency Department Visits Fairly Robust to Metric
  - Interpretation of findings similar regardless of exposure assignment approach
  - For homogenous pollutants, spatiotemporal models may add little to explaining variability
  - Slightly lower RRs for the modeled O_3 personal estimates compared to ambient
  - Possible that potential for exposure model misspecification may re-introduce error in the epidemiological analysis results using modeled exposures

Research Needs

Type of an epidemiologic study design influences spatio-temporal resolution needs of exposure data or its surrogates used for health effects research (one size does not fit all in terms of optimally assigning exposures). Key information gaps:

1) When do more refined estimates of exposure provide more information than the central-site monitor, by: 1) Type of study (e.g. case-crossover vs. cohort); 2) Acute vs. chronic exposures/effects, 3) Spatial vs. temporal variability of pollutant of interest

It is important to better understand the sources and factors influencing uncertainties in ambient pollution epidemiology analyses as well as compounding of errors as exposure metrics are refined. Key information gaps:

2) What is the best way to apply distributional exposure estimates?

3) How much infiltration, activity patterns, local source emissions and pollution composition account for the predicted variability in the exposure and effect estimates?

4) How to incorporate multipollutant considerations in modeling exposures and epidemiological analyses, since appropriate selection of exposure surrogates become more complicated due to pollutant-specific relationships with their exposure surrogates and the underlying covariance structure among the ambient pollutant concentrations (i.e.., exposure misclassification concerns vs. statistical collinearity issues)?

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