Quantifying Air Pollution Exposure Inequality: Methods and Challenges

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Webinar 5: Inequalities of Air Pollution Exposures and Associated Health Effects in the U.S.

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Healey links COVID-19 and race, poverty, pollution

Researcher: Variety of factors contribute to hotspots

The deadly mix of Covid-19, air pollution, and inequality, explained

Covid-19 is disproportionately affecting black and brown communities in New York and elsewhere. Air pollution seems to be one reason why.

By Lois Parshley | Apr 11, 2020, 8:50am EDT

Connecting the Dots Between Environmental Injustice and the Coronavirus

Policy context

- EO 12866
  - …agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity)
- EO 12898
  - …provide guidance to Federal agencies on criteria for identifying disproportionately high and adverse human health or environmental effects on minority populations and low-income populations

Regulatory Impact Analysis
for the
Clean Power Plan Final Rule

7.10 Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

"The Administrator placed weight on the fact that certain groups, including children, the elderly, and the poor, are most vulnerable to climate-related health effects."

"In areas where this rulemaking reduces exposure to $PM_{2.5}$, ozone, and methylmercury, low-income populations will also benefit from such emissions reductions."

Another policy example: The Transportation and Climate Initiative

- Regional collaboration among Northeast/mid-Atlantic states to reduce carbon emissions from transportation

- Proposed "cap and invest" structure

- Questions regarding air pollution and other health co-benefits, equity implications of policy

What can you quantify? (Harper et al. 2013)

- Inequality:
  - Comparisons between groups, i.e., differences in the distribution of goods
- Inequity:
  - A subset of measured inequalities judged to be unfair (was it avoidable, unfair, or remediable?)
- Injustice:
  - Adding a layer related to process

(How) can you quantify exposure or risk inequality?

- Many indicators developed originally for income inequality
- Cox 2011: "…risk distributions differ from income distributions in essential ways that call into question the applicability of income inequality indexes and the desirability of any univariate inequality index"
  - Good vs. bad
  - Transferability

| Inequality measure	Reference group	Absolute or relative inequality	Explicit inequality aversion parameter	Ordered social groups
Absolute Difference	Best off	Absolute	No	Yes
Relative Difference	Best off	Relative	No	Yes
Regression-Based Relative Effect	Best off	Relative	No	Yes
Regression-Based Absolute Effect	Best off	Absolute	No	Yes
Slope Index of Inequality	Average	Absolute	No	Yes
Relative Index of Inequality	Average	Relative	No	Yes
Index of Disparity	Best off	Relative	No	No
Population Attributable Risk	Best off	Absolute	No	No
Population Attributable Risk%	Best off	Relative	No	No
Index of Dissimilarity	Average	Absolute	No	No
Index of Dissimilarity%	Average	Relative	No	No
Relative Concentration Index	Average	Relative	Yes	Yes
Absolute Concentration Index	Average	Absolute	Yes	Yes
Between-Group Variance	Average	Absolute	No	No
Squared Coefficient of Variation	Average	Relative	No	No
Atkinson Index	Average	Relative	Yes	No
Gini Coefficient	Average/All those better off	Relative	No	No
Theil Index	Average	Relative	No	No
Mean Log Deviation	Average	Relative	No	No
Variance of Logarithms	Average	Relative	No	No

Harper et al. 2013

Atkinson index

$$1 - \left[\frac{1}{n} \sum_{i=1}^{n} \left[\frac{x_i}{\bar{x}} \right]^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}$$

- Fulfills all standard axioms for using applying income inequality indicators to health
- Subgroup decomposable (between-group vs. within-group inequality)
- Societal preferences about inequality incorporated through ε
  - Higher ε = more weight on transfers at low end

Some additional indicator "axioms"

- Use a measure as close to health risk as possible
  - Risk > Exposure > Concentration > Proximity
- Baseline distribution must be considered
- Inequality indicators should primarily be used when comparing multiple competing policy alternatives
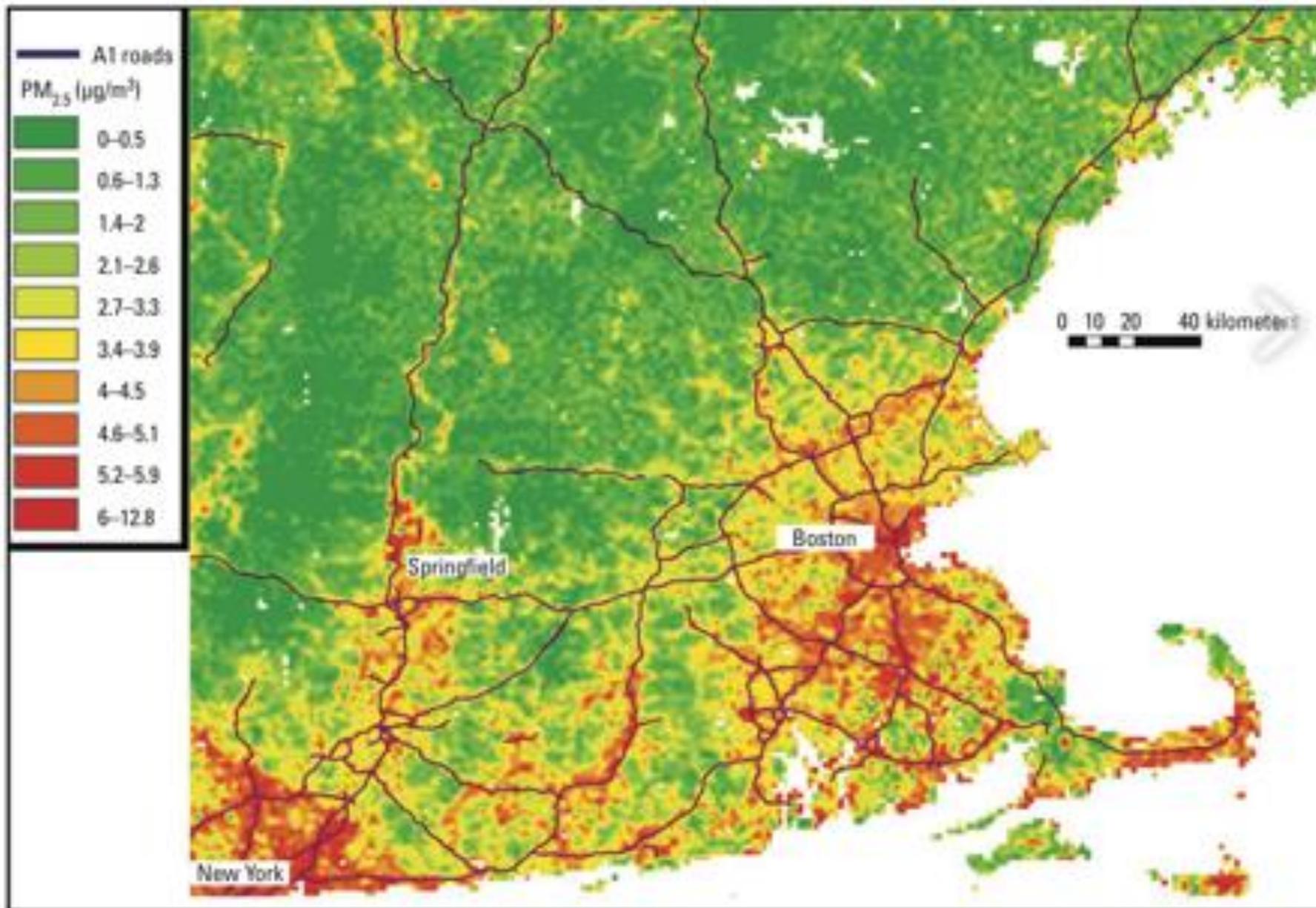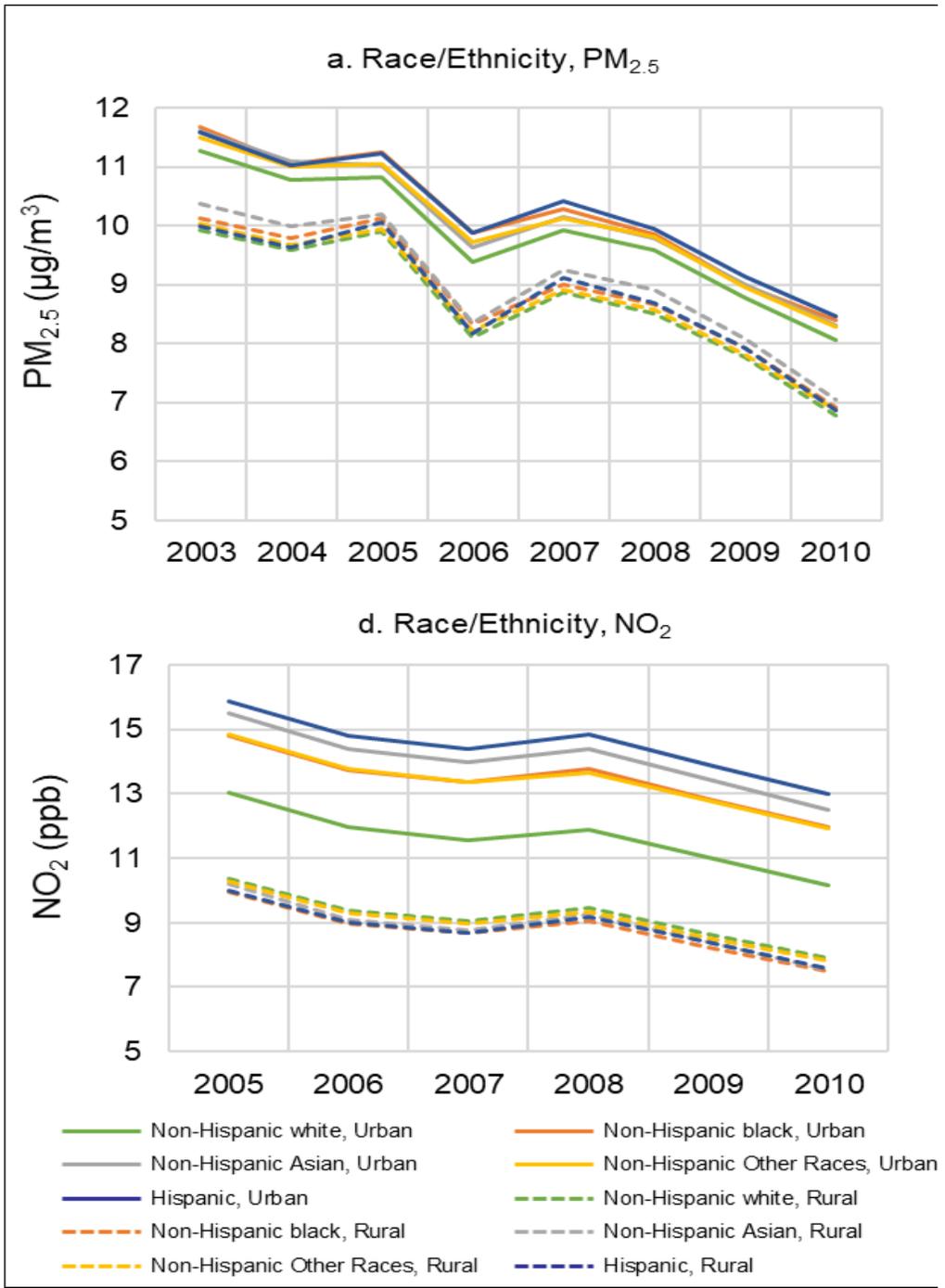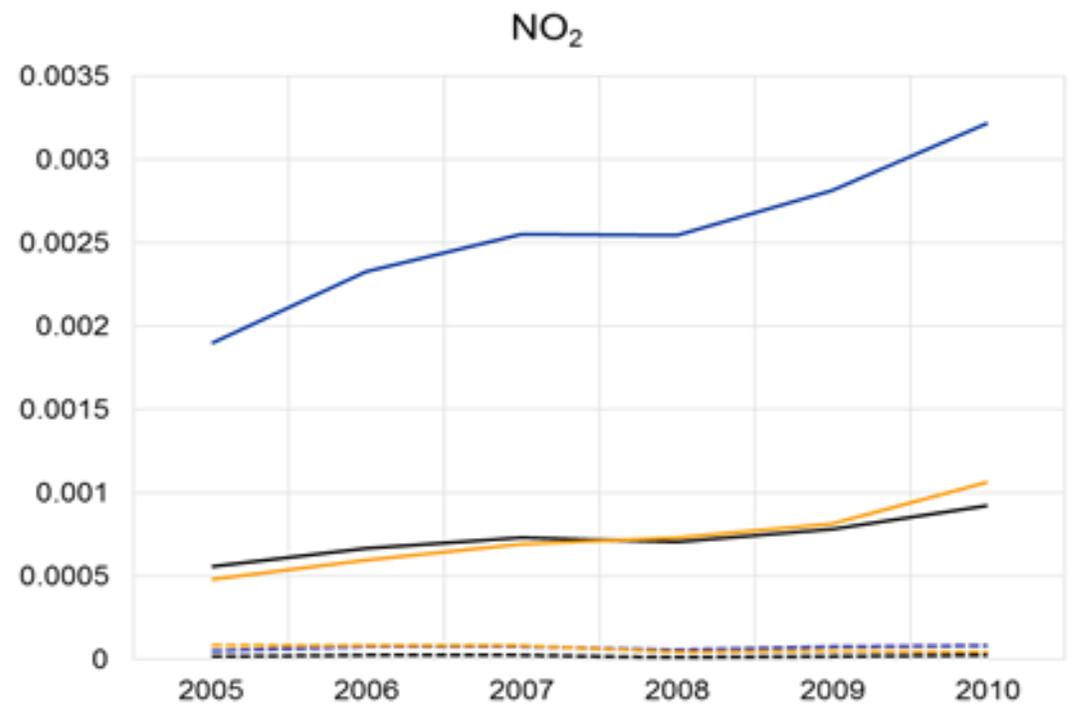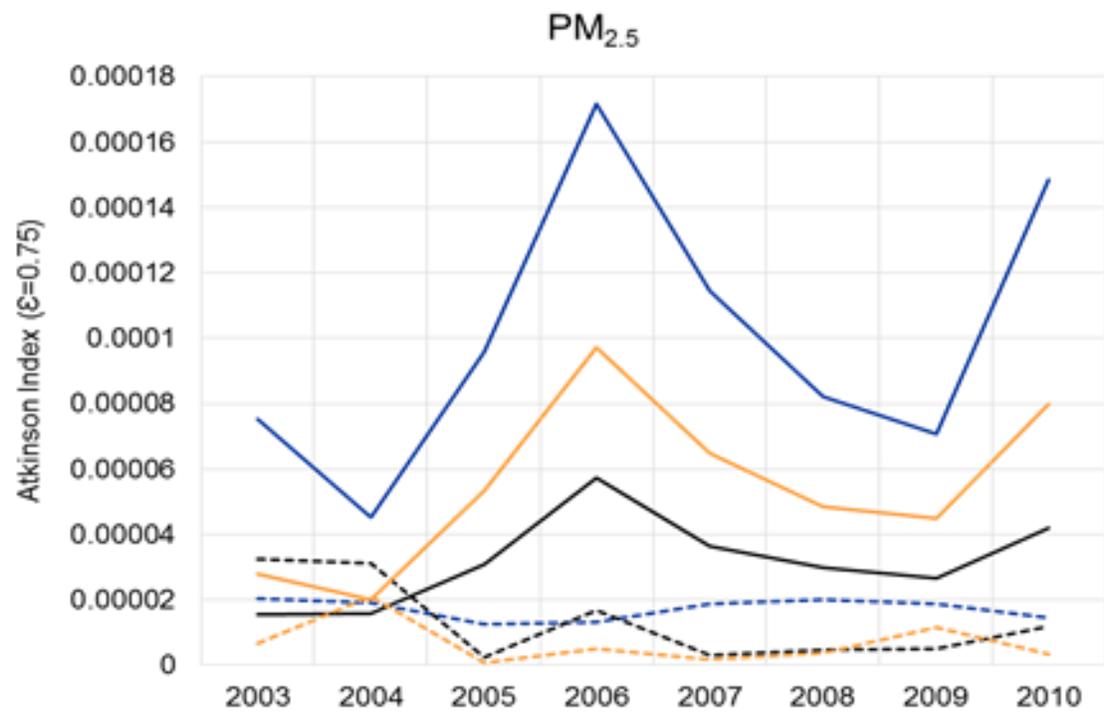
Levy et al. 2006

Shi et al. 2016

Rosofsky et al. 2018

Rosofsky et al. 2018

Detroit air pollution control example

Table I. Avoided Health Impacts for Status-Quo and Multipollutant/Risk-Based Scenarios (90% Confidence Interval)[a]

	Air Quality Scenario			
Health Endpoint	**Status-Quo**		**Multipollutant/Risk-Based**	
Mortality (populations 30–99)[b]	71 (51–91)		130 (95–170)	
Asthma hospitalization (populations <65)	6.8 (3.3–10)		16 (7.6–24)	
Education-Stratified Estimates[c]	**Incidence Estimate**	**Percent of Total[a]**	**Incidence Estimate**	**Percent of Total[a]**
Mortality (populations 30–99, <grade 12)	18 (7.3–28)	24%	40 (16–63)	28%
Mortality (populations 30–99, = grade 12)	24 (9.6–38)	32%	46 (19–74)	32%
Mortality (populations 30–99, >grade 12)	34 (15–53)	45%	58 (25–90)	40%

Fann et al. 2011

Detroit air pollution control example

	Atkinson	Vulnerable/Susceptible Decomposition, Mortality Susceptible and AQ Vulnerable	
		Between	Within
Baseline	0.437776	0.002749	0.436227
Status-quo	0.437661	0.002803	0.436081
Multipollutant risk-based	0.436940	0.002318	0.435632

Challenges

- Available variables for stratification, especially given goal for alignment with health evidence

- Resolution of air pollution estimates

- Interpretability of indicators by decision makers and others

Conclusions

- Air pollution exposure or health risk inequality can be meaningfully quantified, informing equity considerations
- Applications will be most meaningful when:
  - Comparing across alternative scenarios
  - Using high-resolution exposure data
  - Applying multiple inequality indicators
  - Ideally incorporating evidence of differential health impacts across subpopulations
- Future work should include applications in varied settings to increase understanding/interpretability, routine use in regulatory analyses, increased use of personal exposure data