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Analyzing Risk Inequality Impacts of Air Quality Regulations in Two Urban Areas

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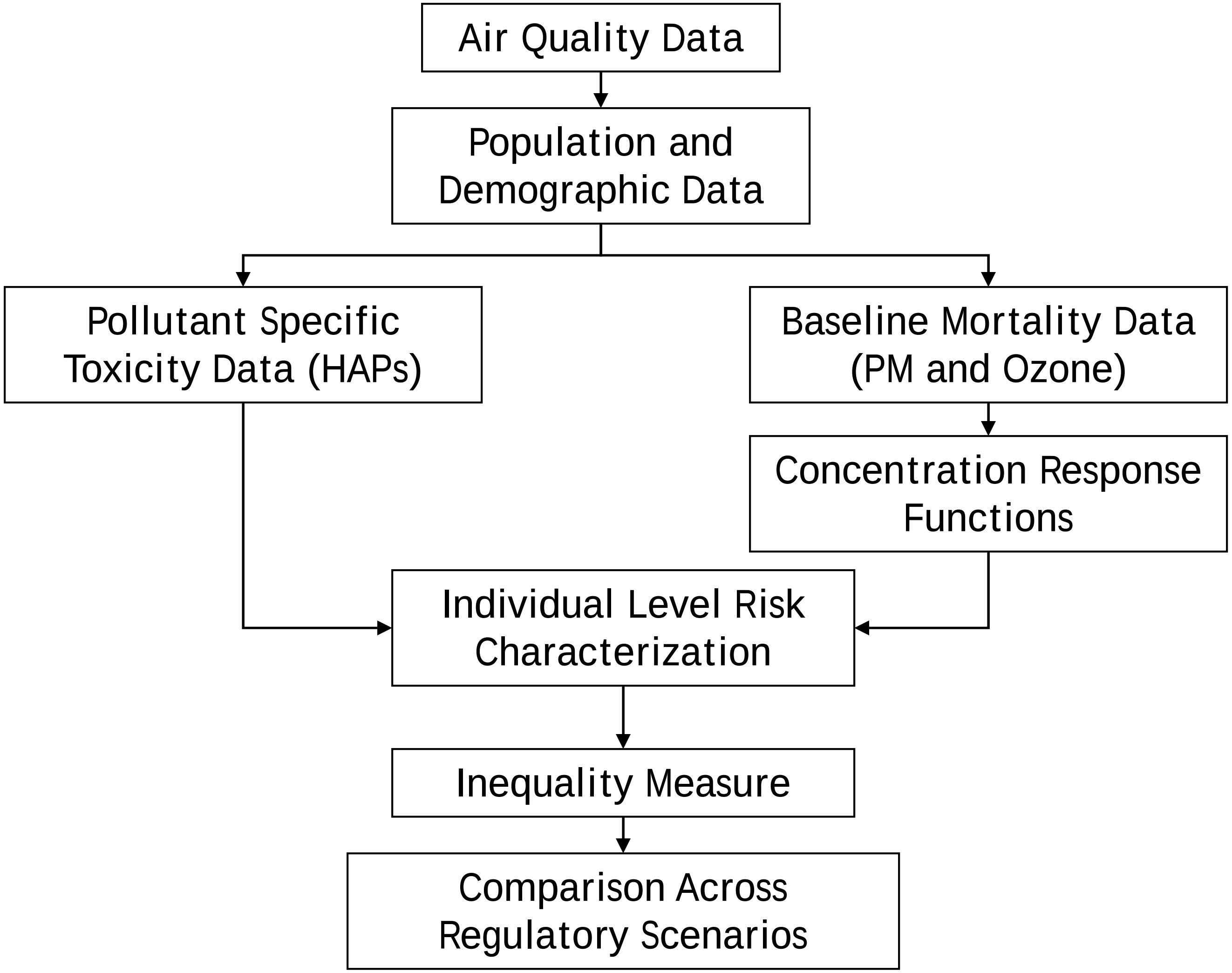
Background

- IEc supporting EPA's Office of Air and Radiation in methods development for air toxics regulatory analysis.
- April 2009 EPA workshop on benefits estimation for Hazardous Air Pollutants (HAPs)
- Addressing inequality in health risk is part of the goal of Title III of Clean Air Act (CAA) (air toxics/HAPs regulation)
- Inequality analysis extends Dr. Levy's work – two urban scale analyses using readily available data from EPA.
- Detroit analysis – traditional vs. multi-pollutant control strategies for PM, ozone, and HAPs
- Houston analysis – effect of CAAA programs on inequalities in benzene risks

Analytical Framework



Study Areas - Detroit

- Control Strategies
  - CS1 – "traditional" pollutant-by-pollutant approach
  - CS3 – integrated multipollutant approach
- Data
  - HAP Concentrations for 1km grid cells in Detroit area in 2020
  - PM and Ozone Concentrations for 1km grid cells in Detroit area in 2020
  - Population and demographic data from BenMAP
  - Age-stratified background mortality data from Michigan Dept. of Community Health (2006-2008) at zip code level.

Study Areas - Houston

- With and Without CAA scenarios from 812 case study
- Data:
  - Benzene concentrations for both scenarios at census tract and census block group level in 2020
  - Population and demographic data from BenMAP
  - Future sensitivity analysis using Benzene concentrations from 2002 National Air Toxics Assessment (NATA)

Inequality Measures

- Generally developed for analysis of income inequality
- Atkinson Index chosen for primary inequality assessment
  - See Levy et al. (2006) for assessment and selection of Atkinson Index for use in health benefits analysis

- Atkinson Index:

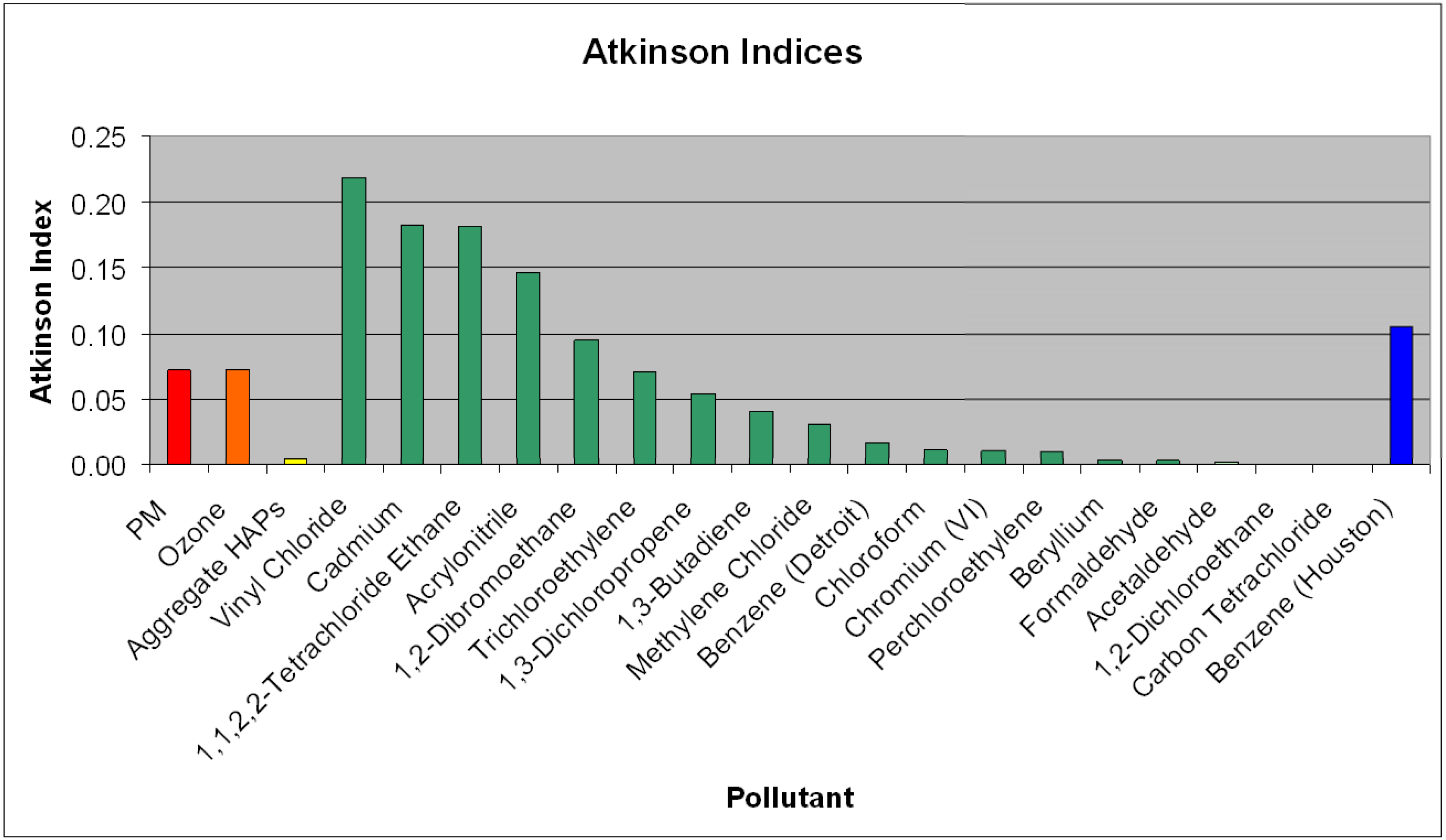
$$1-\left[\frac{1}{n}\sum_{i=1}^{n}\left[\frac{x_i}{\bar{x}}\right]^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$$

- Used epsilon value of 0.75

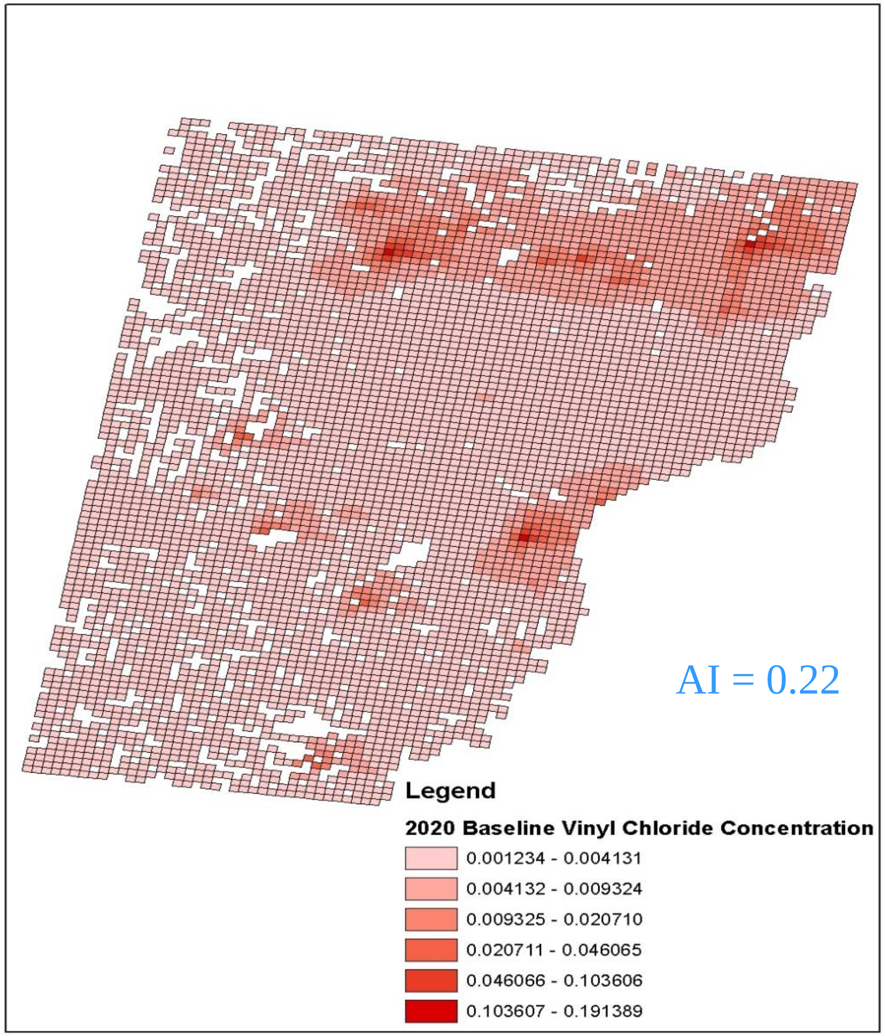
Calculations

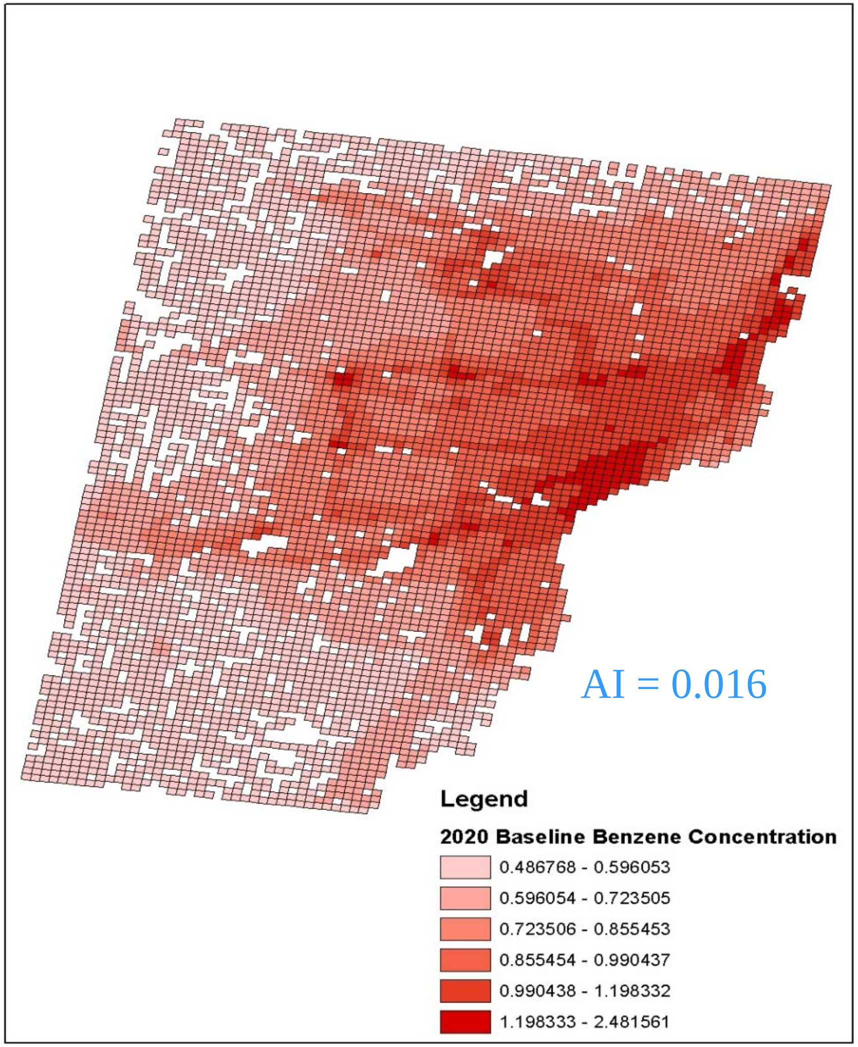
- Developed Microsoft Access© database
  - Inputs: air quality data, population data with demographic attributes, baseline mortality data, toxicity and concentration response data
- Calculate risk for individuals
- Calculate mean risk for study population
- Calculate Atkinson Index
- Calculate Between and Within group Atkinson indices for analysis of variability between demographic groups

Results - Baseline Atkinson Indices

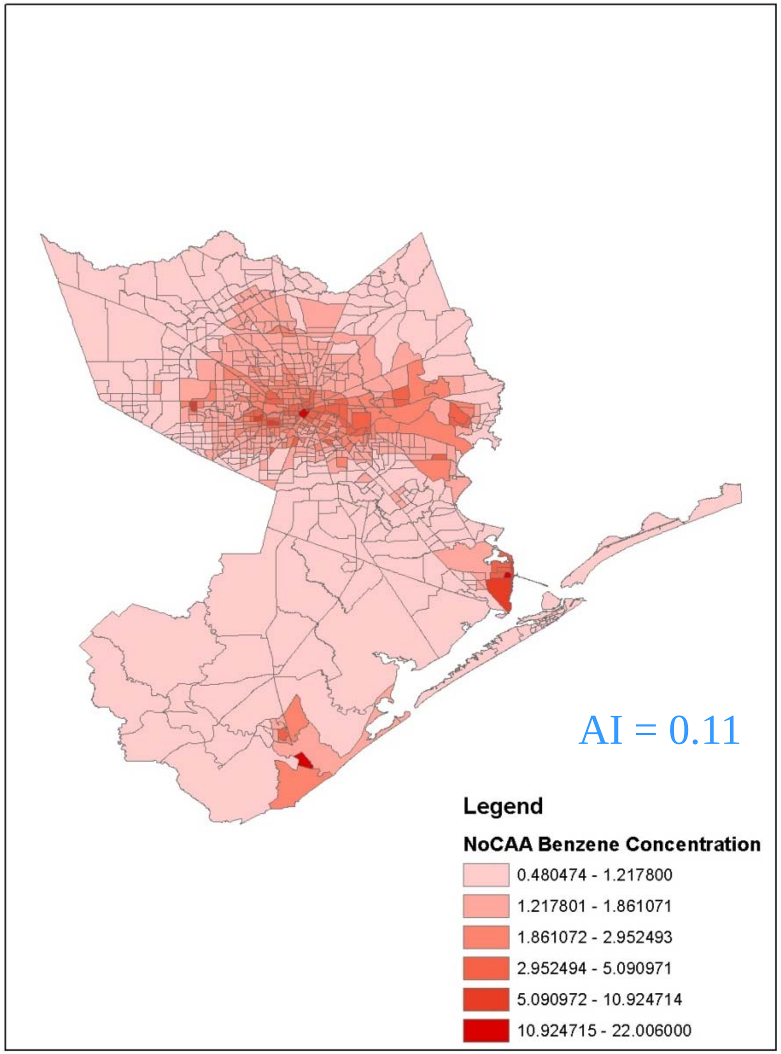


Baseline Vinyl Chloride vs. Benzene (Detroit)





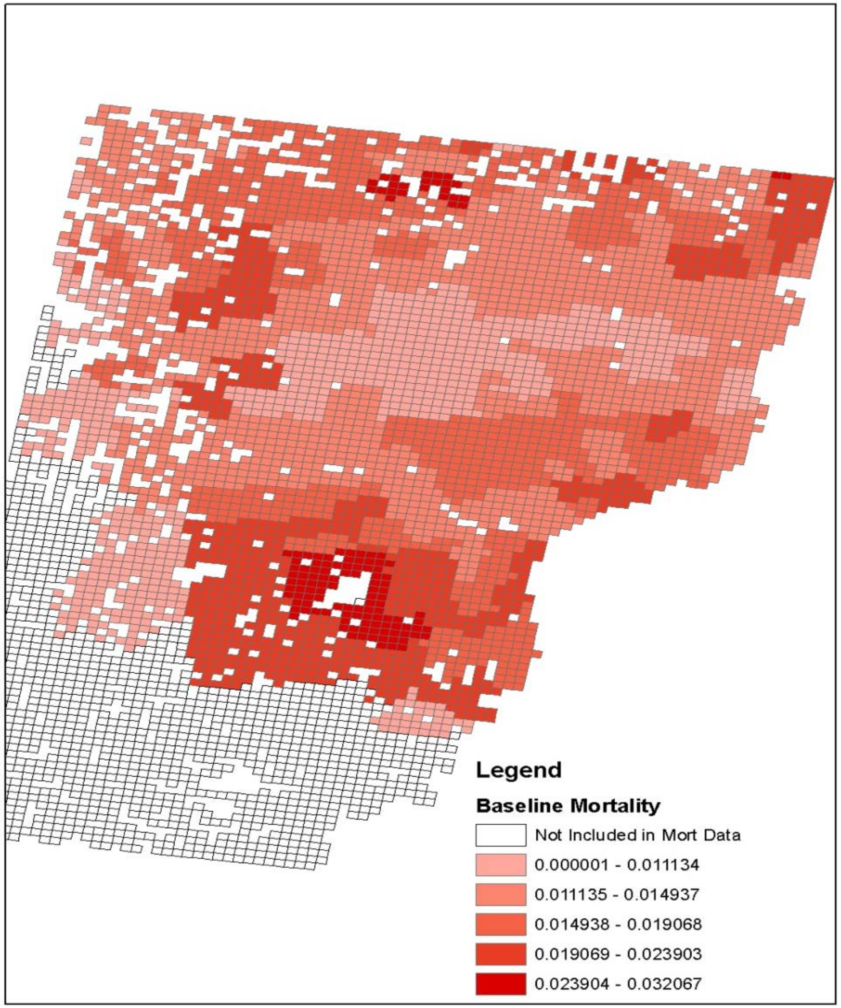
Baseline Benzene (Houston)

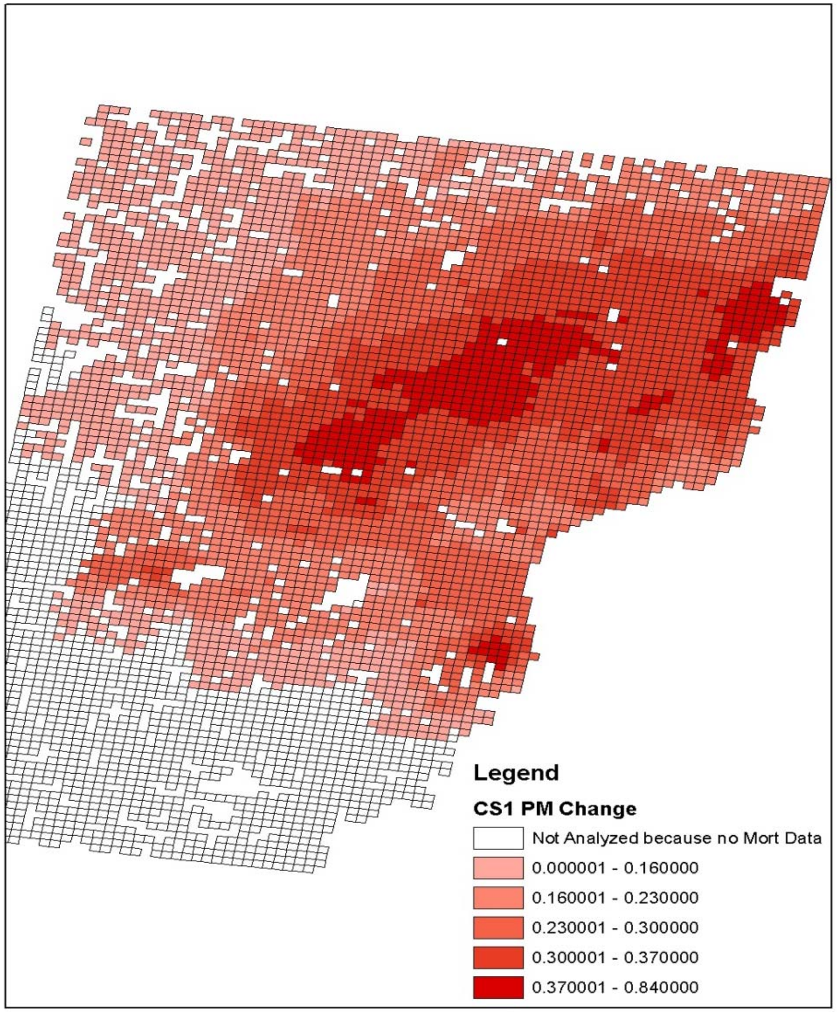


Results

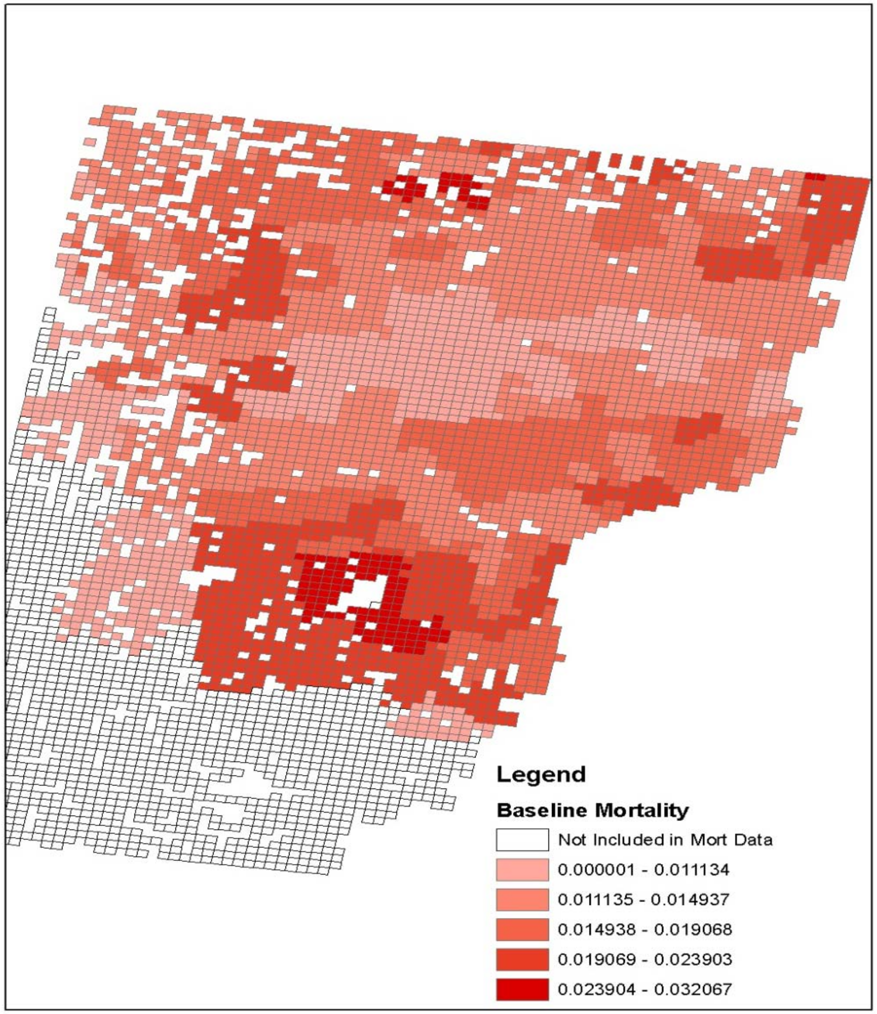
Detit Area 1km Grid Atkinson Indices								
	PM2.5			Air Toxics (Cancer Risk)				
Control Scenario	Mortality Risk	Conc. Only	Ozone Mortality Risk	Vinyl Chloride	Cadmium	1,1,2,2-Tetrachloro-ethane	Acrylonitrile	All Carc. HAPs
Baseline	0.072	0.0020	0.072	0.22	0.18	0.18	0.146	0.0038
Control Strategy 1	0.04%	-5%	-0.0004%	-0.0016%	0.0213%	0.0001%	-0.0003%	-4%
Control Strategy 3	-0.05%	-5%	0.001%	-0.0020%	-0.0088%	-0.0001%	-0.0018%	-11%

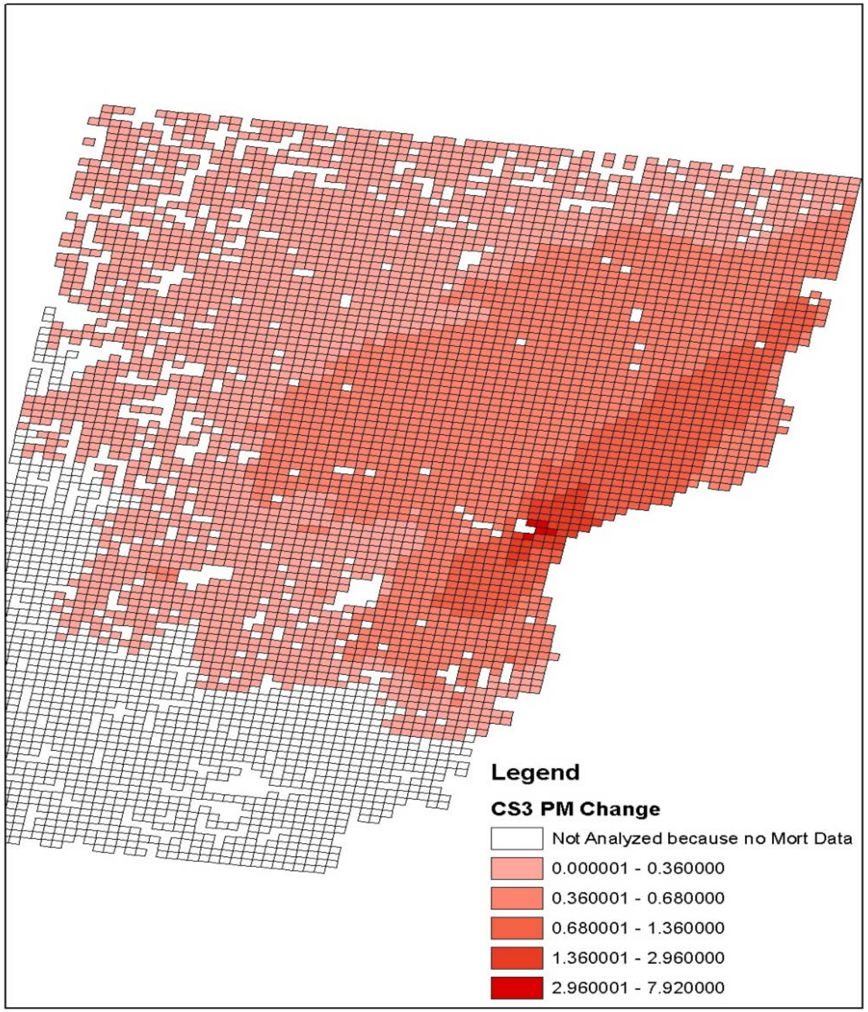
Control Strategy 1 – PM Reductions vs. Baseline Risk





Control Strategy 3 – PM Reductions vs. Baseline Risk





Results

Houston Area Atkinson Indices		
Control Scenario	Benzene Cancer Risk Census Tract	Benzene Cancer Risk Block Group
Without-CAAA	0.11	0.13
With-CAAA	-79%	-77%

Subgroup Decompositions of Atkinson

- Decomposed Atkinson on race, ethnicity, and age (<65 and 65 and over)
- Also decomposed vinyl chloride Atkinson based on susceptibility/age (<20 and 20 and over)
- In all cases within-group inequality dominated between group inequality, both in baseline and following the implementation of controls. No evidence of significant inequality across groups.

Sensitivity Analyses

- Alternate inequality metrics (mean log deviation, Theil's entropy, GINI coefficient in process)
- Alternate values for epsilon (0.25, 1.5, 3)
- Geographic scale (Houston only)
- Crude vs. standardized (default) mortality rates
- Concentration vs all-cause mortality risk

- Results appear robust to alternative assumptions about metrics, epsilon values, and geographic scale

Conclusions

- In Detroit, the multi-pollutant control strategy is more effective at reducing risk inequalities than the pollutant-by-pollutant approach, particularly for PM and HAPs. Performance of pollutant approach is mixed.
- In Houston, CAAA programs addressing benzene are effective in reducing inequality in benzene leukemia risk, by reducing risks to highly exposed individuals.
- Neither case study revealed significant inequalities between racial, ethnic, or age groups.
- Atkinson index provides a useful metric for comparing inequality reductions across regulatory programs or strategies.
- Use of concentration data as opposed to risk data to measure inequality can produce spurious results for PM or ozone, where variance in baseline risk is key to assessing inequality improvements.

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