Estimating PM$_{2.5}$ and Ozone-Related Health Impacts at the Urban Scale

Applying local emissions, air quality and health data to generate better estimates of air pollution health impacts

Neal Fann and Karen Wesson
U.S. Environmental Protection Agency
Overview

• Analytical objectives
• Methods
• Results
• Directions for future research
• Questions
Analytical objectives

• Estimate multi-pollutant air-pollution related health impacts at the urban scale, using Detroit as an example
• Understand how local-scale health impacts estimates are influenced by:
  – Resolution of exposure estimates
  – Scale of baseline incidence rates
  – Geographic specificity of health impact functions
Baseline Air Quality

Post-Policy Scenario Air Quality

Incremental Air Quality Improvement

PM$_{2.5}$ Reduction

Population Ages 18-65

Background Incidence Rate

Effect Estimate

Mortality Reduction

$\Delta Y = Y_0 (1-e^{-\beta \Delta PM}) \times \text{Pop}$

August 28th, 2009 Neal Fann 2009 ISEE Presentation
National-Scale Modeling Calls for Coarse-Scale Health Inputs

- Coarse-scale air quality modeling
- Coarse-scale population exposure
- Regional or national-scale Baseline incidence and $\beta$ estimate
- Regional or national Incidence count
Local-Scale Modeling Calls for Location-Specific Health Inputs

- Fine-scale air quality modeling
- Fine-scale population exposure
- City-specific baseline incidence and $\beta$ estimate
- Local Incidence count

August 28th, 2009
Neal Fann 2009 ISEE Presentation
Specifying the Air Quality Strategies

- Two example air quality strategies for the Detroit metropolitan area:
  - One that aimed to achieve ozone and PM$_{2.5}$ air quality targets
  - One informed by expected health impacts of emission controls
## Air Quality Strategies

### Strategy 1

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Emission Reductions (tons/year)</th>
<th>Percentage from Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>$PM_{2.5}$</td>
<td>1,800</td>
<td>6%</td>
</tr>
<tr>
<td>$SO_2$</td>
<td>10,000</td>
<td>5%</td>
</tr>
<tr>
<td>$VOC$</td>
<td>5,800</td>
<td>6%</td>
</tr>
<tr>
<td>$NOx$</td>
<td>31</td>
<td>0.03%</td>
</tr>
<tr>
<td>$CO$</td>
<td>1,600</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

### Strategy 2

| Pollutant | Emission Reductions (tons/year) | Percentage from Baseline |*
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$PM_{2.5}$</td>
<td>3,200</td>
<td>10%</td>
</tr>
<tr>
<td>$SO_2$</td>
<td>2,400</td>
<td>1%</td>
</tr>
<tr>
<td>$VOC$</td>
<td>8,600</td>
<td>8%</td>
</tr>
<tr>
<td>$NOx$</td>
<td>2,000</td>
<td>2%</td>
</tr>
<tr>
<td>$CO$</td>
<td>64,000</td>
<td>15%</td>
</tr>
</tbody>
</table>

*Bold indicates an increase in emission reductions compared to strategy 1
*Italics indicate a decrease in emission reductions compared to strategy 1.
Air Quality Results

- Control strategy two yields significantly larger air quality improvements
- Air quality improvements occur in highly populated areas
## Population-weighted AQ changes

<table>
<thead>
<tr>
<th></th>
<th>Strategy 1</th>
<th></th>
<th></th>
<th>Strategy 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12km</td>
<td>1km</td>
<td>% Difference</td>
<td>12km</td>
<td>1km</td>
<td>% Difference</td>
</tr>
<tr>
<td>Total Population</td>
<td>0.249</td>
<td>0.271</td>
<td>8%</td>
<td>0.706</td>
<td>0.721</td>
<td>2%</td>
</tr>
<tr>
<td>Black Non-Hispanic</td>
<td>0.249</td>
<td>0.258</td>
<td>3%</td>
<td>0.802</td>
<td>0.803</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Asian Non-Hispanic</td>
<td>0.254</td>
<td>0.282</td>
<td>10%</td>
<td>0.626</td>
<td>0.652</td>
<td>4%</td>
</tr>
<tr>
<td>White Non-Hispanic</td>
<td>0.249</td>
<td>0.278</td>
<td>10%</td>
<td>0.613</td>
<td>0.658</td>
<td>7%</td>
</tr>
</tbody>
</table>

Strategy two achieves a **2.7x** larger population-weighted air quality change across the total population.
Incorporating Local Health Data

<table>
<thead>
<tr>
<th>Area</th>
<th>Age Range</th>
<th>Value (per 10,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nationwide*</td>
<td>0-17</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>18-64</td>
<td>17.8</td>
</tr>
<tr>
<td></td>
<td>65+</td>
<td>149</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Detroit*</th>
<th>0-17</th>
<th>No reported cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18-64</td>
<td>0 to 36</td>
</tr>
<tr>
<td></td>
<td>65+</td>
<td>31 to 320</td>
</tr>
</tbody>
</table>

*Nationwide rates represent defaults used for national-scale analyses, drawn from National Hospital Discharge Survey. Detroit estimates provided by Wayne County Dept. of Environmental Quality.
Certain Incidence Rates are Highly Correlated with Subpopulations

African-American Population

Asthma Hospitalization Rate

August 28th, 2009
Neal Fann 2009 ISEE Presentation
Distribution of Health Impacts

Asthma hospitalizations (national incidence rates)

Asthma hospitalizations (local incidence rates)
Distribution of Health Impacts

Acute myocardial infarctions among populations >65 (national rates)

Acute myocardial infarctions among populations >65 (local rates)
Directions for Future Research

• Develop new approaches for:
  – interpolating baseline incidence rates
  – using baseline health information to inform emission control strategy development

• Systematically assess the bias introduced by using coarse-scale baseline incidence rates

• Consider distributional impacts across sensitive subpopulations