Addressing Uncertainties in PM Epidemiological Studies

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1997: Top 9 Reasons Not to Regulate PM2.5

- Time Series Associations confounded
- Exposure uncorrelated with ambient
- All Harvesting
- Thresholds
- No Mechanism/Biological Plausibility
- Only due to Some Particles, will Regulate Wrong Ones
- Don’t know who is Susceptible
- Only 2 Cohort Studies/Faked
- Don’t know if lower PM2.5 means fewer deaths
Confounding in Time Series

- Case-Crossover/Matching
- Exposure Studies
- Hierarchical Modeling Approach
- NMMAPS/APHEA
Case-Crossover Analysis

• Match each death with control day nearby in time
  – Schwartz and Bateson (1999, 2001) showed how to choose so can control for Season
  – Lumley (2000) showed how to choose so avoid Selection Bias
  – Can Match on Same Concentration of Other Pollutant or Temperature
14 Cities with Daily PM10

- Controls Matched on Temperature
  - 0.39% (0.19—0.58) Increase per 10 µg/m³ PM10 (Schwartz, OEM 2004)

- Controls Matched on Other Pollutants:
  - CO 0.53% [0.04, 1.02]
  - O₃ 0.45% [0.12, 0.78]
  - NO₂ 0.78% [0.42, 1.15]
  - SO₂ 0.81% [0.47, 1.15]
    - Schwartz, EHP 2004
    - Two day mean gives larger effects
    - Not confounded
Statistical Approaches to Exposure Error

• Two arguments about exposure
  – Ambient poor surrogate for personal exposure
  – Better measured pollutant will “steal” effect from worse measured pollutant

• Zeger et al (2000)
  – Stealing very unlikely
  – Bias is downward
Hierarchical Approach

• Suppose we fit Single Pollutant Models in many Cities
• Control for Confounding by Second Pollutant Across City in Meta-analysis
• Advantage-Reduces Effect of Measurement Error (Schwartz and Coull, Biostatistics 2003)
Application: Fine Vs Coarse Particles

Air Pollution and Daily Deaths in Six US Cities (1996)
Fine Particles not Coarse (large) ones

<table>
<thead>
<tr>
<th>Particle Measure</th>
<th>Standard Estimate</th>
<th>Corrected Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM2.5</td>
<td>0.0149 (0.00197)</td>
<td>0.0342 (0.00287)</td>
</tr>
<tr>
<td>Coarse Mass</td>
<td>-0.00206 (0.00491)</td>
<td>-0.0235 (0.00616)</td>
</tr>
</tbody>
</table>

Paper recently published in Biostatistics.
Application: Reanalyze NMMAPS

- 90 Cities
  - Slightly larger effect of PM10 (less measurement error)
  - Zeka and Schwartz, EHP in press
Exposure and Confounding

• In Baltimore and Boston
  – Ambient Ozone, NO2, SO2 are better predictors of Exposure to PM2.5 than of Exposure to themselves
  – NO2 and CO better predict traffic particles
  – Ozone better predicts Sulfates

• Suggests in Eastern US two pollutant models are just source apportionment for PM effects, and need personal monitoring to study gases
Threshold?

- Combine data across multi-city studies
Dose Response between PM2.5 and Daily Deaths

Random Effects Model
Harvesting?

Combine over 10 European Cities
Look at effects out to 40 days
4 Degree Distributed Lag in 10 Cities - Random Effect Model
Only Some Sources produce Toxic Particles?

Laden et al, EHP 2000

Traffic, Coal and Residual Oil particles all toxic

Seattle Studies ➔ Wood Smoke Toxic
Spatial U.S. Variability of PM$_{2.5}$ Factors

- Soil
- Motor Vehicles
- Coal
- Oil

Locations:
- Phoenix, AZ
- Los Angeles, CA
- Pittsburgh, PA
- New York City, NY
Cohort Studies

- Reanalyzed and found to be Robust (HEI)
- New Cohort in Netherlands finds effects of traffic particles on mortality
- Children’s Health Study finds Air Pollutants (including particles) impair Lung Growth in Children
Mortality and Air Pollution in 6 US Cities in 2 Followup Periods
**So Where Are We?**

<table>
<thead>
<tr>
<th>Time Series Confounding?</th>
<th>Exposure Uncorrelated with Ambient?</th>
<th>Harvesting?</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓</td>
<td>✓ ?</td>
<td>✓</td>
</tr>
<tr>
<td>Thresholds?</td>
<td>Biologically Plausible?</td>
<td>Which Particles?</td>
</tr>
<tr>
<td>✓</td>
<td>✓ ?</td>
<td>✓ ?</td>
</tr>
<tr>
<td>Susceptibility?</td>
<td>Cohort Studies?</td>
<td>Only Correlation?</td>
</tr>
<tr>
<td>✓ ?</td>
<td>✓ ?</td>
<td>✓</td>
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</tbody>
</table>
Future Epidemiologic Studies

• Susceptibility
  – New groups (Pregnancy Outcomes, Diabetics, etc)

• Mechanisms of Toxicity
  – Use drugs, etc to test pathways

• Separate out Different Sources/Characteristics of Particles

Chronic Effects (sources, pathways, etc)