Ozone Effect on Mortality
A multi-site time series study

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Outline of Presentation

- Introduction
- Aims
- Method and analysis
- Summary
- Future work
Ozone & Morbidity / Mortality

- Pulmonary function declines with repeated daily ozone exposure (<0.25 ppm).
- Positive association has been found between respiratory admission & summer ozone exposure.
- Significant association has been found between daily mortality & ozone in Los Angeles, New York.
- Ozone exposure might be related to daily fluctuations in admissions for congestive heart failure in the elderly.

NMMAAPS Data

(The national mortality morbidity Air pollution study)

- **Mortality** (1987 – 1994)
  -- National Center for Health Statistics
  - Total, CVD, RESP, Oth for three age groups ( <65, 65-75, >75 )

- **Air pollution** (1987 – 1994)
  -- Environmental Protection Agency
  - $\text{PM}_{10}$, $\text{O}_3$, CO, $\text{SO}_2$, and $\text{NO}_2$

- **Meteorology** (1987 – 1994)
  -- National Climatic Data Center
  - Temperature and dew point

- **Summer months only** (6,7,8,9)
Location of Cities
Outcome

- CVDRESP death = CVD + RESP

Reasons:

- People with existing respiratory diseases might be more sensitive to ozone exposure.

- Ozone exposure might be related to congestive heart failure in the elderly.

- O3 exposure is likely not to be associated with other-cause related death.

Aims

1. to estimate city-specific and overall relative rates of CVD & RESP mortality from summer exposure to ozone combining information across the largest 20 US cities.

2. to explore the exposure-response time lag.

3. to investigate the confounding effects of other pollutants

4. to explore the sensitivity of the results to the adjustment for trends.
Confounding

- Meteorology confounders:
  - Temperature
  - Dew point temperature

- Biologic confounders:
  - Age
  - Time
  - Day of week.

- Confounding from other pollutants:
  - PM$_{10}$, CO, SO$_2$, and NO$_2$
Stage I - city-specific effect

- Poisson time series regression by Generalized Additive Model
- Model:
  \[
  \log (E[y]) \sim [O3] + \text{age} + \text{dow} + s(\text{Time},8) + s(\text{temperature},8)
  \]
  \[
  \log (E[y]) \sim [O3] + [\text{mix pollutant}] + \text{age} + \text{dow} + s(\text{Time},8) + s(\text{temperature},8)
  \]
- [O3]: different lag --- lag 0/1/2
- [mix pollutant]: PM$_{10}$, CO, SO$_2$, and NO$_2$
Stage II – Bayesian Hierarchical model

- $\beta_i^c \sim N(\theta_i^c, \sigma_i^2)$
- $\theta_i^c, \sim N(\mu, \tau^2)$

- $\mu$: the overall log odds ratio of CVD & RESP mortality from summer ozone exposure combining information across the largest 20 US cities.

- Using BUGS for the analysis under non-informative prior.
Univariate Ozone Effect

95% Confidence Interval for O3-lag2 coefficient, for summer

Ozone estimates with 95% confidence interval
Ozone Effect Adjusted by PM10, lag 2
### Estimates on Overall ozone effect

#### Table 5, O3 - 20 cities total effect on CVD & RESP

<table>
<thead>
<tr>
<th>slope</th>
<th>O3 + PM$_{10}$</th>
<th>O3 + NO$_2$</th>
<th>O3 + SO$_2$</th>
<th>O3 + CO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>O3 lag 0</strong></td>
<td>0.088 (-1.169, 1.36)</td>
<td>0.303 (-0.186, 0.764)</td>
<td>0.267 (-0.233, 0.756)</td>
<td>0.314 (-0.151, 0.751)</td>
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<td>0.359 (-0.117, 0.836)</td>
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<tr>
<td><strong>O3 lag 1</strong></td>
<td>-0.397 (-1.348, 0.512)</td>
<td>0.534 (-0.014, 1.02)</td>
<td>0.456 (-0.003, 0.888)</td>
<td>0.50 (0.074, 0.89)</td>
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<td>0.504 (0.083, 0.900)</td>
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<tr>
<td><strong>O3 lag 2</strong></td>
<td>1.247 (0.435, 2.123)</td>
<td>0.663 (0.127, 1.146)</td>
<td>0.665 (0.179, 1.11)</td>
<td>0.649 (0.191, 1.06)</td>
</tr>
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<td>0.660 (0.206, 1.065)</td>
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Results

- Overall, there is statistically significant positive association between ambient summer O3 and CVD & RESP mortality at lag 1 and lag 2.
- The association between mortality and summer ozone is confounded by PM$_{10}$, but not confounded by CO, SO$_2$, and NO$_2$.
- The city-specific and overall ozone effects results under univariate and multi-pollutants models are not sensitive to the selection of the number of d.f. in the smooth function of time.
Discussion

- Measurement error
- Multi-pollutants model
- Comparison of Case-crossover design and Time-series design
- Clustering on synoptic whether to control temperature effect
- Is the association between ambient O3 and mortality confounded by ultra-fine particle?
Acknowledgments

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- Thank Dr. Bandeen-Roche for the great information on confounding.
Any Questions?