Seasonal Analyses of Air Pollution and Mortality in 100 U.S. Cities

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(Joint with Dominici, F., Pastor-Barriuso, R., Zeger, S., and Samet, J.)
Time series studies of air pollution and mortality

- Examine short-term effects of air pollution on mortality (on the order of a few days)
- Compare *within-city* day-to-day variation of pollution with day-to-day variation in mortality
- Recent multi-city studies: APHEA (2000), NMMAPS (2002), and analyses of Canadian cities
Why seasonal analysis?

• Particulate matter (PM) mixture changes
  – Different sources
  – Meteorology

• Understand spatial-temporal variation in short-term effects of particulate matter
  – Examine seasonal patterns by region

• Guide the specification of hypotheses about toxic constituents
Data

• Updated from the original National Morbidity, Mortality, and Air Pollution Study (NMMAPS)

• Original NMMAPS had daily mortality, pollution, and weather data for 90 cities, 1987—1994

• Updated database covers 1987—2000 and has data on 100 cities
NMMAPS Cities
Data (cont’d)

• Daily mortality, air pollution, and weather
• Causes of death
  – Total non-accidental, CVD, respiratory, COPD, pneumonia, accidental
• Pollutants
  – PM$_{10}$, PM$_{2.5}$, SO$_2$, NO$_2$, O$_3$, CO
• Weather
  – temperature, dew point, relative humidity
Daily mortality in 10 largest cities

Los Angeles  New York  Chicago  Dallas/FW  Houston  Phoenix  Anaheim  San Diego  Miami  Detroit
PM$_{10}$ by season and region

![Graph showing PM$_{10}$ levels by season and region.]
City-specific Models

Overdispersed Poisson regression models

\[ Y_t \sim \text{Poisson}(\mu_t) \]
\[ \text{Var}(Y_t) = \mu_t \phi \]
\[ \log \mu_t = \beta(t) \ x_{t-1} + \text{DOW} + \text{AgeCat} \]
\[ + s(\text{temp}_t; 6 \ df) + s(\text{temp}_{1-3}; 6 \ df) \]
\[ + s(\text{dew point}_t; 3 \ df) + s(\text{dew point}_{1-3}; 3 \ df) \]
\[ + s(\text{time}; 7 \ df/\text{year}) \]
\[ + s(\text{time}; 1 \ df/\text{year}) \times \text{AgeCat} \]
Seasonally varying effects

\[ \beta(t) = \gamma_1 \text{Winter} + \gamma_2 \text{Spring} + \gamma_3 \text{Summer} + \gamma_4 \text{Fall} \]

\[ \beta(t) = \beta_0 + \beta_1 \sin(t \frac{2\pi}{365}) + \beta_2 \cos(t \frac{2\pi}{365}) \]
Pooling results across cities

Hierarchical model

\[ \hat{\beta}_{city} \sim N(\beta_{city}, \hat{\sigma}^2_{city}) \]
\[ \beta_{city} \sim N(\alpha, \tau^2) \]

\( \alpha \) is the national average effect
Seasonally varying effect of PM$_{10}$ at lag 1 by region
Adjusting for seasonal and long-term trends

![Graph showing mortality trends](image-url)
Future Work

• Examine data from EPA’s PM speciation trends network
• Characterize spatial-temporal trends in PM constituents across the U.S.
• Explore the relationship between PM constituents and short-term effects of PM
NMMAPSdata Package

- R package containing entire updated NMMAPS database
- Tools for managing versions of the database
- Supplemental code for reproducing seasonal analyses

- [http://www.ihapss.jhsph.edu/](http://www.ihapss.jhsph.edu/)
- [http://www.biostat.jhsph.edu/~rpeng/](http://www.biostat.jhsph.edu/~rpeng/)