Seasonal Analyses of PM10 and Mortality

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May 17, 2004

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Seasonal Analyses of PM10 and Mortality
Why a seasonal analysis?

• Better understand the health effects of PM constituents
• Guide future analyses of PM constituent data

Meteorology

• Different sources

Particulate matter mixture changes with season

• of particulate matter (PM)

• Understand temporal and regional variation in short-term effects

Why a seasonal analysis?
Updated NMMAPS Data


Availability of PM$_{10}$ data varies by city and by time period:

- Every day
- 1 in 3 days
- 1 in 6 days

Updated NMMAPS Data
\[ Y_t = \text{Poisson regression for day } t \]

\[ \log(\phi_t) = (\mathbf{X}_t) \gamma_t \]

\[ \text{Var}(\phi_t) = (\mathbf{X}_t) \Psi_t \]

\[ (\mathbf{Y}_t) \text{Poisson regression models} \]

\[ \mathbf{X}_t: \text{mortality count for day } t \]

\[ x_{t-j} \text{ pollution exposure at day } t \text{ and lag } j \]

\[ x_t: \text{age category} \times \text{time; } 1 \text{ per year} \]

\[ x_t: \text{time; 7 per year} \]

\[ x_t: \text{dewpoint temp} + s(\text{dewpoint temp}) \]

\[ x_t: \text{time; 1 per year} \]

\[ x_t: \text{time; 7 per year} \]

\[ x_t: \text{dewpoint temp} + s(\text{dewpoint temp}) \]

\[ x_t: \text{time; 7 per year} \]

\[ x_t: \text{time; 1 per year} \]

\[ x_t: \text{Indicator for age category} + \text{DOW} \]

\[ \mathbf{Y}_t: \text{mortality count for day } t \]

\[ \text{age category} \times \text{time; } 1 \text{ per year} \]

\[ \text{time; 7 per year} \]

\[ \text{dewpoint temp} + s(\text{dewpoint temp}) \]

\[ \text{time; 7 per year} \]

\[ \text{time; 1 per year} \]

\[ \text{Indicator for age category} \]

\[ \text{DOW} \]

\[ \text{pollution exposure at day } t \text{ and lag } j \]
Seasonal models

Seasonal indicator: 
\[
(t)\theta' = (t)\theta
\]

Smooth periodic: 
\[
(t)\theta' + \int_{\text{Winter}} dS\theta + \int_{\text{Spring}} S\theta + \int_{\text{Summer}} I\theta + \int_{\text{Fall}} F\theta = (t)\theta
\]
Season

Daily mortality counts

Los Angeles
New York
Chicago
Dallas/FW
Houston
Phoenix
Anaheim
San Diego
Miami
Detroit
San Diego
Miami
Anaheim
Phoenix
Houston
Dallas/FW
Chicago
New York
Los Angeles
Seasonal patterns by region

Day in Year

% incr. in mortality with 10μg/m³ incr. in PM_{10}

Industrial Midwest
North East
North West
Southern California
South East
South West
Upper Midwest
All Regions
\[ (\frac{\theta}{365}) \cos(\theta) + (\frac{\theta}{365}) \sin(\theta) = (t) \theta \]

Posterior distribution for seasonal coefficients
Sensitivity to the smooth function of time (Lag 1)

Day in year

% incr. in mortality with 10

mg

incr. in PM

Industrial Midwest

North East

North West

South West

Southern California

Upper Midwest

South East

All Regions

3 df 5 df 7 df 9 df 11 df 13 df

100 200 300

0

1.5 1.0 0.5 0.0 −0.5

% incr. in mortality with 10μg/m³ incr. in PM

10
Seasonal patterns by region and exposure lag

Day in year

% incr. in mortality with 10\(\mu g/m^3\) incr. in PM10

Industrial Midwest
North East
North West
Southern California
All Regions
Upper Midwest
South West
Southeast
North East
Midwest

Lag 0
Lag 1
Lag 2
Seasonal distributed lag model for 19 cities

% Increase in mortality with 10 μg/m³ increase in PM10

Season

Fall  Summer  Spring  Winter
What next?

The current NAAQS for PM is both size and mass-based and implicitly assumes that all particles of a given size have the same toxicity per unit mass, irrespective of chemical composition. A better understanding of characteristics that modulate toxicity could lead to targeted control strategies specifically addressing those sources having the most significant adverse effects on public health. To inform regulatory discussions on control strategies, a better understanding of the mechanisms of PM effects is required to develop a better systematic research effort.

HEI Perspectives, April 2002.

Continuing Research Progress, NRC, March 2004

Research Priorities for Airborne Particulate Matter: IV...to inform regulatory discussions on control strategies.
Develop a better understanding of the toxicity of PM components

Examine spatial-temporal variation of PM constituent/speciation data.

Develop specific hypotheses for PM and mortality.

What next?