

**A Multi-Site Time Series Study of
Hospital Admissions and Fine
Particles:
A Case-Study for National Public
Health Surveillance**

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A NATIONAL ANALYTIC SYSTEM FOR TRACKING POPULATION HEALTH

- Multiple government databases contain massive amounts of information on the environmental, social, and economic factors that determine health
- Research on population health could be rapidly advanced by integrating these existing databases and bringing to bear new statistical models that would describe major threats and their causes
- These integrated databases and new analysis tools would create a **national analytic system for population health research**

Hospital Admissions and Fine Particles: Objectives

1. assemble a national database of time series data for the period **1999-2002** on hospital admissions rates for cardiovascular and respiratory diseases, fine particulates, and weather for approximately **400 US** counties
2. develop state-of-the-art statistical methods
3. estimate maps of relative risks of hospital admissions associated with short-term changes in fine particles
4. illustrate how integration and analysis of national databases can lead to a **national health monitoring system**

Particle air pollution clearly causes substantial deaths and illness, but what makes fine particles so toxic—the size, the chemical compound, or both?

Mounting Evidence Indicts Fine-Particle Pollution

Now the issue is getting another look as EPA faces a December 2005 deadline for revisiting its PM_{2.5} standard. EPA scientists,

after reviewing piles of new data implicating PM_{2.5} in health effects, have proposed tightening the 1997 standard to further reduce ambient concentrations of fine particles. Some scientists and industry groups remain skeptical, noting that researchers still haven't pinned down what makes particles dangerous—whether it's mainly size, and that the tiniest particles are most potent; or chemistry, such as metal content; or some combination

of the two. Despite 8 years and some \$400 million in research, finding out exactly how fine particles do their dirty work has proved frustratingly elusive, researchers say. "We've

gotten glimpses, but we don't yet have enough systematic coverage of the problem," says epidemiologist Jon Samet of Johns Hopkins University in Baltimore, Maryland.

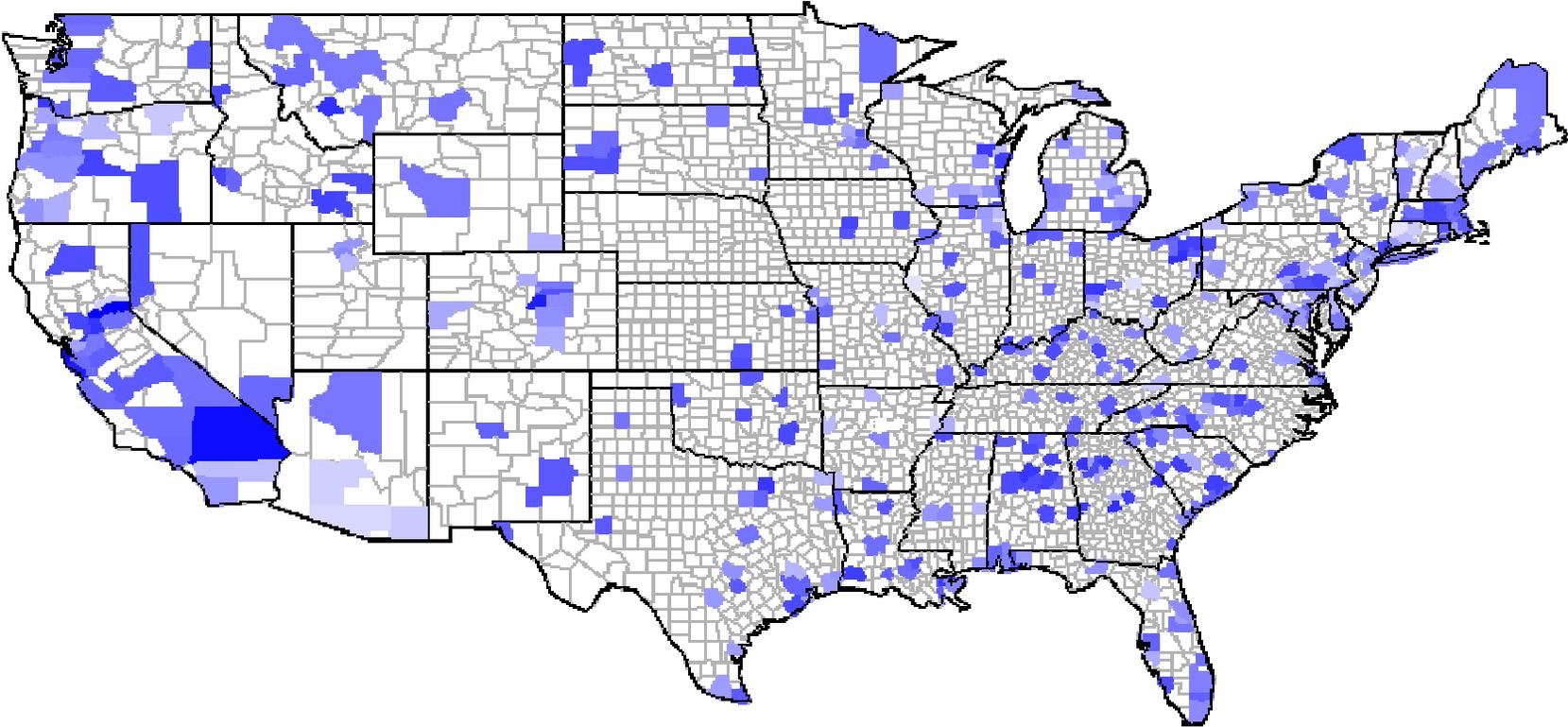
Urgent need to estimate:

- **short-term effects of PM_{2.5} on mortality and morbidity on average for the entire country**

National Medicare Cohort (1999–2002)

- National study of fine particles (PM_{2.5}) and hospital admissions in Medicare
- Data include:
 - Billing claims (NCHF) for everyone over 65 enrolled in Medicare (~48 million people),
 - date of service
 - treatment, disease (ICD 9), costs
 - age, gender, and race
 - place of residence (ZIP code/county)
 - Approximately 400 counties linked to the air pollution monitoring

Medicare counties linked to air pollution monitoring



Linking National Databases for Tracking Population Health

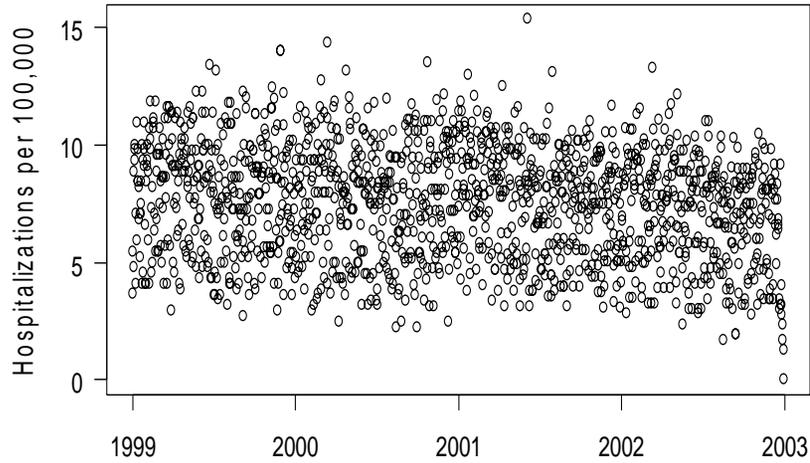
- We have identified the largest **400 counties** in the USA with PM2.5 daily data available for the period **1999-2002**
- For each of these counties, we have constructed daily time series of hospitalization rates for the following diseases:
 - COPD (*239 counties*)
 - Respiratory Infections (*239*)
 - Ischemic heart diseases (*251*)
 - Heart failure (*247*)
 - Cerebrovascular diseases (*250*)
 - Heart rhythm (*241*)
 - Accidents (*265*)

Multi-site time series studies

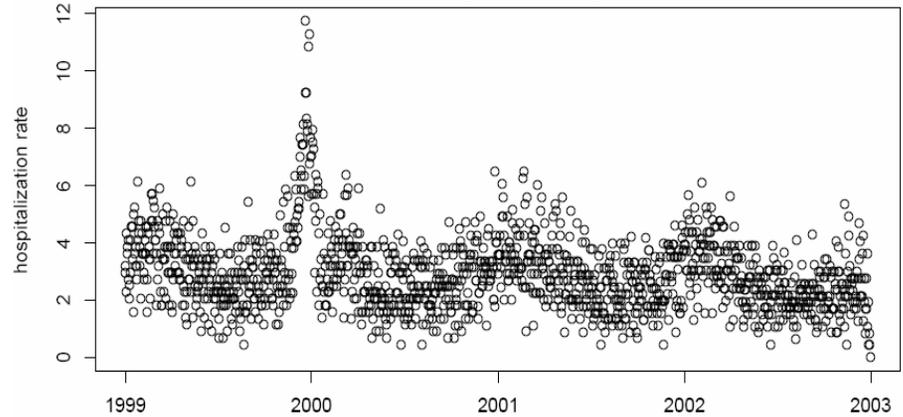
- Compare day-to-day variations in hospital admission rates with day-to-day variations in pollution levels within the same community
- Avoid problem of unmeasured differences among populations
- Key confounders
 - Seasonal effects of infectious diseases and weather

Daily time series of hospitalization rates and PM_{2.5} levels in Los Angeles county (1999-2002)

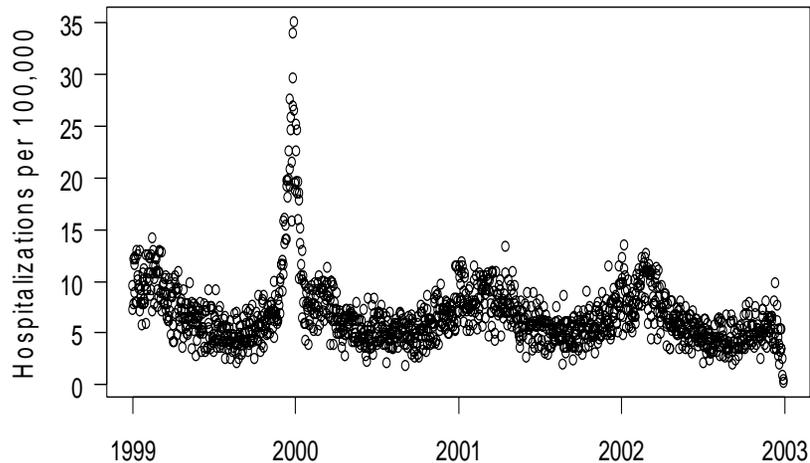
Ischemic heart disease, Los Angeles County, 1999--2002



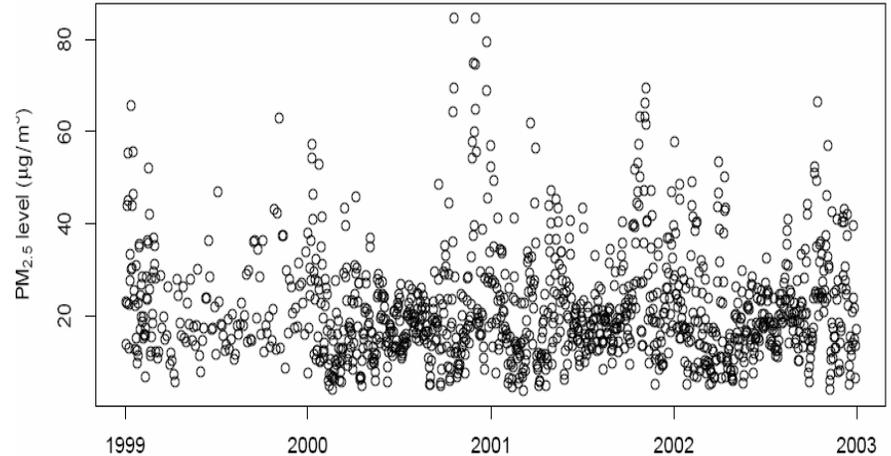
Daily COPD hospitalization rate (per 100,000) for Los Angeles County, CA



Respiratory infection, Los Angeles County, 1999--2002



Daily PM_{2.5} for Los Angeles County, CA

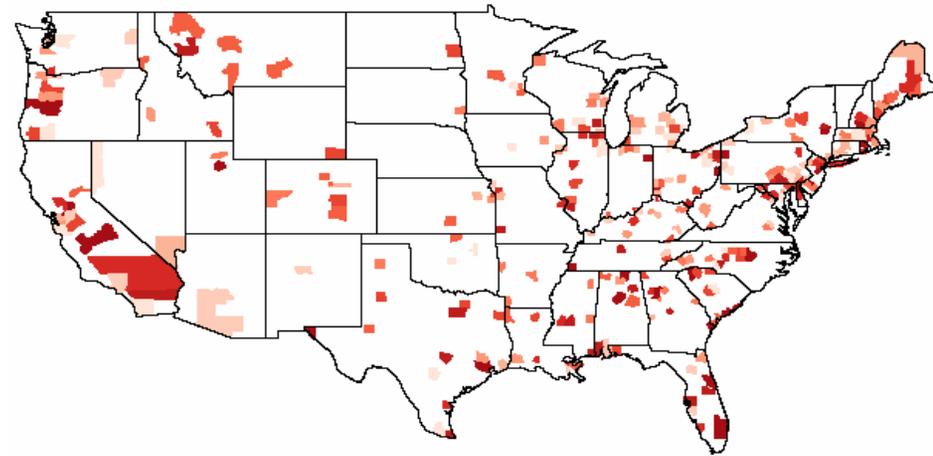
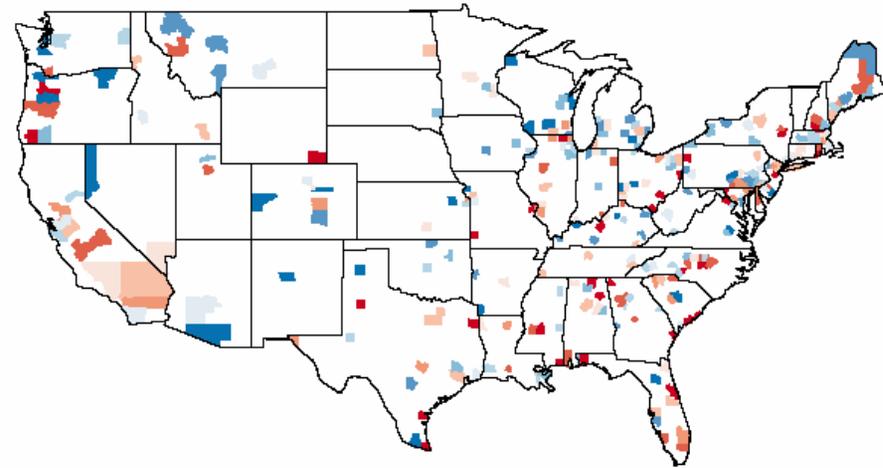


National Maps of short-term effects of PM_{2.5} on hospital admissions for COPD

County-specific estimates of short-term effects of PM2.5 on COPD hospitalizations (239 counties, 1999-2002)

Using only county-specific information

Borrowing strength across counties



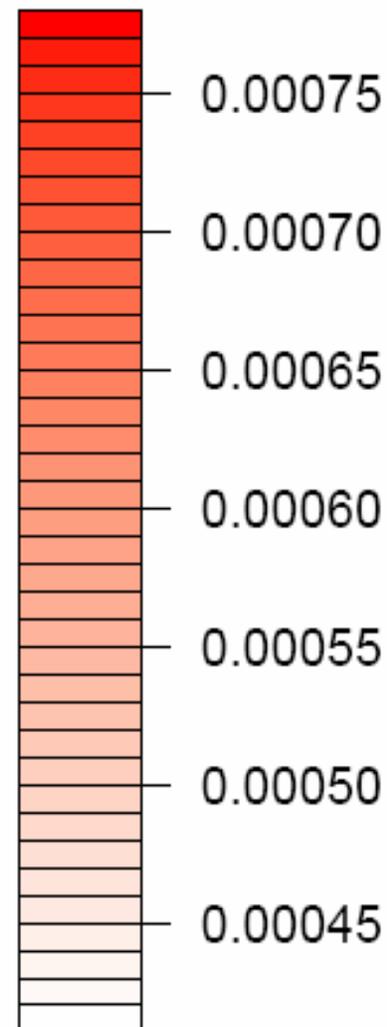
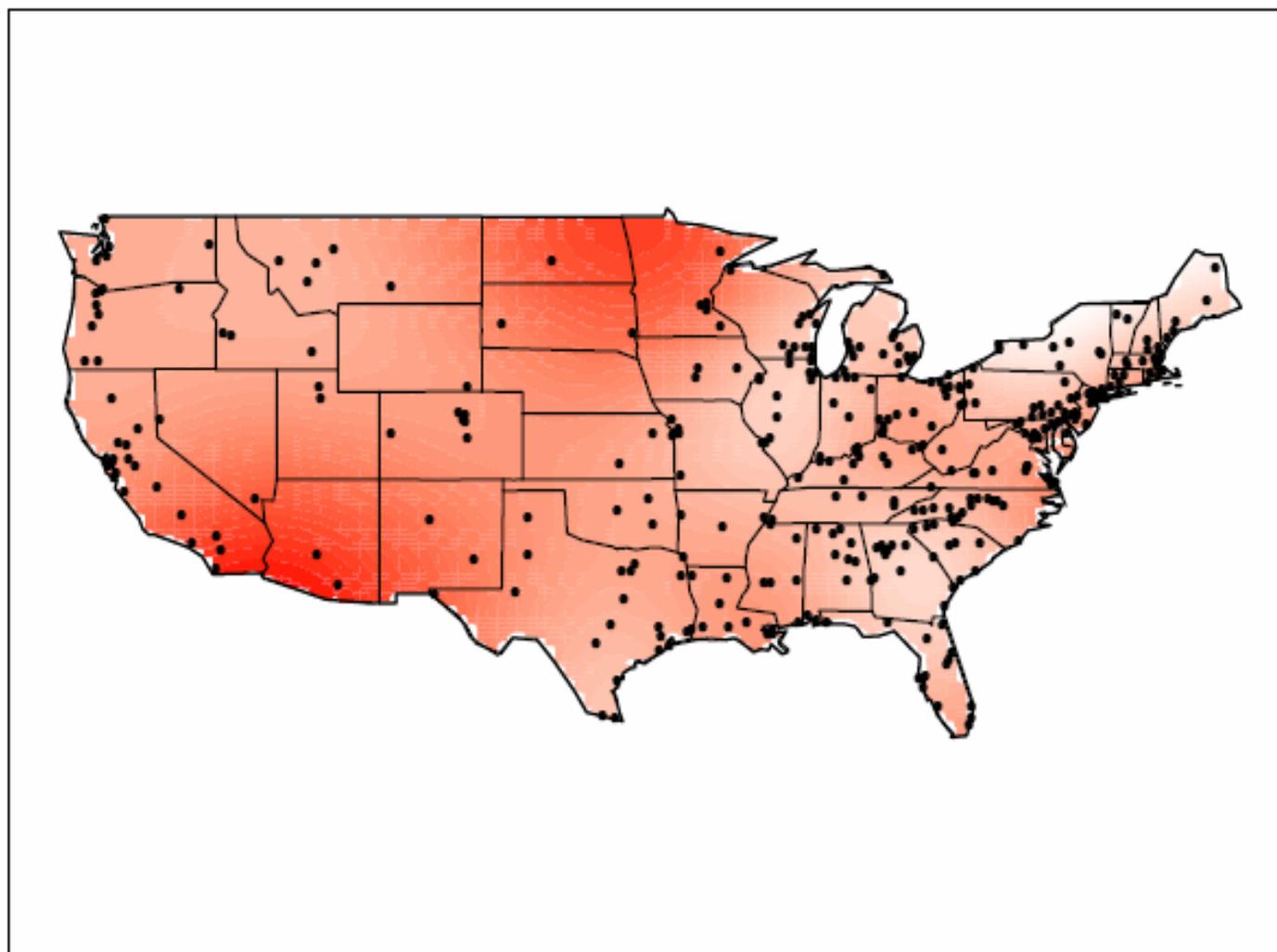
Maximum likelihood estimates, 314 counties

Bayesian estimates, 314 counties



By combining information across counties, we found that the percentage increase in COPD hospitalizations associated with a 10 units increase in PM2.5 varies between 0 and 3.1% across the country

Short-term effect of PM_{2.5} on COPD admissions, 1999–2002



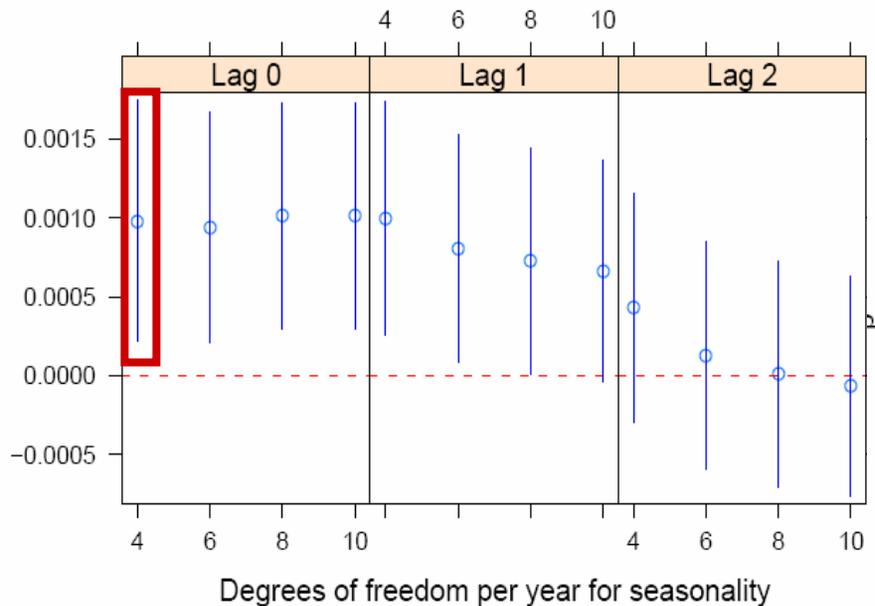
Why do a joint analysis of all the counties?

- Individual counties can be selected to show one point or another
- Results from individual counties are much more sensitive to model assumptions and are swamped by statistical error
- There is not reason to expect that two neighboring counties with similar sources of particles would have qualitative different relative risks

**National average estimates of
the short-term effects of
PM2.5 on hospital admissions
for respiratory and
cardiovascular diseases**

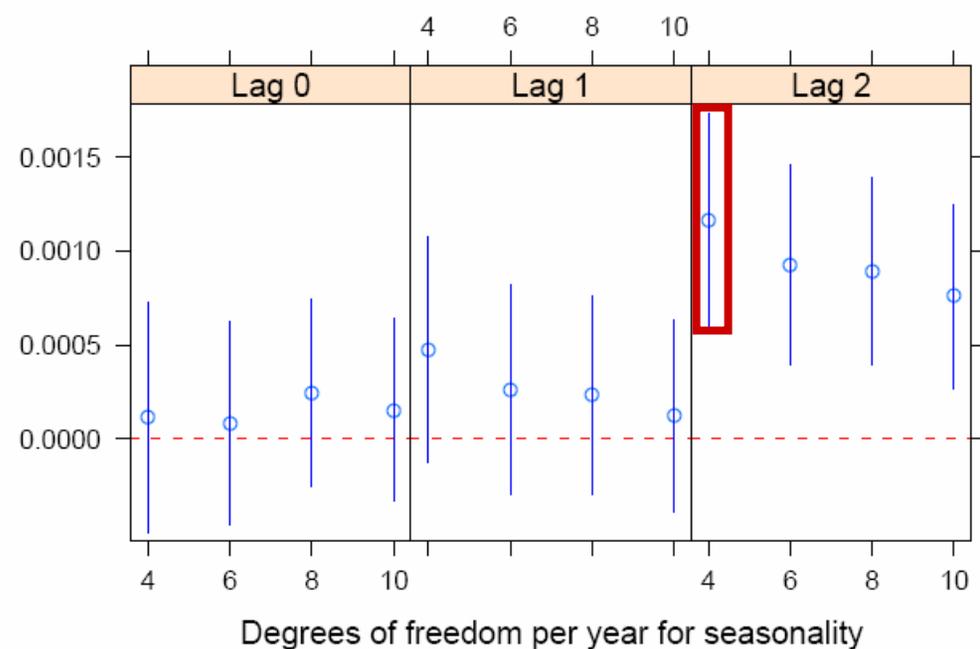
PM2.5 and Respiratory Outcomes: National averages risks (1999-2002)

PM_{2.5} and admissions for COPD (239 counties)



A 10 units increase in PM_{2.5} on the same day is associated with a 1% increase in hospital admissions for COPD

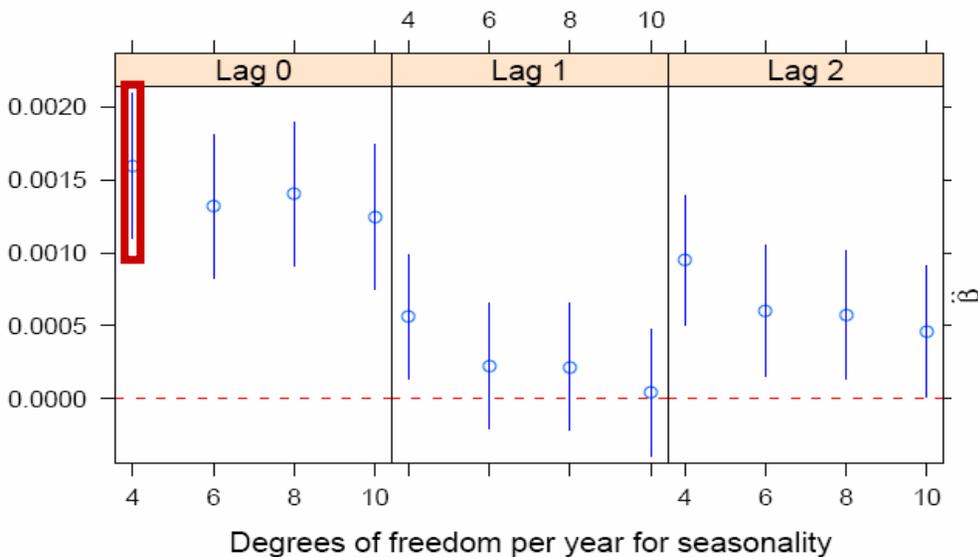
PM_{2.5} and admissions for respiratory infection (239 counties)



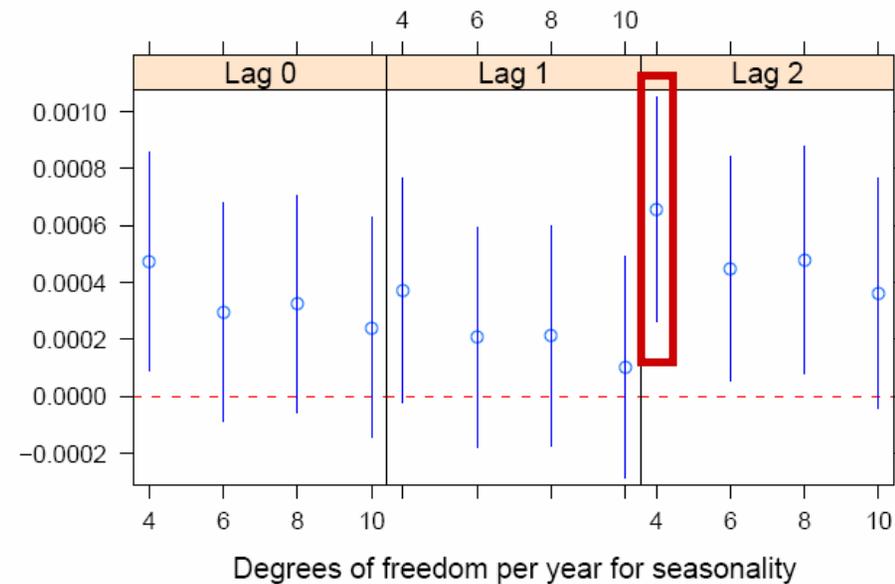
A 10 units increase in PM_{2.5} at lag 2 is associated with a 1.2% increase in hospital admissions for respiratory inf

PM2.5 and Cardiovascular Outcomes: National averages risks (1999-2002)

PM_{2.5} and admissions for heart failure (251 counties)



PM_{2.5} and admissions for ischemic heart disease (247 counties)



A 10 units increase in PM_{2.5} on the same day is associated with a 1.7% increase in hospital admissions for heart failure

A 10 units increase in PM_{2.5} on the same day is associated with a 0.75% increase in hospital admissions for ischemic heart disease

Results

- **We have illustrated a case study of tracking health risks associated to a short-term exposure to fine particles on a national scale**
- **We have linked by county of residence Medicare hospital rates for different diseases to daily ambient concentration of pollution and weather variables**
- **National analyses indicate that short-term exposure to PM_{2.5} is significantly associated with an increase of hospital admission rates for respiratory and cardiovascular outcomes**
- **National maps of short-term effects of PM_{2.5} on COPD hospital admission rates indicate that these effects vary across the country between 0 to 3.1%**

Air pollution and health: Questions and (some) answers

- **Is there a risk?**

- Multi-site time series studies such as NMMAPS (1987—2000) provide strong evidence of short-term association between air pollution and mortality
- Preliminary results from Medicare data (1999—2002) indicate that current air pollution levels still affect health

- **How can we estimate it?**

- National datasets are powerful resources for assessing the health effects of air pollution
- Statistical models that can integrate information across space and time
- National average estimates for the effect of PM are robust to various model formulations and statistical methods

Discussion

- Linking national databases and developing statistical methods that can properly analyze these them, are essential steps for **a successful national public health tracking system**
- Because of the small risks to be detected and the large number of potential confounders, single-site studies are generally swamped by statistical error
- **A national analytic system**, that routinely analyze data from multiple locations in a systematic fashion, **is a very promising approach for tracking population health**

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Air pollution and health: Common challenges

- **Estimating small effects (with potentially large exposures)**
- **Results inform substantial policy decisions, affect many stakeholders**
- **Complex statistical methods employed, partially due to complexity of data**
 - **Statistical methods subjected to intense scrutiny from all sides**

County-specific model

$\log(\text{expected mortality at day } t) \sim \log(\text{number of people at risk at day } t) +$
long term trends + season + weather + **pollution** + others

- Poisson regression
- Smooth functions of time, season, and weather

Multi-site time series models of air pollution and mortality

- **Stage 1 (within county):** Poisson regressions for estimating short-term association between air pollution and mortality, controlling for time-varying confounders
- **Stage 2 (between counties):** Hierarchical model for pooling information across neighboring cities and obtaining a national average effect