Air Pollution Kills

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Bottom Line

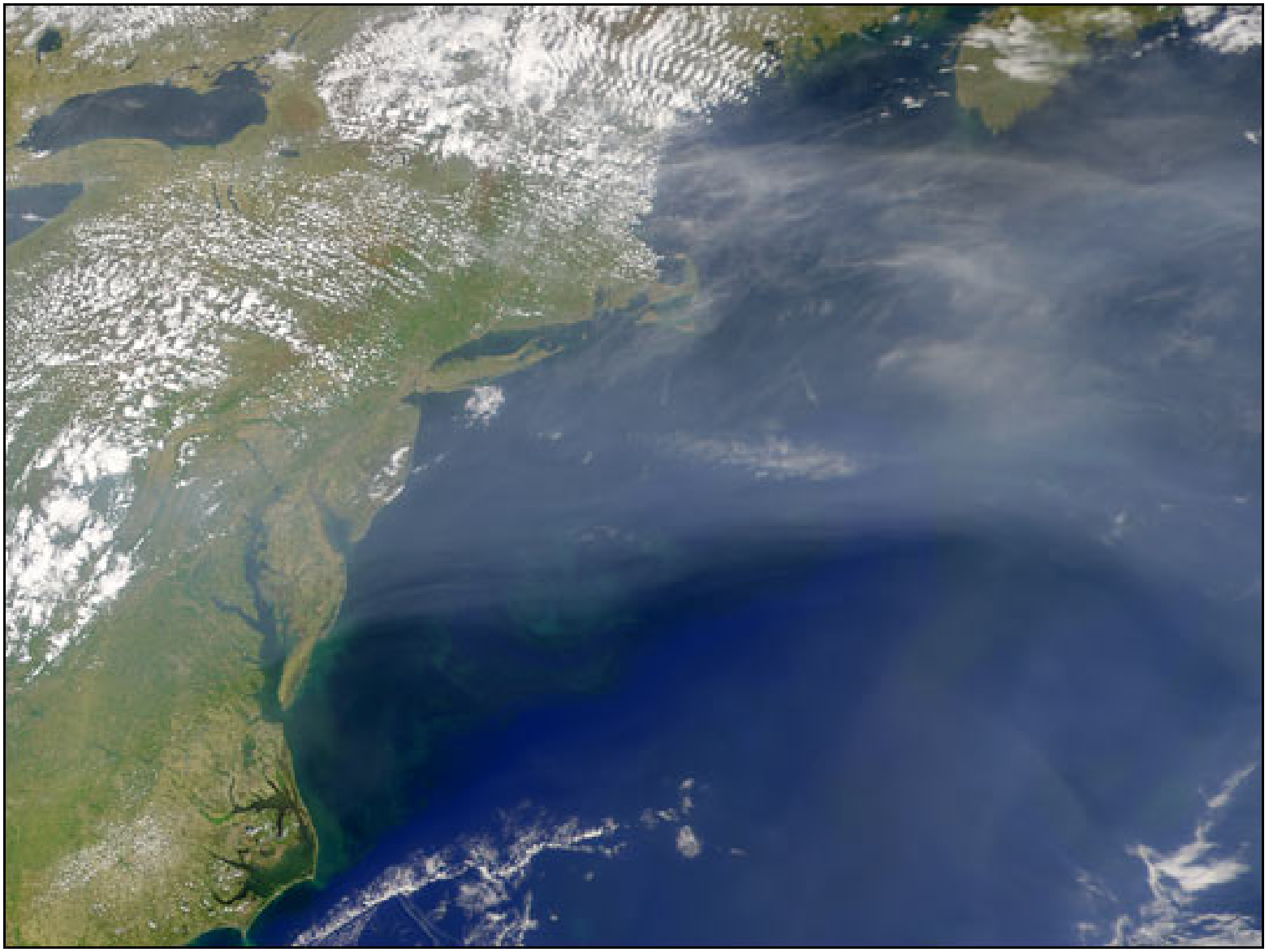
- Particulate Air Pollution kills more people each year than AIDS, Breast Cancer, and Prostate Cancer put together
- The difference is we know how to cure Particulate Air Pollution
  - Scrubbers
  - Diesel Particle Filters
  - Catalysts for NOx and HC

Why should you believe me?

What is Particulate Air Pollution?

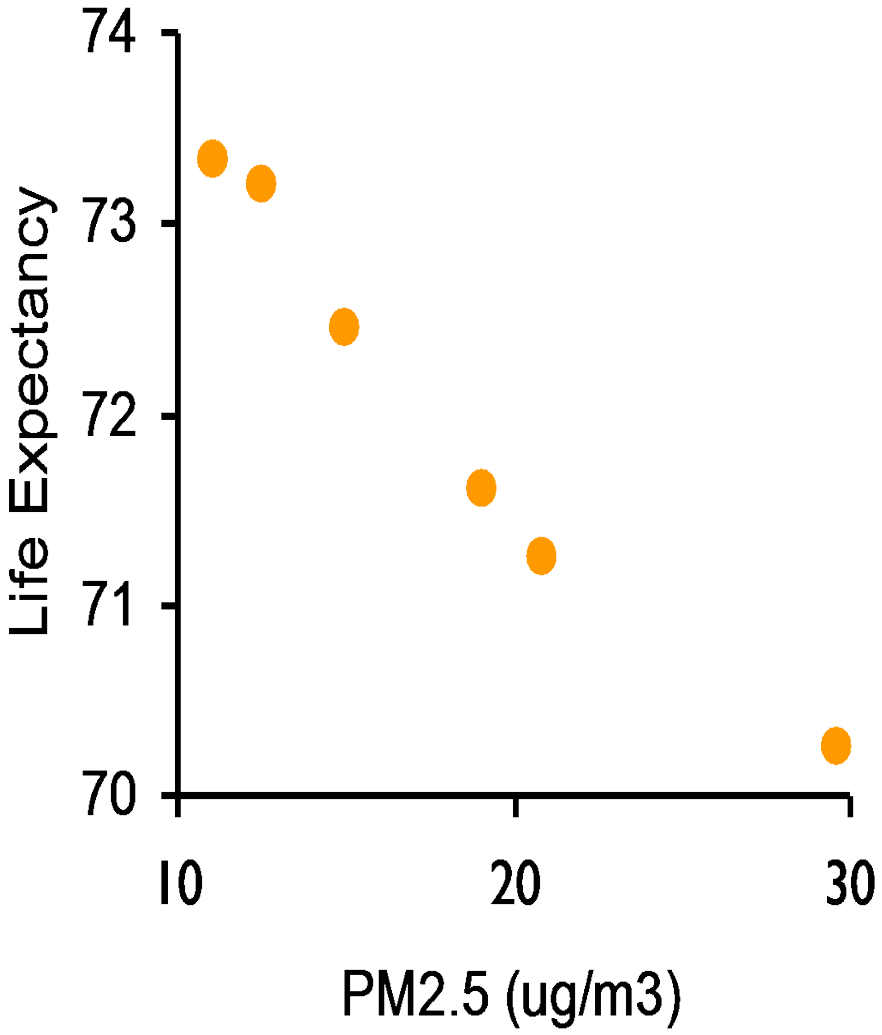
- Is there evidence that more people die when it is higher?

Sulfate Haze 5/4/2002

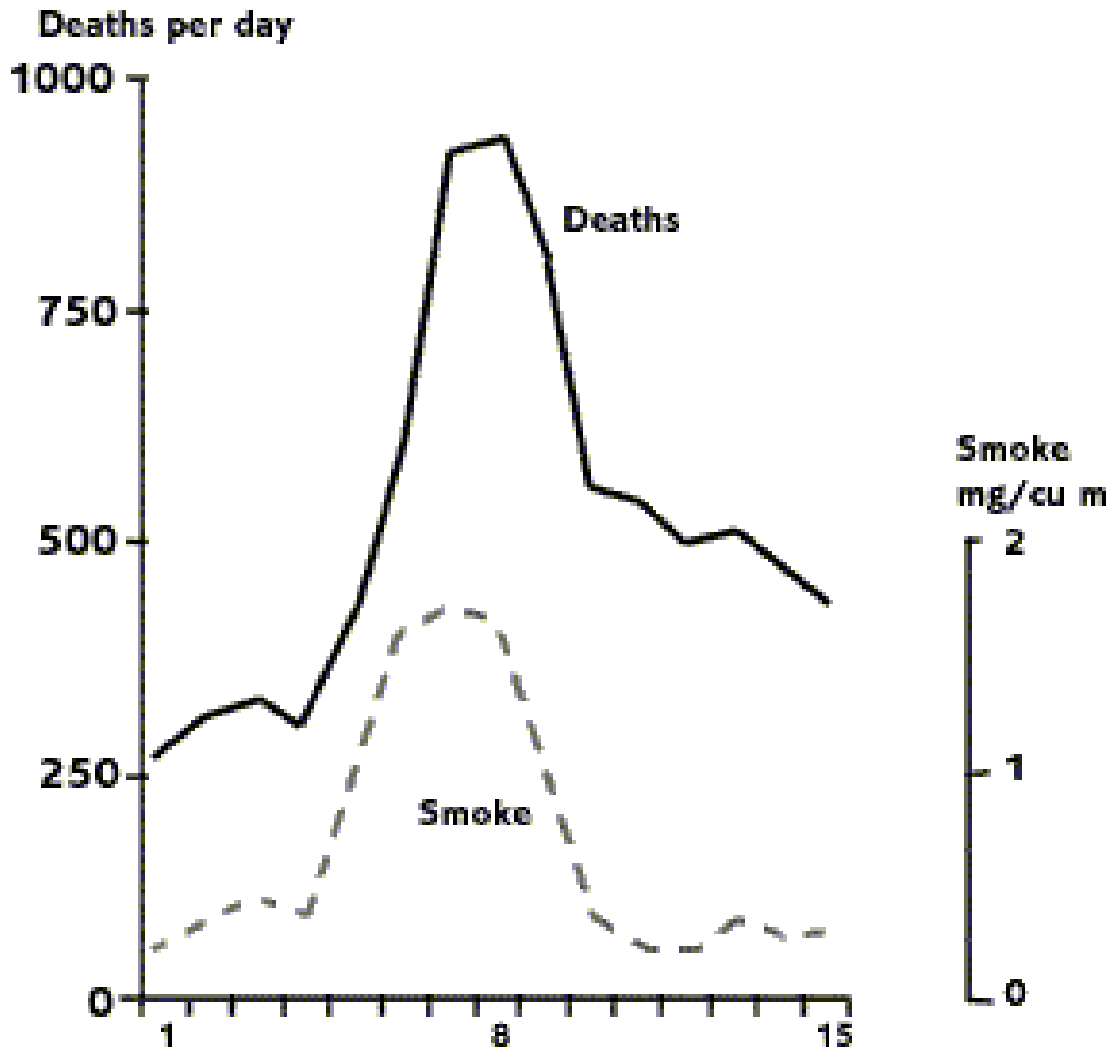


Harvard Six Cities Mortality

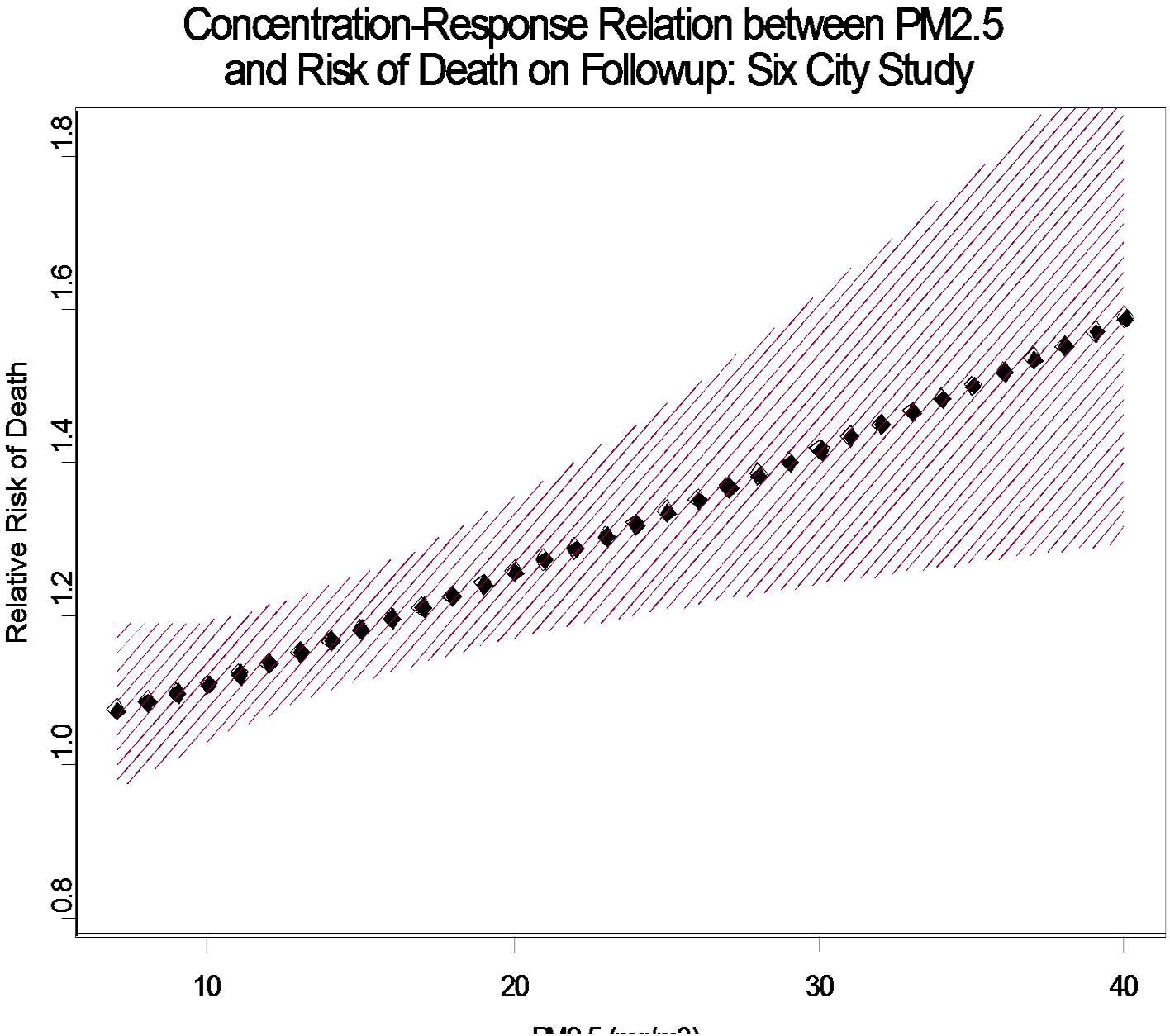
Controlling for high blood Pressure, smoking, diabetes etc

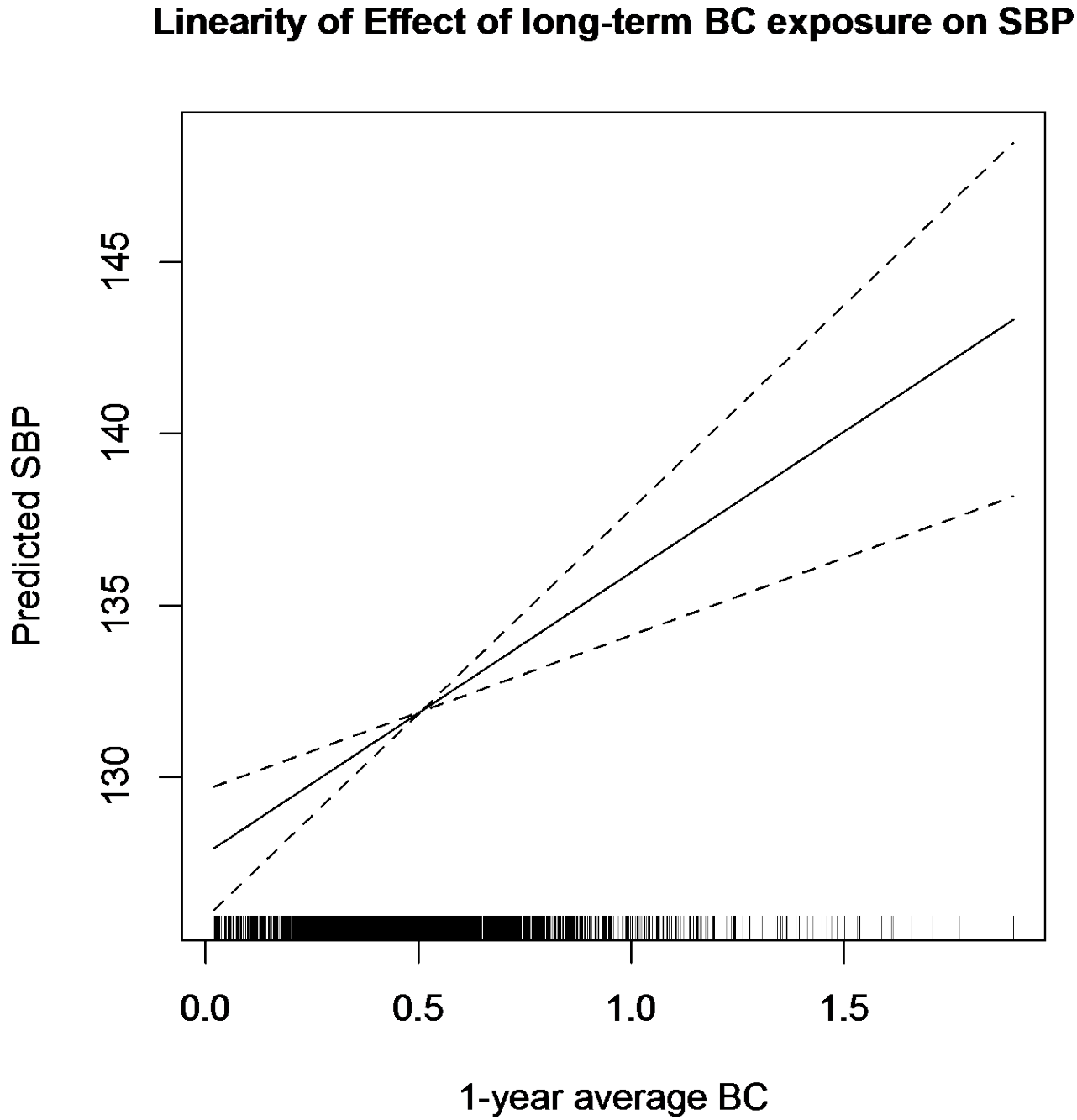


London Smog, December 1952

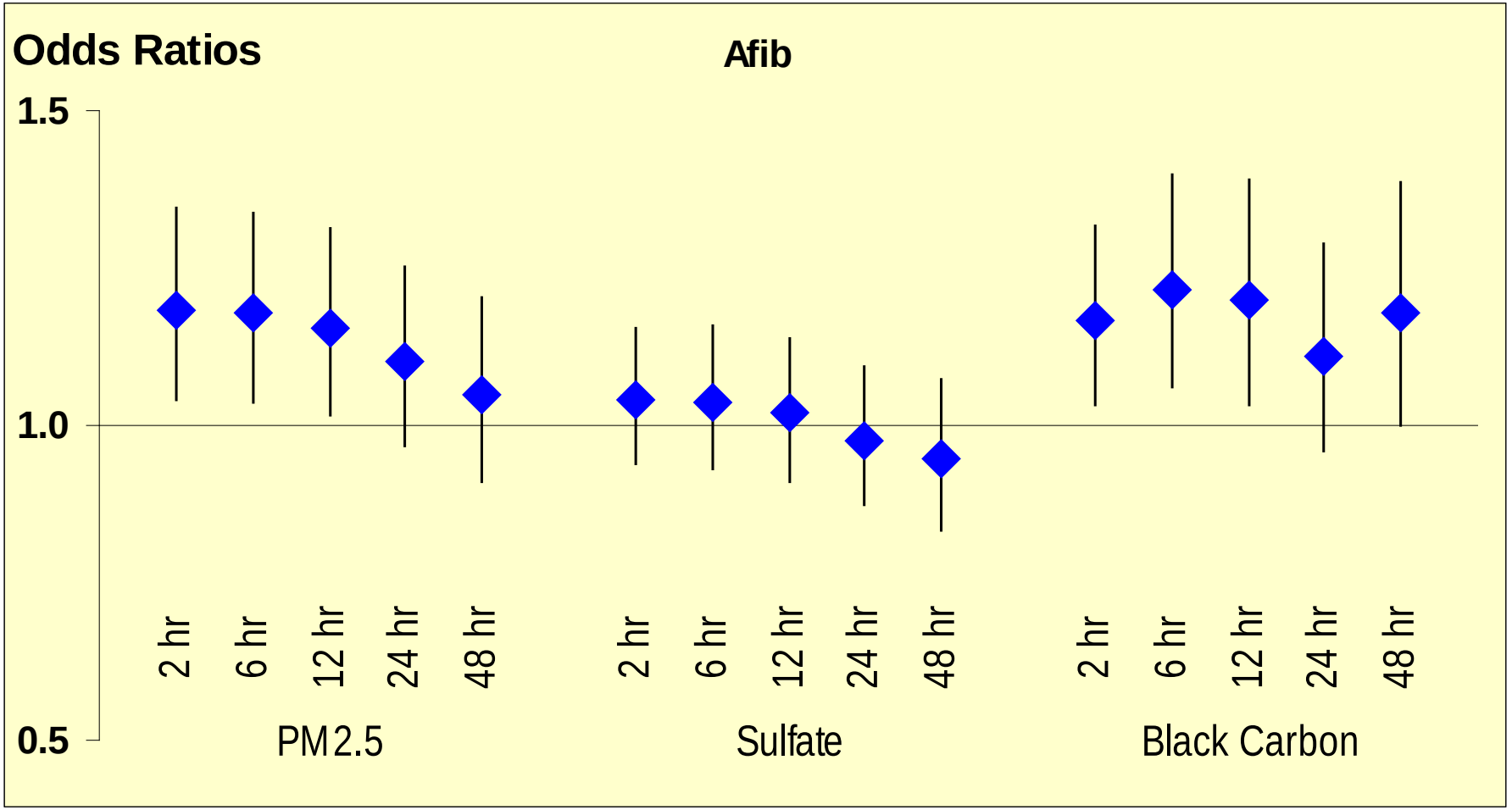


Is it Still happening at today's levels?


Concentration-Response Relation between PM2.5 and Risk of Death on Followup: Six City Study
Relative Risk of Death
0.8
1.0
1.2
1.4
1.6
1.8
10
20
30
40


Linearity of Effect of long-term BC exposure on SBP
Predicted SBP
130
135
140
145
0.0
0.5
1.0
1.5
1-year average BC

Atrial Fibrillation:
OR with IQR increase of particles



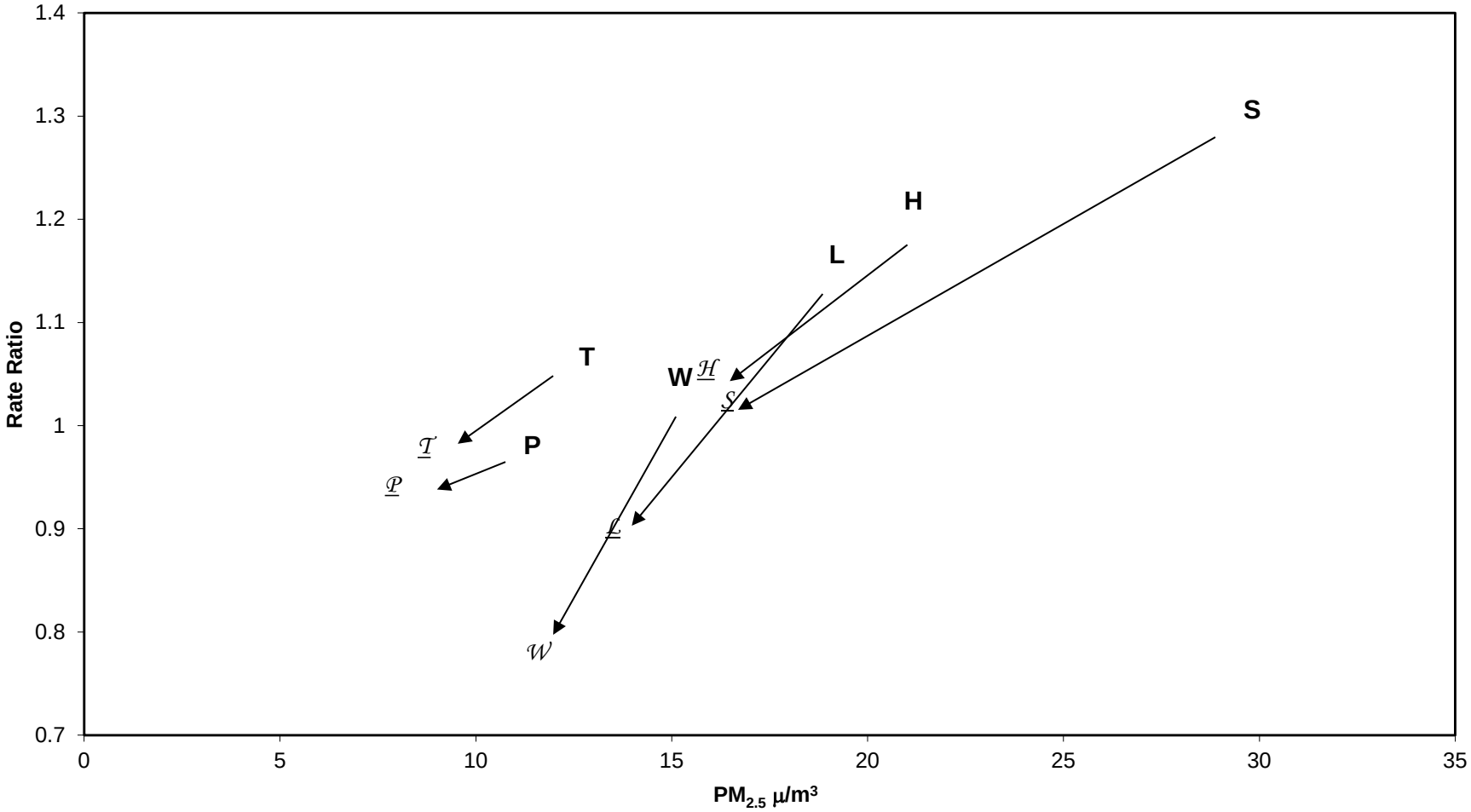
IQR: 4.2-5.7

IQR: 1.5-1.8

IQR: 0.35-0.50

What happens if we Lower Air Pollution?

Relative Risk of Death in Six US Cities during Two Follow-up Periods



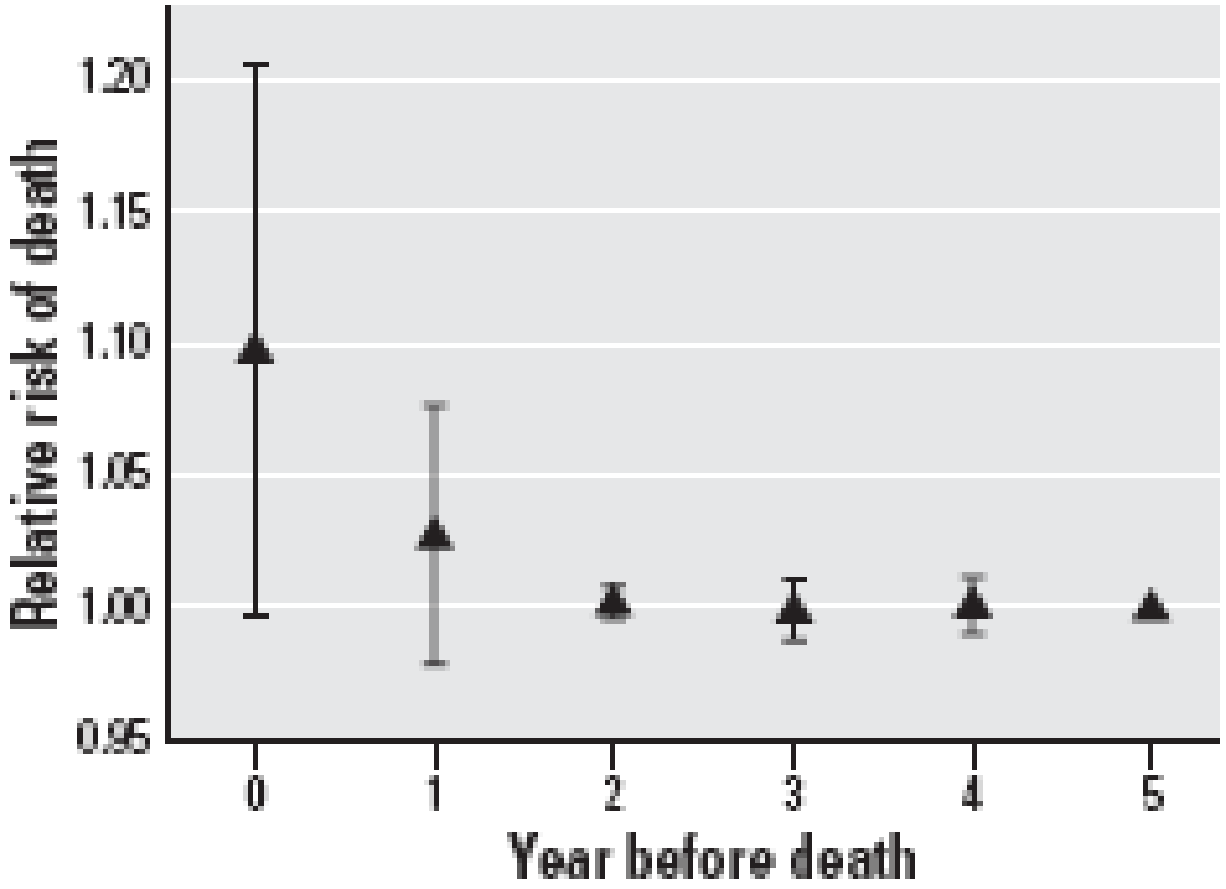
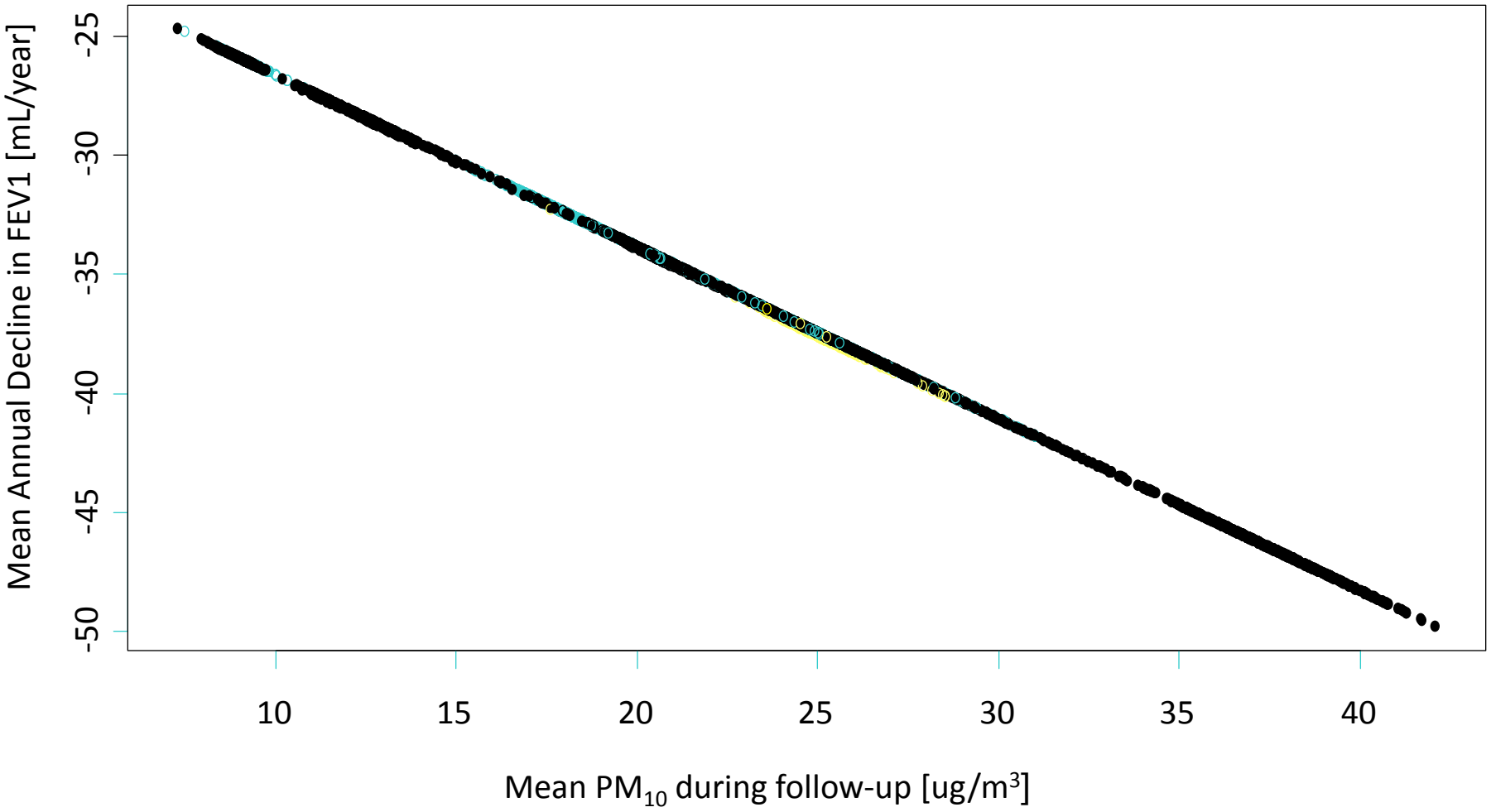


Figure 4. The model-averaged estimated effect of a 10-μg/m^3 increase in $PM_{2.5}$ on all-cause mortality at different lags (in years) between exposure and death. Each lag is estimated independently of the others. Also shown are the pointwise 95% CIs for each lag, based on jacknife estimates.

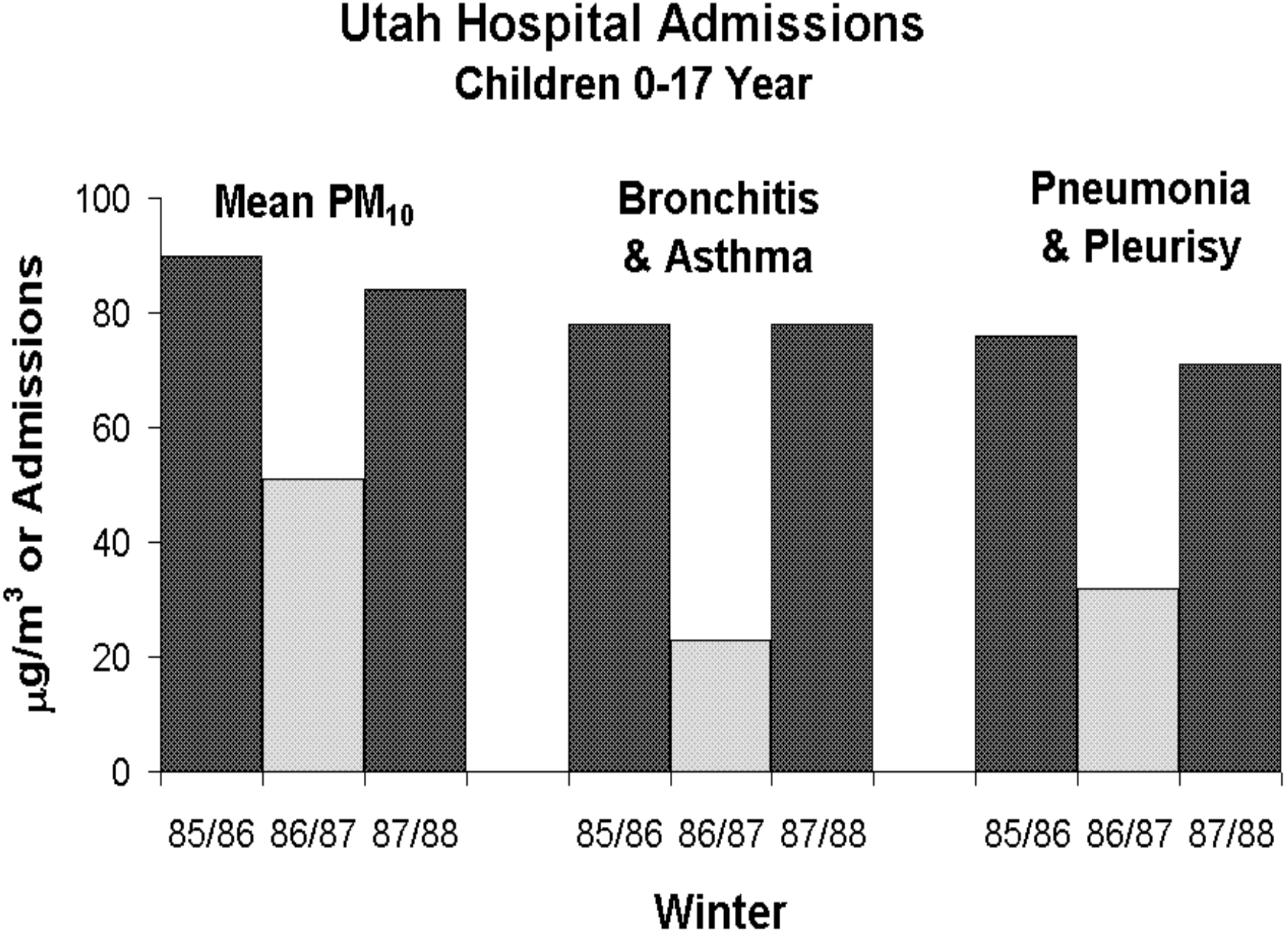
Annual Decline In Lung Function Vs PM in Interval



Natural Experiments

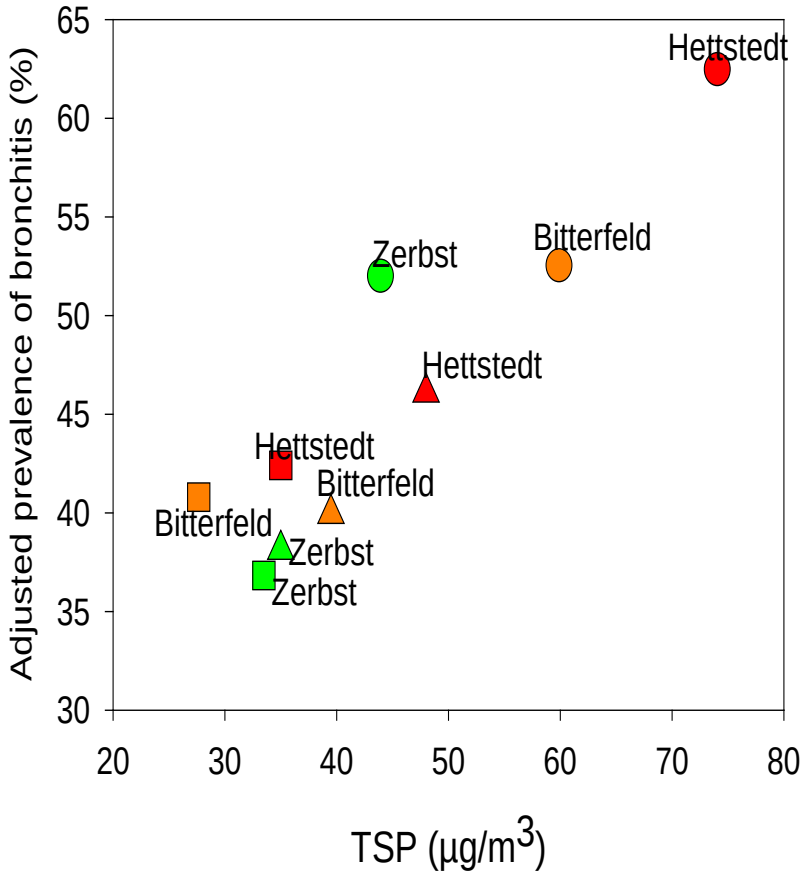
Pope Smelter Strike

- Smelter Strike Reduced Sulfates in U.S. Southwest by ~60%
- 2.5 ug/m^3 decrease in Sulfates
- 2.5% Reduction in Mortality
- Avol Lung Function Growth in Southern California Children's Cohort
  - Children who moved to more polluted areas had slower growth
  - Children who moved to less polluted areas had faster growth

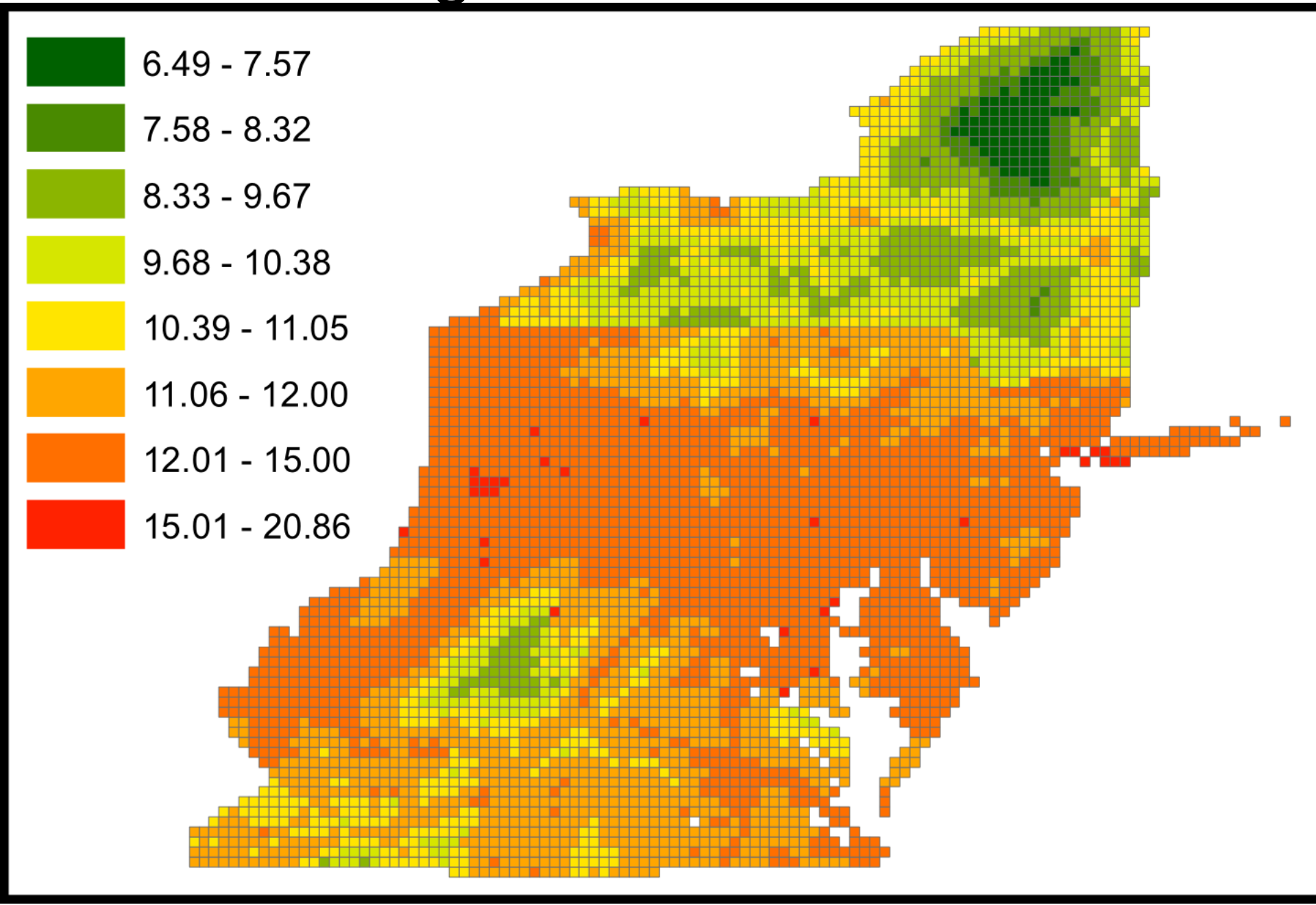


Pope, Amer J Public Health 1989; 79: 623

Adjusted prevalence of bronchitis in children and annual TSP two years prior to the examination



Average PM2.5 2000-2008



Randomized Trials

What about Pittsburgh?

- How do we randomize exposure?
- Look at year to year fluctuations in exposure around their mean/trend.
- Random weather events (less wind, more inversions, different average wind directions) drive this
- Do year to year fluctuations in exposure correlate with years to year fluctuations in mortality around its trend?

For PM2.5

- Medicare Population (65 +)
- With Previous Heart Attack
  - 18% increase in Death Rate per 10 μg/m^3
- With Chronic Lung Disease
  - 12% increase in Death Rate per 10 μg/m^3

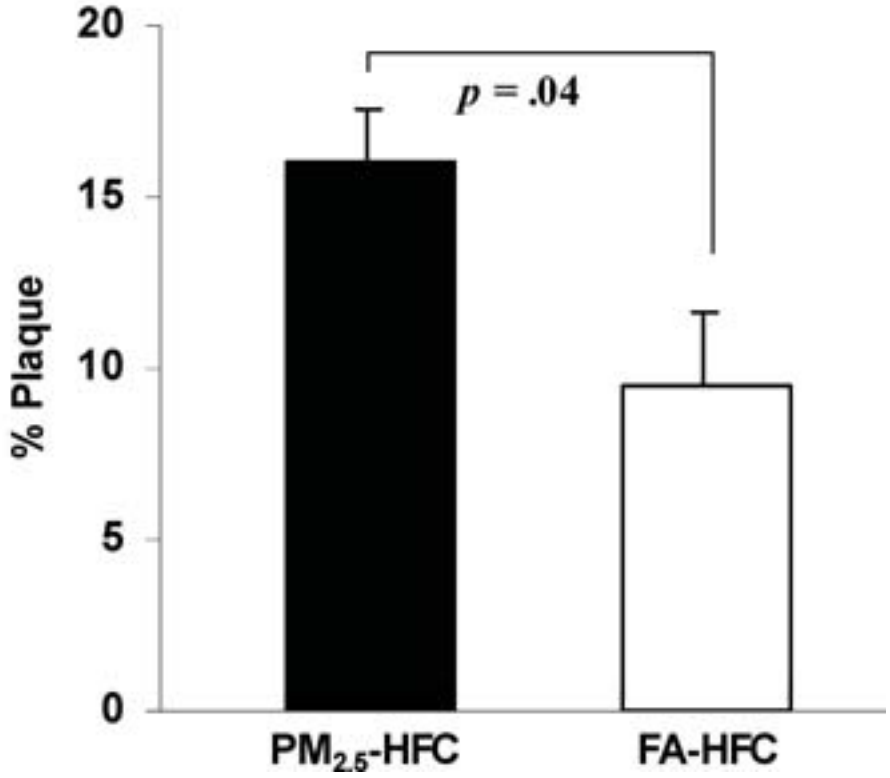
Ozone

- April to October ozone season
- Medicare Population
  - With previous Heart Attack
    - 29% increase in death rate for 5 ppb increase in seasonal average
  - With Diabetes
    - 21% increase in death rate for 5 ppb increase in seasonal average

Animal Studies

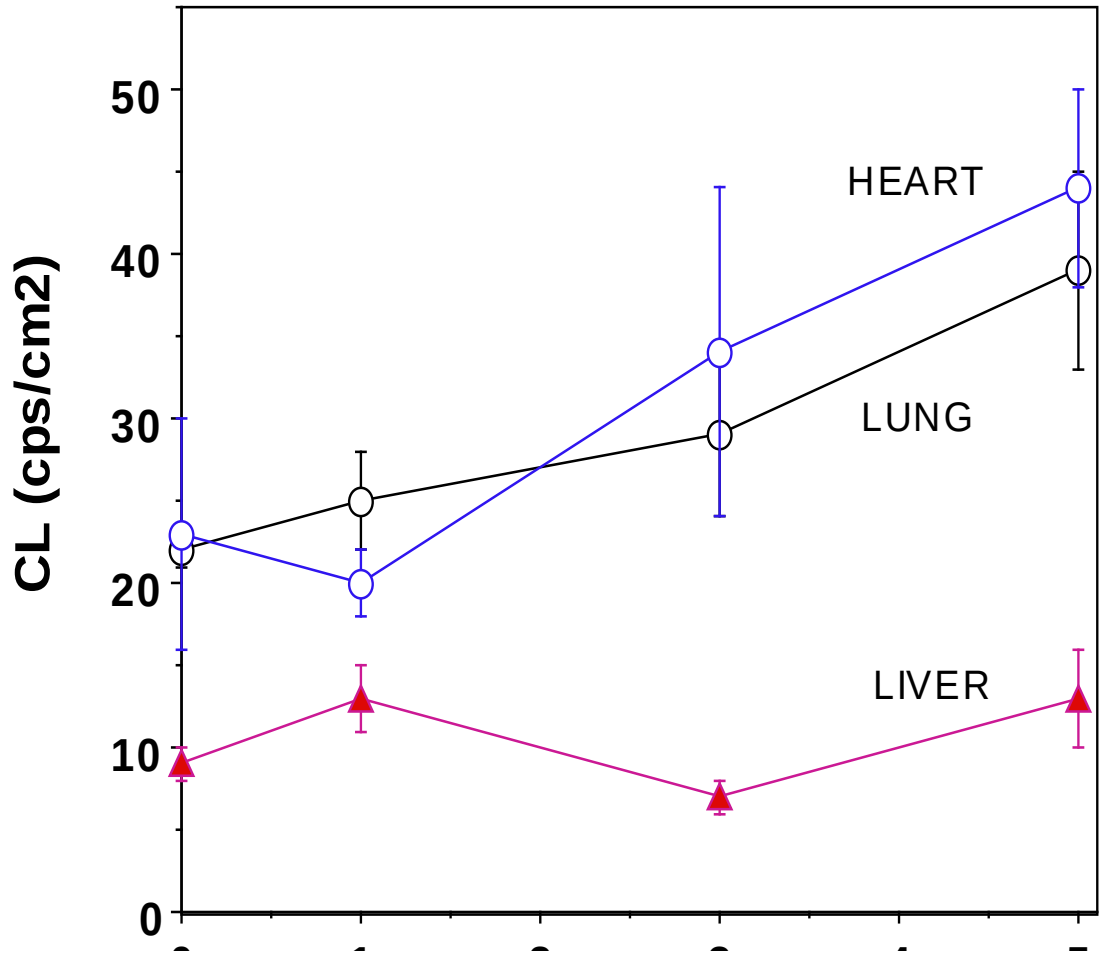
- Particles increase blood clot formation
- Six Month exposure to 15 $\mu g/m^3$ accelerated Atherosclerosis in Mice compared to Filtered Air (Sun 2005, 2008, 2009) and increased Oxidized LDL
- Pregnant mice and their offspring were exposed to 16.8 $\mu g/m^3$ or filtered air. When the reached adulthood, the exposed mice had lower lung function (Mauad 2008).
- Long term exposure results in left ventricular hypertrophy and incipient heart failure (Wold, 2012)

Percent of Aorta with plaque



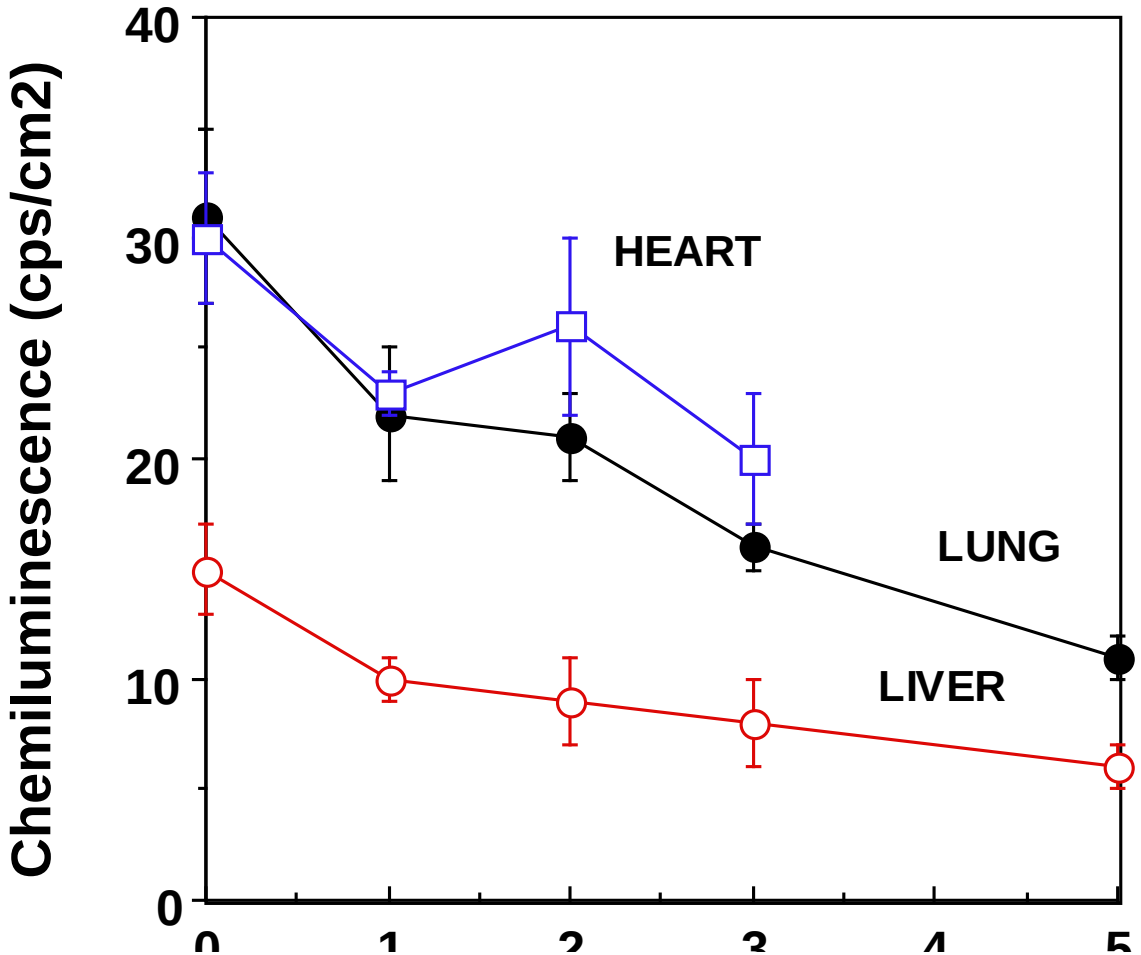
- Particle Exposure makes plaque more likely to rupture (Suwa, 2002)
- Dogs with induced heart attacks hand more and longer Ischemia breathing particles than breathing filtered air (Bartoli, 2009)

Exposure to Particles Increases Oxidizing Compounds in the Heart as well as the Lung



Removal of Particles from the air results in a decrease in the level of oxidants in the Body

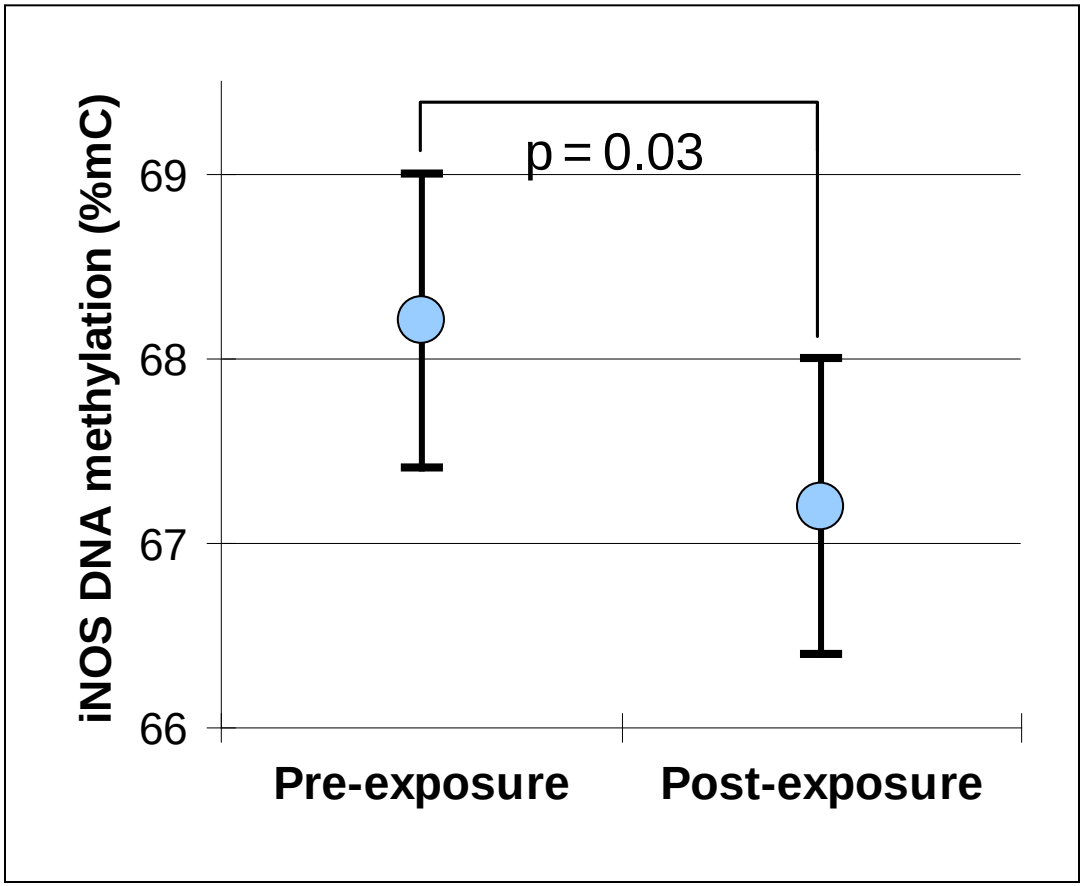
(Evelson & Gonzalez-Flecha, Biochim Biophys Acta, 2000)



Genetically Identical!

Randy Jirtle/Duke University

Tarantini, 2008



How can Particles do so many things?

- Particles effect DNA methylation, which is one of the controls on gene expression
- Particles increase mitochondrial copy number, a measure of cell senesence and aging
- Particle shorten Telomeres, which are necessary for cell division

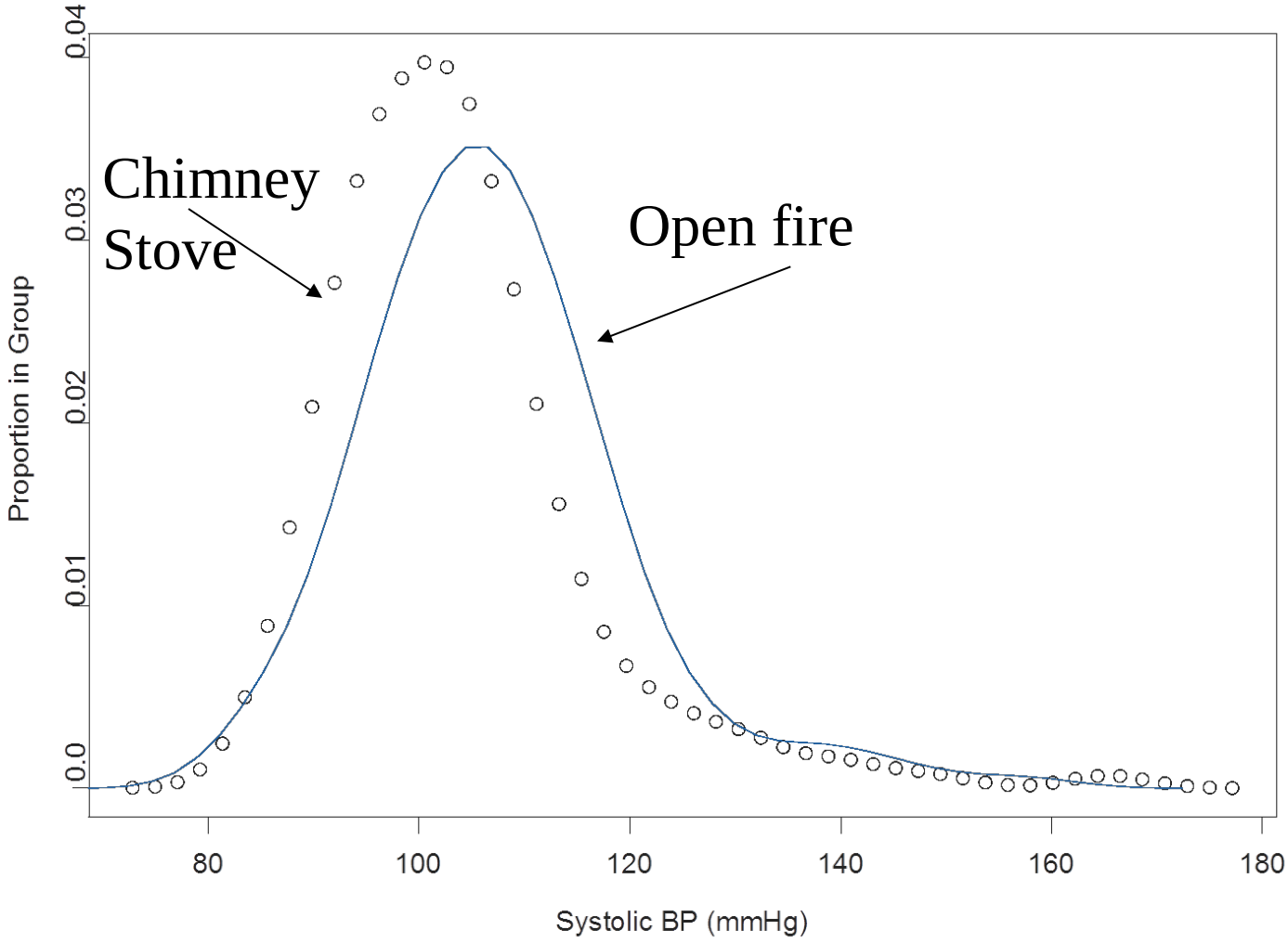
Particles and Cognitive Ability

- Children exposed to traffic particles have lower IQ (Franco-Suglia 2008)
- Adults exposed to PM2.5 have faster rates of cognitive decline (Weuve
- Animals exposed to particles have brain inflammation, particularly in the hippocampal area, which is key to memory (Campball 2005, Fonken 2011)

Beijing Particle Mask Study

- People walked the same route twice
- Once wearing a mask that filtered out particles, once without the mask
- Blood pressure was 3 mmHg lower when they were wearing the mask
- ST segment depression less wearing mask

Randomized Trial: Effect of Stove on Distribution of Systolic Blood Pressure



- Asthmatic students either stayed in the city or were sent to summer camp in the Mountains of Austria
- The children in the city had more lung inflammation

Zelikoff

- Exposed rats to concentrated air particles with concentrations under 100 $\mu g/m^3$
- Exposure after infection with *Strep Pneumonia* doubled the amount of lung with pneumonia within 48 hours, compared to sham exposed rats