

Health Effects of Air Pollution Associated with Energy Use

Commission on Sustainable Development
United Nations
May 2, 2007

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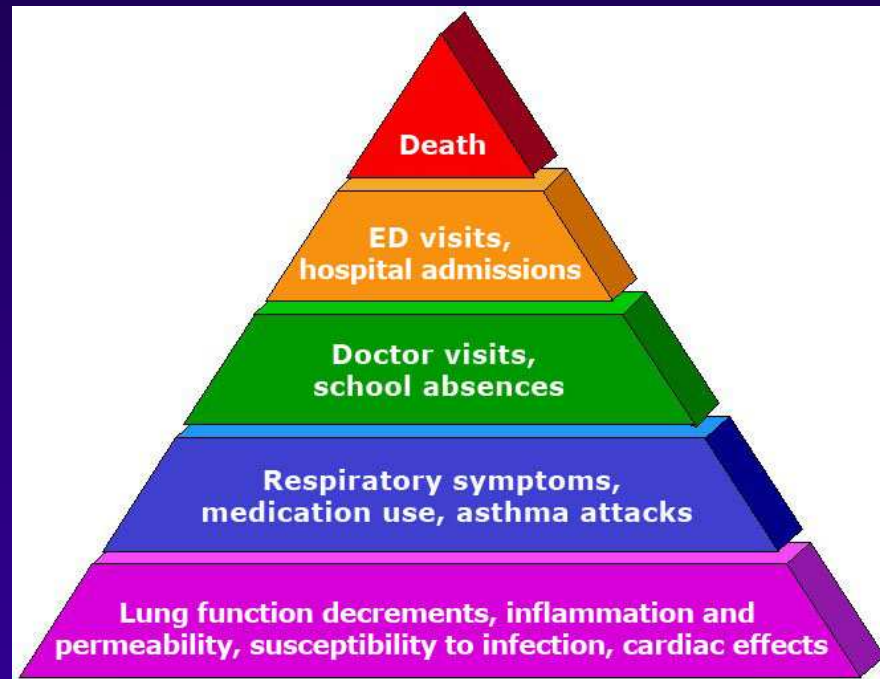


Pollutants Associated with Energy Use

- Group of pollutants that are common in the air – many countries set ambient standards for these pollutants
- Ozone and particulate matter, also known as particle pollution, are the two of most concern in the US; these come from many sources
- Carbon monoxide and nitrogen dioxide are common pollutants related to traffic
- Sulfur dioxide comes from burning fuel high in sulfur; can be high around facilities such as electric generating plants or smelters

“Pyramid of Effects”

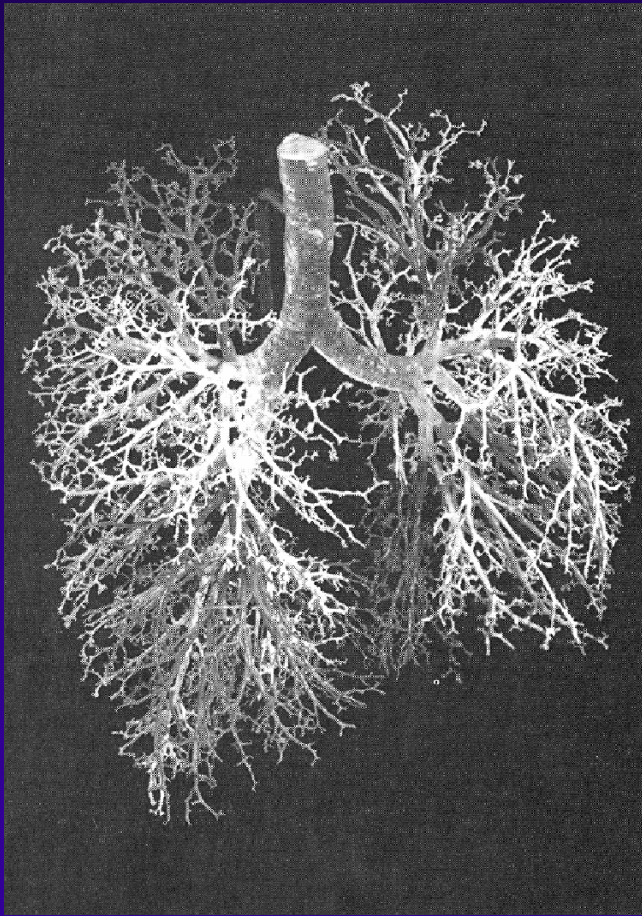
- Consistent and coherent effects seen across a wide range of health outcomes
- Sensitive groups include:
 - People with heart or lung disease
 - Children and older adults
 - People who are active outdoors, such as outdoor workers



Adversity of Effects

Proportion of Population Affected

Human Lung



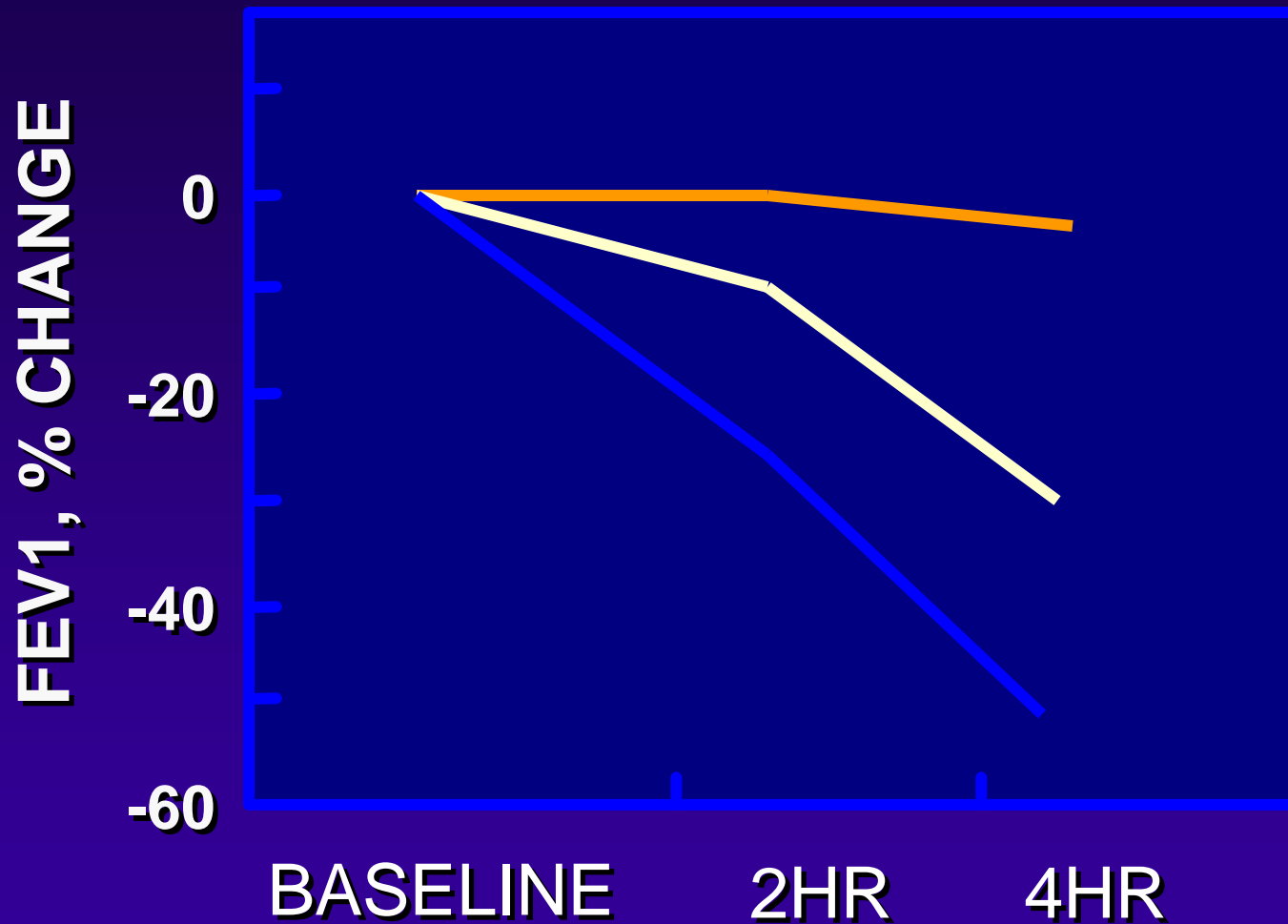
- Air conducting
 - Trachea
 - Bronchi
 - Bronchioles
- Gas exchange
 - Respiratory bronchioles
 - Alveoli

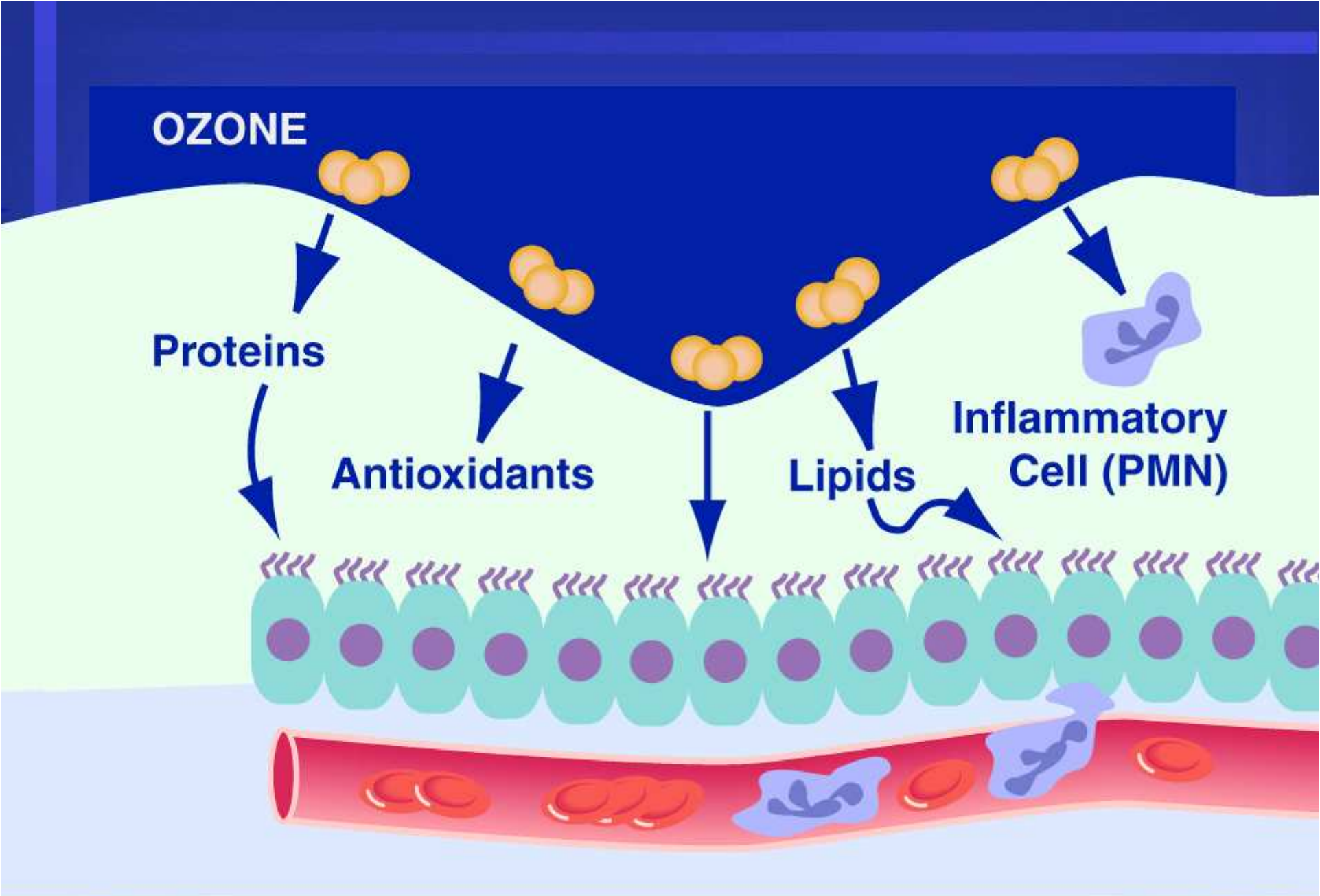
Ozone Irritates Airways

- Symptoms
 - Cough
 - Sore or scratchy throat
 - Pain with deep breath
 - Fatigue
- Rapid onset
- Similar symptoms - people with and without asthma



Ozone Reduces Lung Function

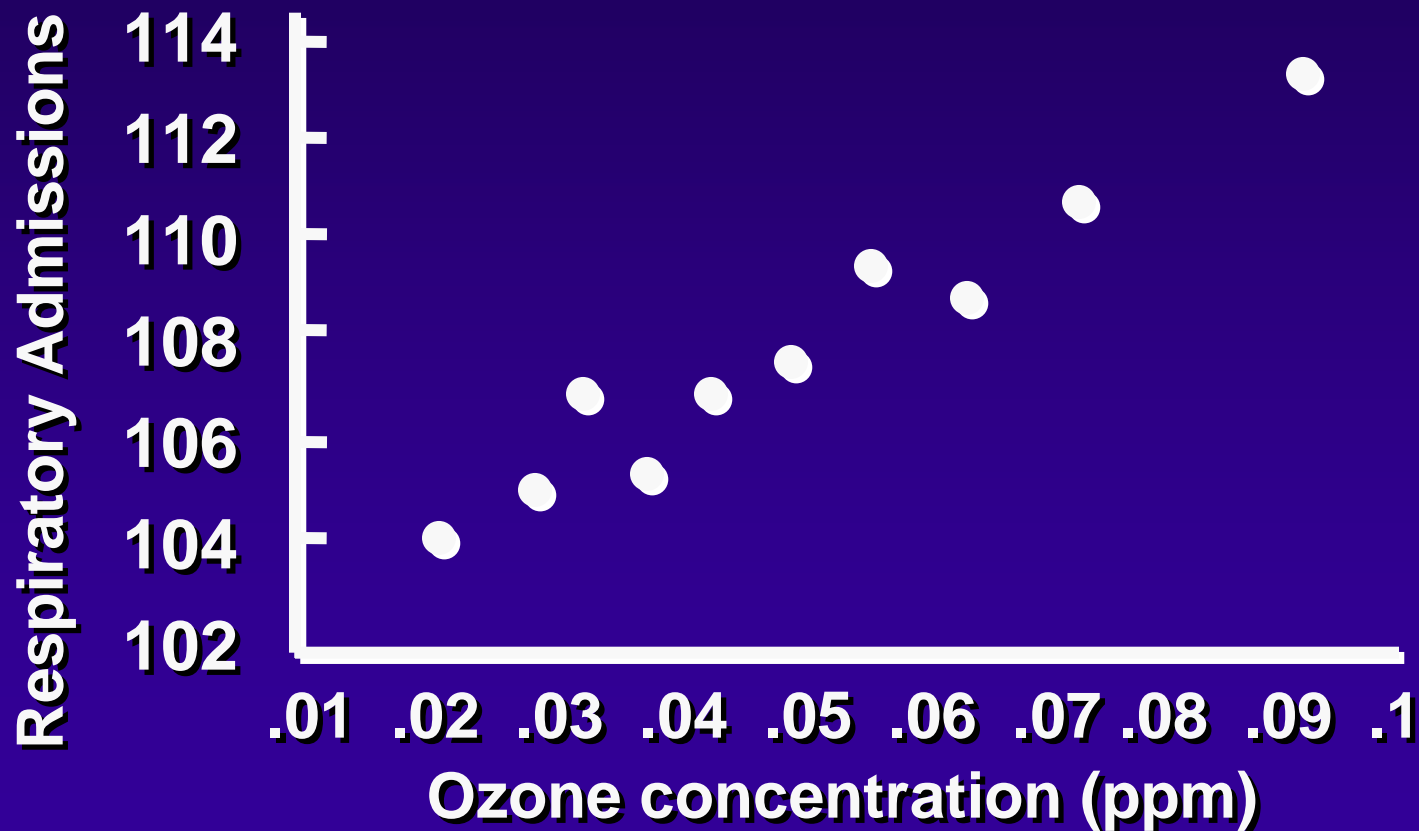




Ozone Causes Inflammation

- Ozone reacts completely in surface layer - forms reactive oxygen molecules
- Influx of white blood cells
- Damages cells that line the airways
- Effect is greater 24 hours after exposure
- Increases airway reactivity
- Concern about repeated exposures

Respiratory Hospital Admissions by Daily Maximum Ozone Level, Lagged One Day (Burnett et al, 1994)



California Children's Health Study



CHS: Pollutant Correlations (R) Across Communities

Table 1. Correlation of Mean Air-Pollution Levels from 1994 through 2000 across the 12 Study Communities.*

Pollutant	O ₃ (10 a.m.–6 p.m.)	NO ₂	Acid Vapor†	PM ₁₀	PM _{2.5}	Elemental Carbon	Organic Carbon
	<i>R value</i>						
O ₃							
1-Hour maximal level	0.98	0.10	0.53	0.31	0.33	0.17	0.25
10 a.m.–6 p.m.		-0.11	0.35	0.18	0.18	-0.03	0.13
NO ₂			0.87	0.67	0.79	0.94	0.64
Acid vapor†				0.79	0.87	0.88	0.76
PM ₁₀					0.95	0.85	0.97
PM _{2.5}						0.91	0.91
Elemental carbon							0.82

R ~ 0.0, little or no correlation

R > 0.0, positive correlation (max is 1.0)

R < 0.0, negative correlation (min is -1.0)

Ozone Effects in Children

- CHS: 20 ppb increase in O₃ associated with an 83% increase in school absences for acute respiratory disease (Gilliland et al., 2001)
- Mortimer et al. 2002: NCICAS – lung function and symptoms in > 800 children, 8 urban areas
 - Incidence of ≥ 10% decrements in morning PEF associated with 30 ppb increase in 8-hr average O₃
 - Morning symptoms (chest tightness, wheeze, shortness of breath) associated with 30 ppb increase in 8-hr average O₃
- Gent et al. 2003: diary study of symptoms in > 250 asthmatic children in New England
 - 50 ppb increase in 1-hr ozone level increased likelihood of wheeze (by 35%) and chest tightness (by 47%)

CHS: Ozone and New-onset Asthma

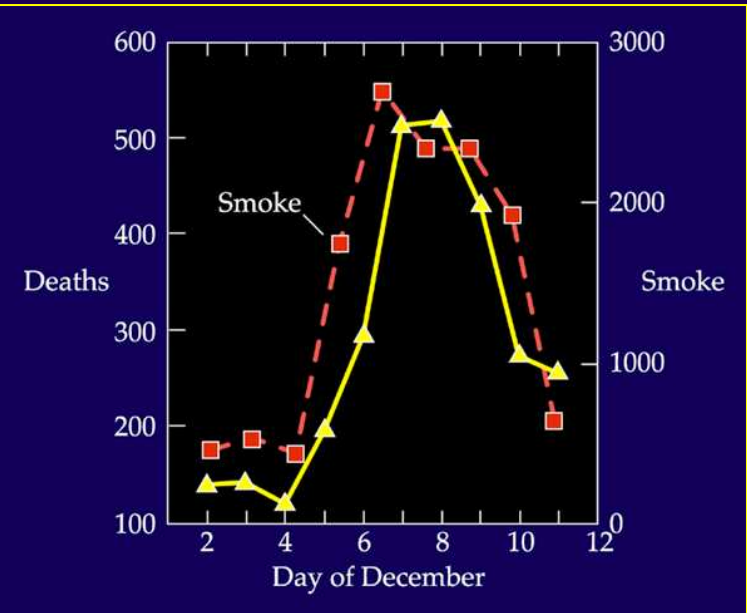
<u>Sports</u>	<u>Low O₃ Towns</u>		<u>High O₃ Towns</u>	
	<u>#</u>	<u>RR</u>	<u>#</u>	<u>RR</u>
0	58	1.00	46	1.00
1	50	1.28	40	1.28
2	20	0.82	16	1.28
≥3	9	0.79	20	3.31

McConnell et al., 2002

Air Pollution Disasters



Donora, PA at noon on Oct. 29, 1948



London buses are escorted by lantern at 10:30 in the morning.



Wood-Burning Stoves



Forest Fires



Heavy Duty Diesel Engines



Natural Sources

Particle pollution is a complex mixture derived from many sources



Cars and Trucks



Non-Road Vehicles



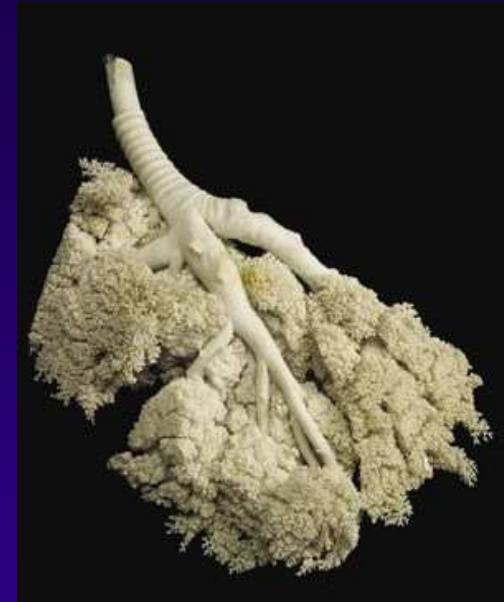
Leaf Burning



Industrial Sources

Particle Deposition

- Larger particles ($> PM_{10}$) deposit in the upper respiratory tract
- Inhalable particles ($\leq PM_{10}$) penetrate into lungs

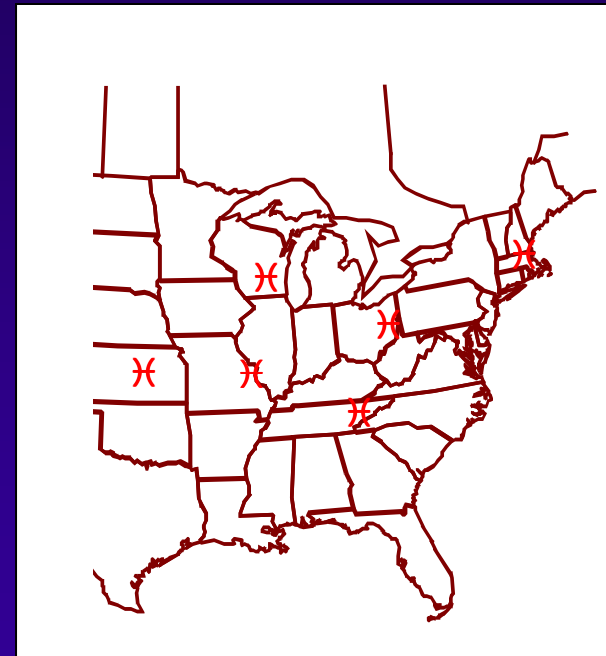


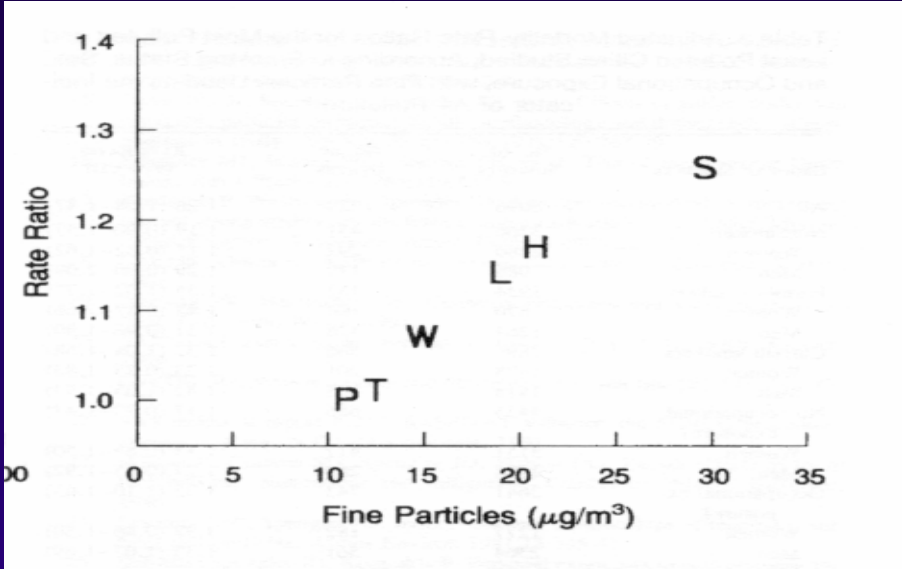
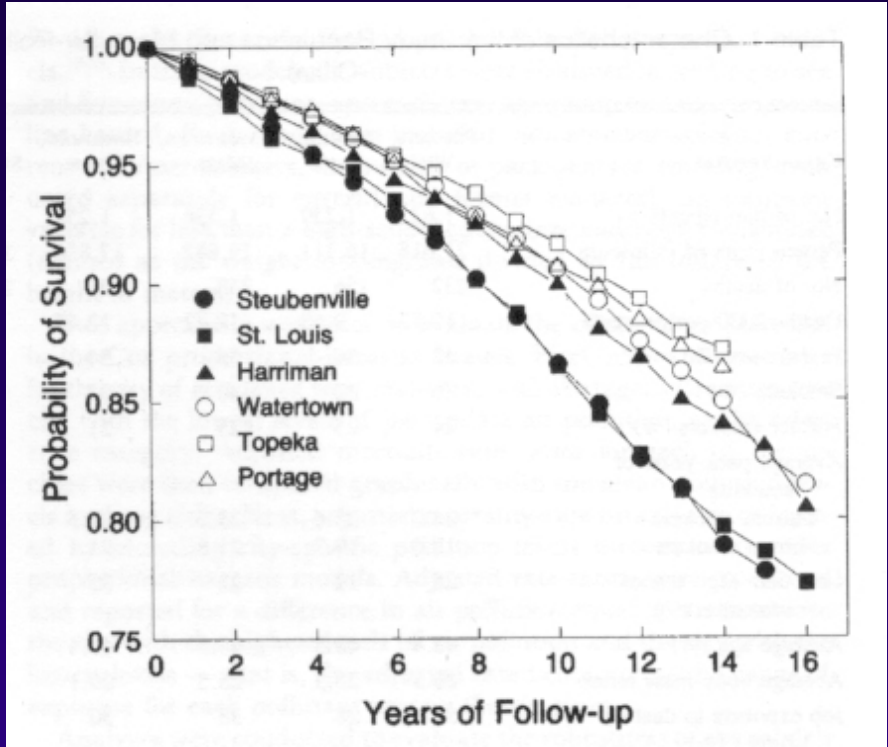
- Some particles (e.g., less than $0.1 \mu m$) may enter bloodstream
- Particles may react, accumulate, be cleared or absorbed

Association Between Long Term Exposure to PM and Mortality

Harvard Six-Cities Adult Cohort

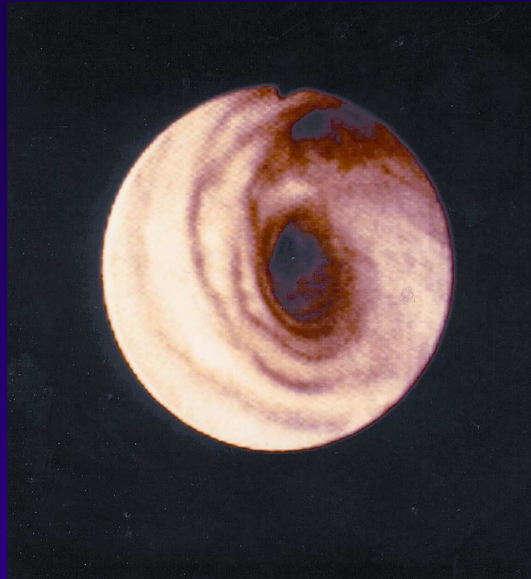
- Purpose was to study the association between pulmonary changes and long term exposure to sulfates and sulfur dioxide
- Enrollment 1974 – 1977
 - 8,111 white men and women
 - About 1,300 in each of six cities
 - Age range 25 to 74 years
- Followed until 1991 (now 1999)
 - 14 to 17 years of follow-up
 - 111,076 person-years
 - 1,430 deaths





Dockery et al., 1993

Particle Pollution Affects the Lungs



You are exposed to particle pollution simply by breathing polluted air.

Exposure increases when you exercise, because you breathe more vigorously and deeply than usual.

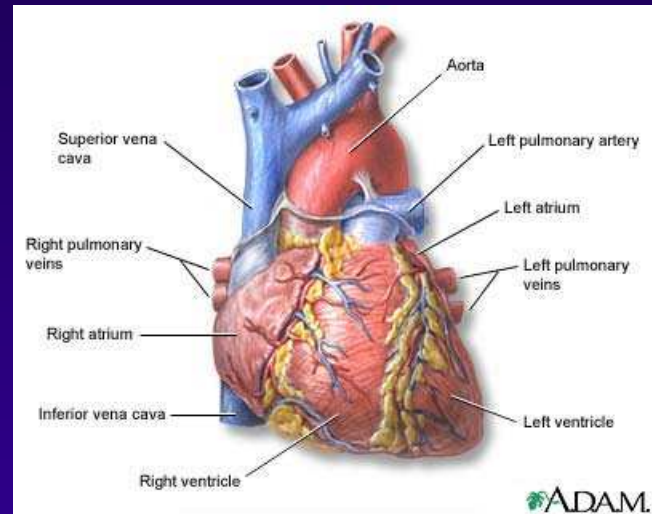
Respiratory effects include:

- **Airway irritation**
- **Cough**
- **Phlegm**
- **Decreased lung function**
- **Airway inflammation**
- **Asthma attacks**
- **Bronchitis**
- **Chronic bronchitis**

And Particle Pollution Affects the Heart

Particle pollution has been linked to changes that indicate your heart isn't as healthy as it should be. Those include:

- Arrhythmias and changes in heart rate.
- Changes in the variability of your heart rate.
- Blood component changes
 - C-reactive protein
 - Fibrinogen
 - Plasma viscosity
- Some studies indicate that particle exposure may cause **heart attacks**. And particles are linked with **death from heart disease**.

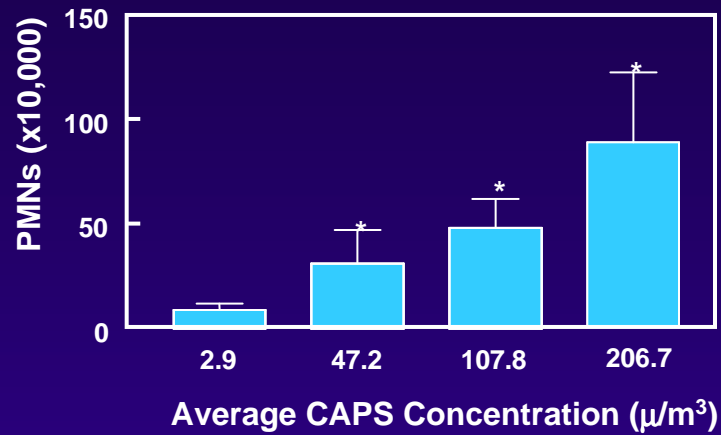


Particle exposure has been linked to heart attacks

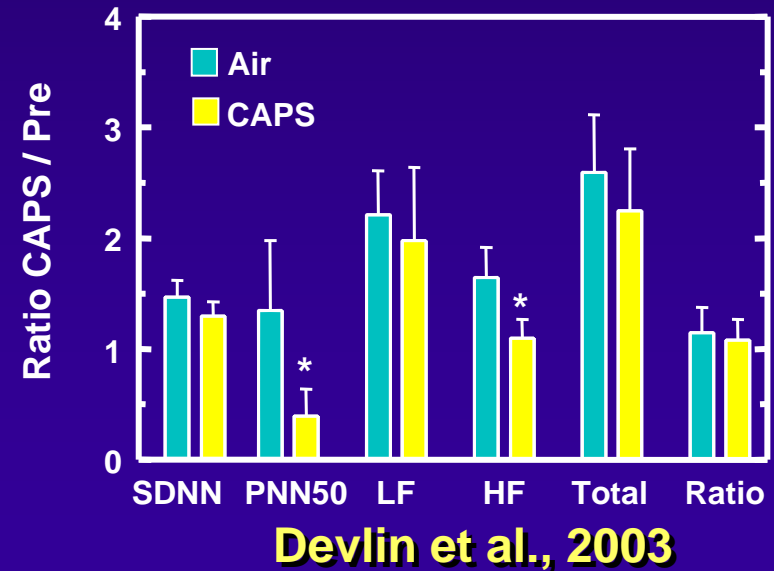
It's a Public Health Concern

- When **particles aggravate heart and lung diseases** that means increases in:
 - **Hospital admissions**
 - **Doctor and emergency room visits**
 - **Medication use**
 - **Absences from work or school**
- **Particulate matter is linked to significant public health risks** – including **premature death** from heart and lung disease.
- Sensitive groups include: people with heart or lung disease, older adults, children

PM Can Cause Effects in Healthy People



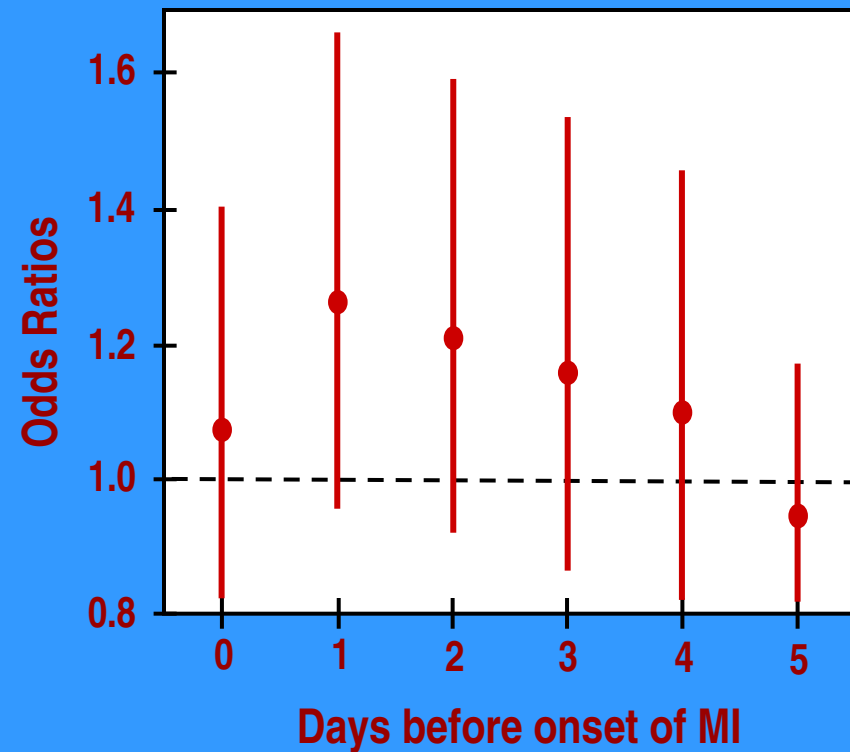
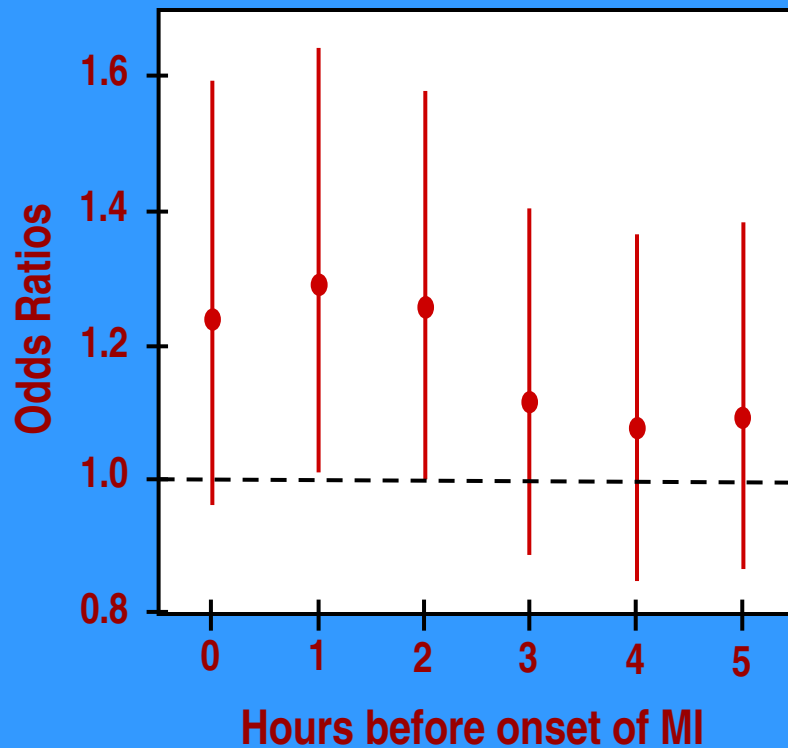
Ghio et al., 2003



Devlin et al., 2003

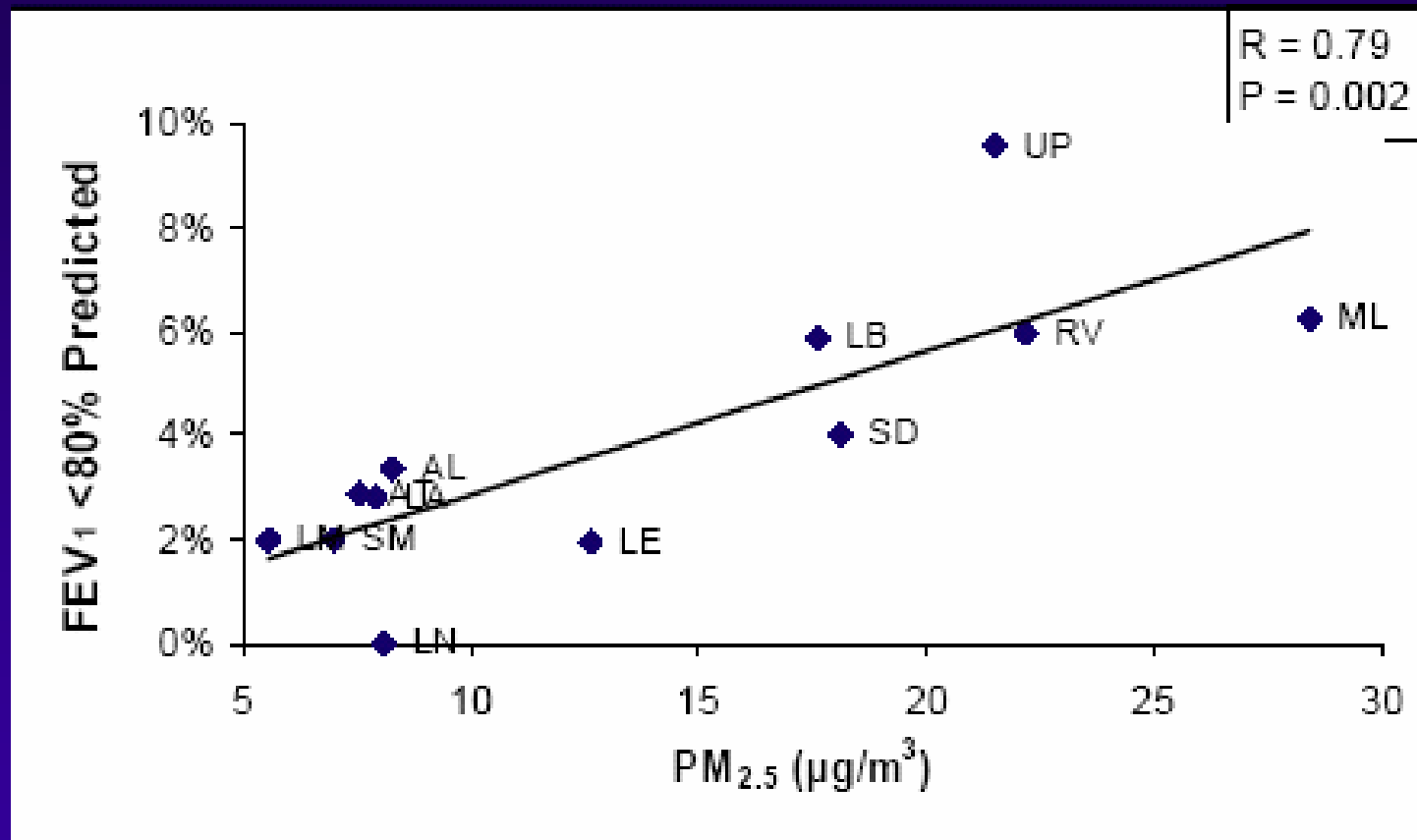
Particles Trigger Heart Attacks

772 MI patients who survived 24 hours and completed interview



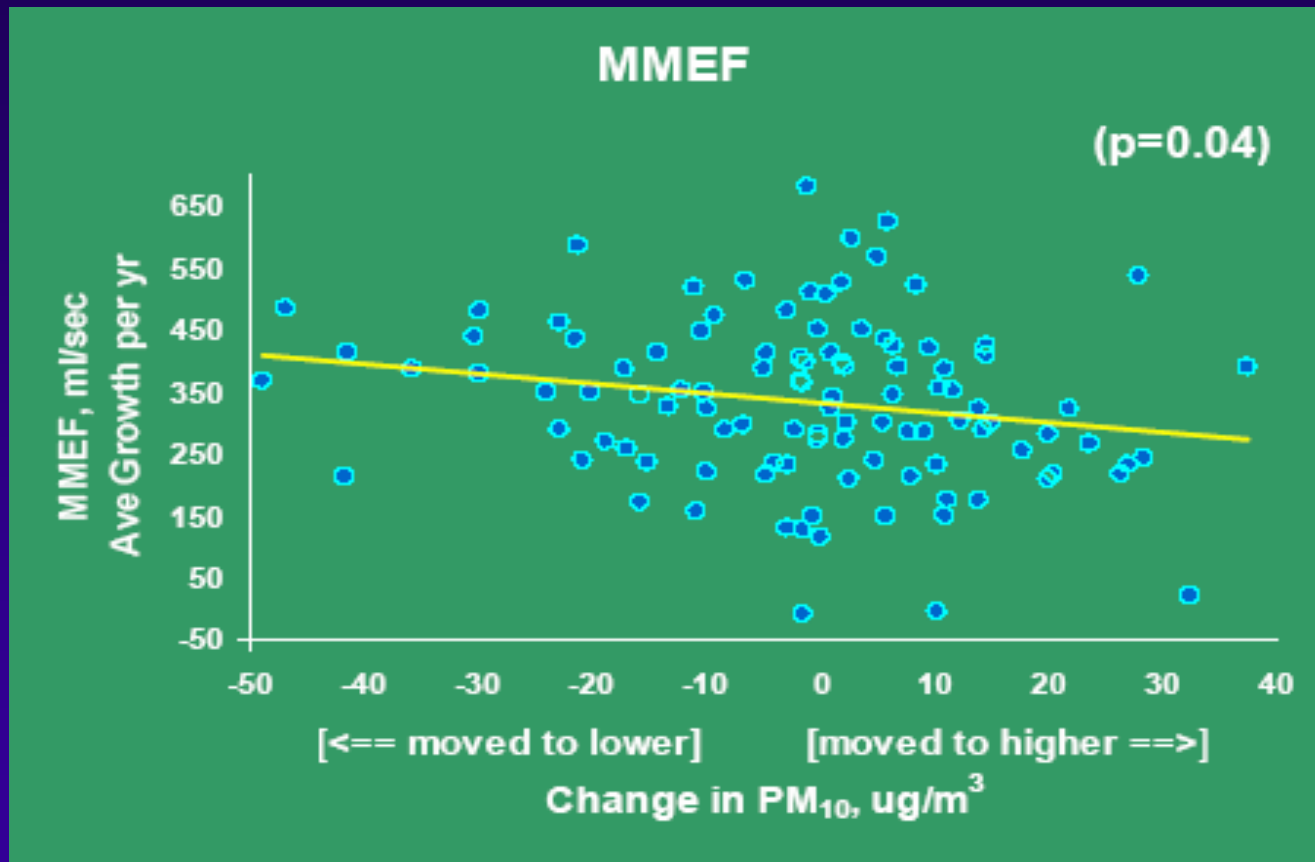
Peters et al., 2001

CHS: Low FEV₁ at Age 18 vs. Pollution



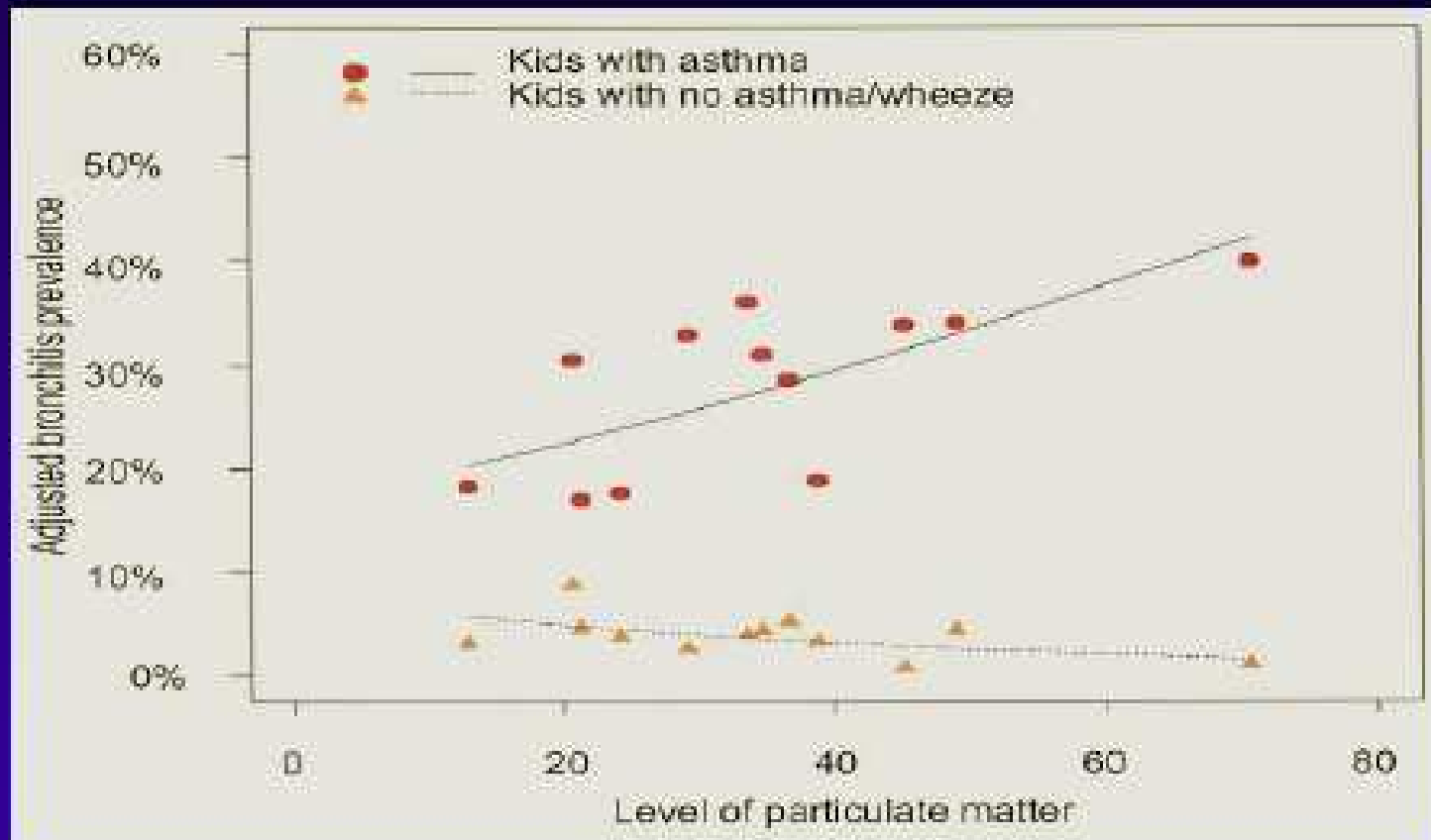
Gauderman et al., 2004

CHS: Lung Function Growth in Movers



Avol et al., 2001

CHS: PM₁₀ and Bronchitis in Asthmatic Children



McConnell et al., 1999

Traffic Exposures

- Traffic exposure linked to respiratory symptoms and lung function in several European studies
- San Francisco bay area study linking pollution exposures at schools to symptoms (Kim et al., 2004)
- CHS study of residential NO₂, traffic linked to asthma prevalence, symptoms, and medication use (Gauderman et al., 2005)

SO₂ Effects

- SO₂ - primarily around large point sources burning high sulfur fuel
- Short-term SO₂ peaks
- SO₂ reduces lung function
 - Moderate ventilation rates – oronasal breathing – required for exposure
 - Bronchoconstriction happens quickly
 - Lung function returns to normal about an hour after exposure ends

The Utah Valley

