

US EPA ARCHIVE DOCUMENT

# *Health Effects and What We Know and Can Do about Air Pollution and Cardiovascular Disease in Older Adults*

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Does the  
Environmental  
Air Particle  
Pollution  
Contribute to  
Adverse  
Cardiovascular  
Health Effects?



**YES!**

# Inhaled Air Pollution Particles Increases Morbidity and Mortality

- Increased levels of air pollution particles are associated with increased morbidity and mortality and attributable to cardiovascular and pulmonary causes particularly in older adults
- Biological mechanisms explaining PM-induced adverse cardiopulmonary health effects are not completely known but significant progress is being made

# Adverse Health Effects of Air Pollution

Increased cardiopulmonary morbidity & mortality -

- Pulmonary

- Acute

- Asthma & COPD

- Chronic

- Lung function, lung cancer, lung development

- Cardiovascular

- Acute

- Heart attacks, arrhythmia, heart failure, stroke

- Chronic

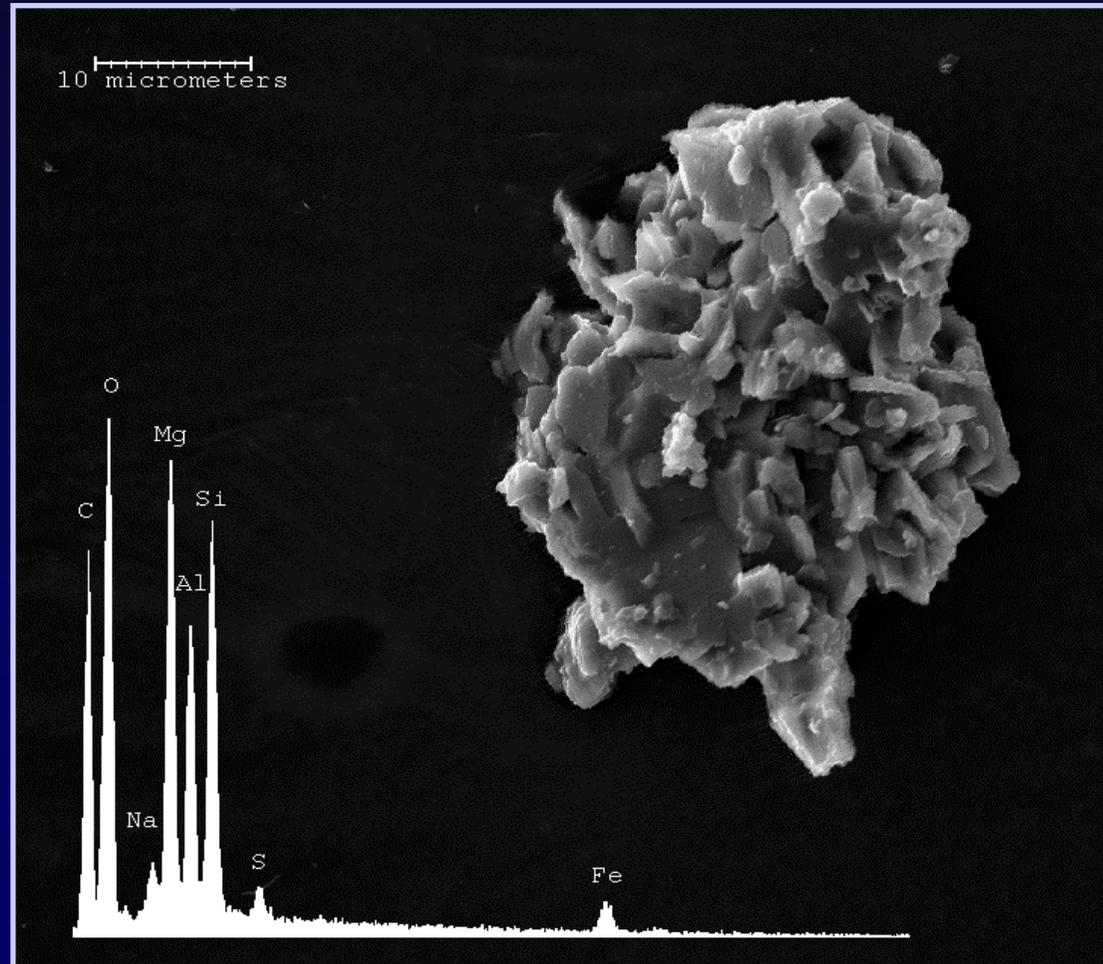
- Premature death

# Major Public Health Risks

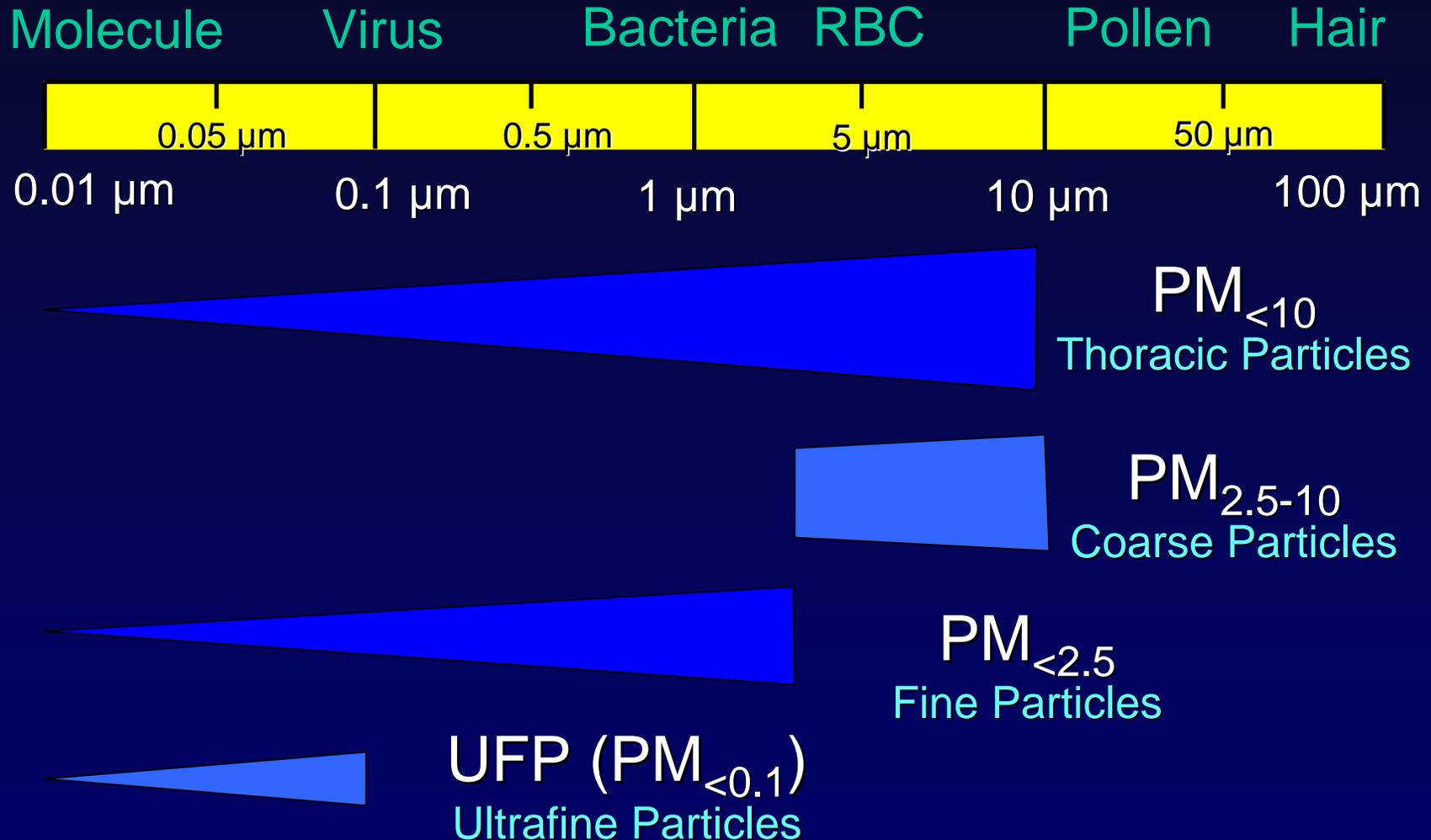
- Diabetes ~ 60,000 deaths annually in the US
- End Stage Renal Disease ~ 60,000 deaths
- Air Particle Pollution ~ 60,000 deaths

# What is Air Particle Pollution?

- Aerodynamic diameter
  - <10  $\mu\text{m}$  ( $\text{PM}_{10}$ )
  - <2.5  $\mu\text{m}$  ( $\text{PM}_{2.5}$ )
- Composition
  - Elemental Carbon
  - Metals
  - Sulfates / Nitrates
  - Organics
- Sources
  - Point
  - Mobile
  - Natural



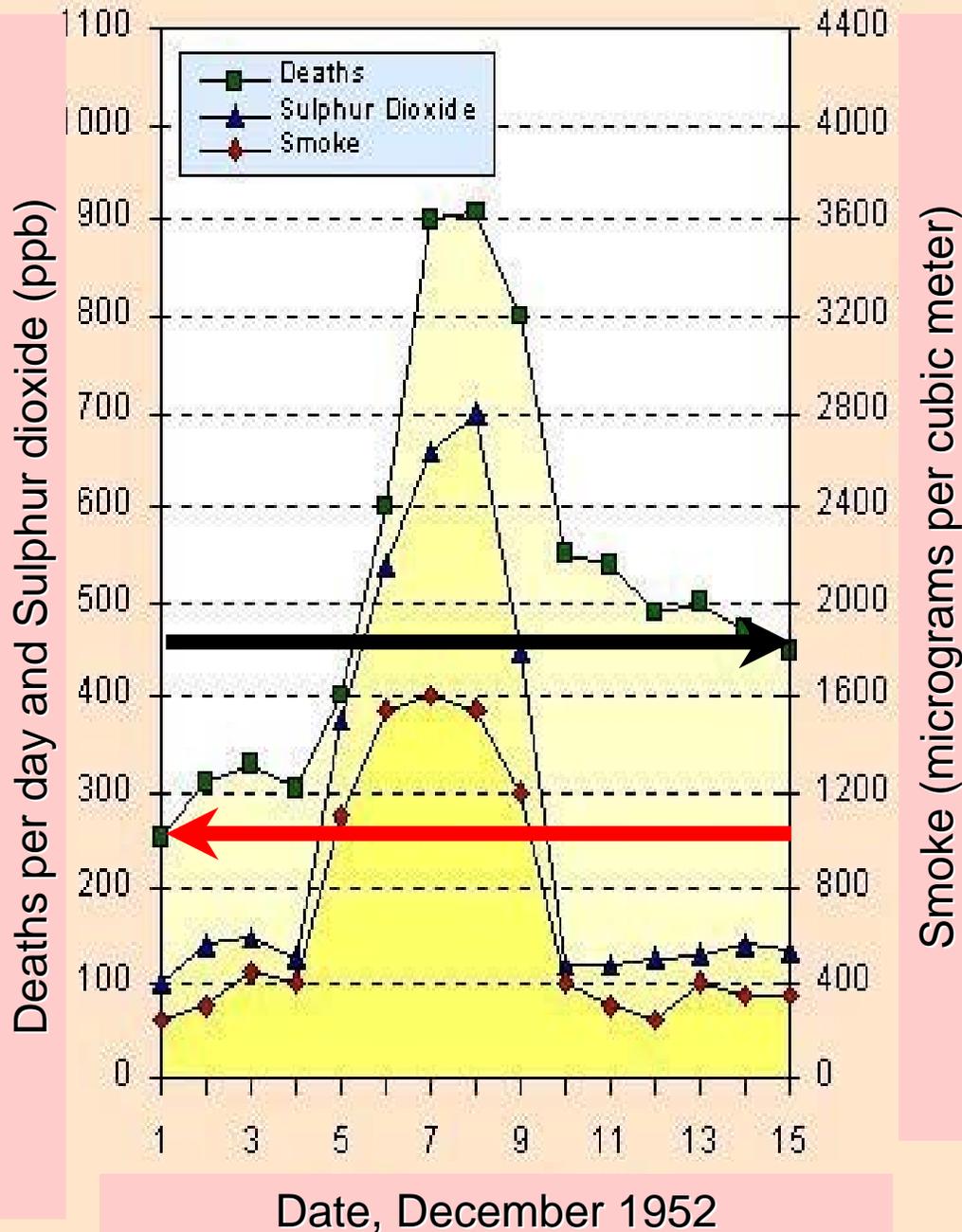
# Size of Air Pollution Particles



# Major Episodes of Lethal Smogs

- Meuse Valley in Belgium Dec 1-5, 1930
  - industrial pollution (steel mills, coke ovens, foundries and smelters)
  - 10x normal mortality rate
- Donora, PA Oct 27-30, 1948
  - metal works, coal-fired home and industrial facilities, coke ovens and a zinc refinery, iron and steel industries
  - 6x normal mortality rate
- London, England Dec 5-9, 1952
  - coal-burning homes, power plants and factories
  - 9x normal mortality rate

# The Great London Smog Dec. 1952



- 12,000 excess deaths
- 2/3 >65 years old
- Increased death rates persisted through the next summer

# U.S. PM<sub>10</sub> NMMAPS

- National Morbidity, Mortality and Air Pollution Study

- Time-series analysis
- Effects on mortality
- Time period 1987 to 1994
- 90 largest U.S. cities

- Major findings

- PM levels positively associated with mortality
- PM levels on the same day, or one and two days before death are positively associated with mortality
- National combined estimate 0.2% excess deaths per 10  $\mu\text{g}/\text{m}^3$  increase in PM<sub>10</sub>
- Association most strongly associated in the Northeast

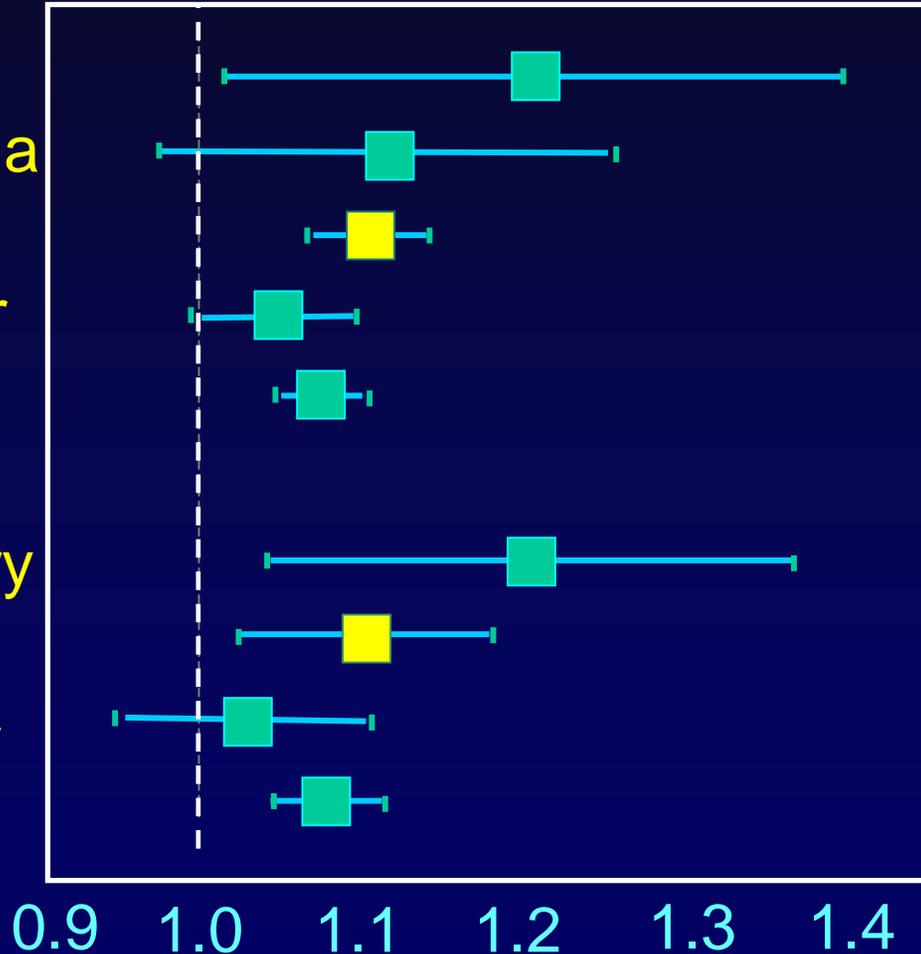
# PM<sub>2.5</sub>-Associated Mortality

Philadelphia

COPD  
Pneumonia  
CVD  
Cancer  
Total

Utah Valley

Respiratory  
CVD  
All other  
Total



Philadelphia  
per 100  $\mu\text{g}/\text{m}^3$

Utah Valley  
per 50  $\mu\text{g}/\text{m}^3$

# PM and Myocardial Infarction

- Peters and colleagues studied determinants of MI in the Myocardial Infarction Onset Study - Harvard University
- Case-crossover study
- 772 patients with acute MI in Boston January 1995 - May 1996
- Associations sought between hourly and 24 hr average concentrations of PM (<math><2.5\mu\text{m}</math>), carbon black and gaseous pollutants and MI

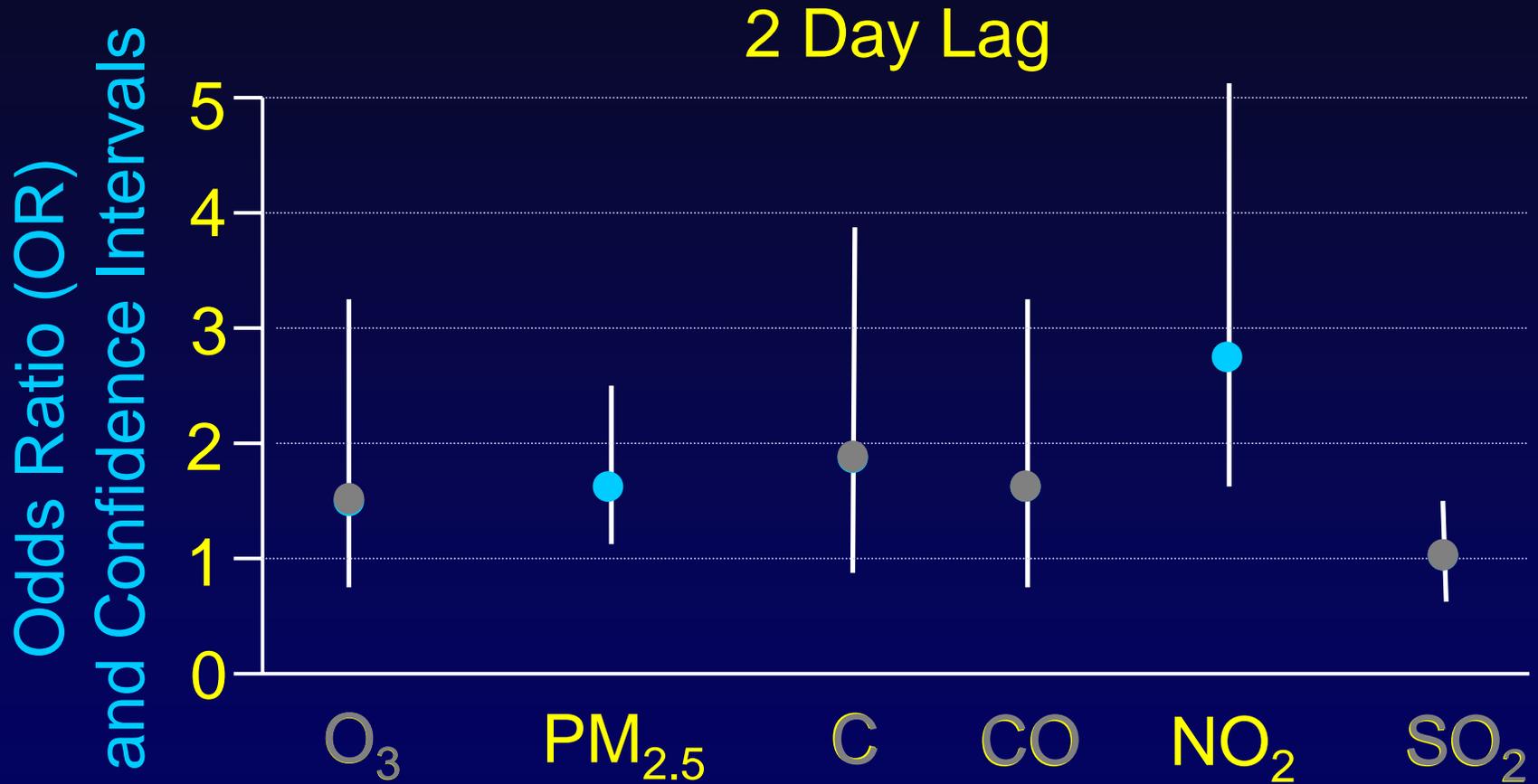
# PM and Myocardial Infarction

	QUINTILES				
	I	II	III	IV	V
2-hour average PM <sub>2.5</sub>					
Range, $\mu\text{g}/\text{m}^3$	0-5.2	5.3-7.9	7.9-11.5	11.6-17.0	17.1-74.8
Odds ratios	1.00	1.15	1.09	1.27	1.44
24-hours average PM <sub>2.5</sub>					
Range, $\mu\text{g}/\text{m}^3$	1.6-6.4	6.5-8.6	8.7-11.5	11.6-16.2	16.3-52.2
Odds ratios	1.00	1.12	1.15	1.31	1.32

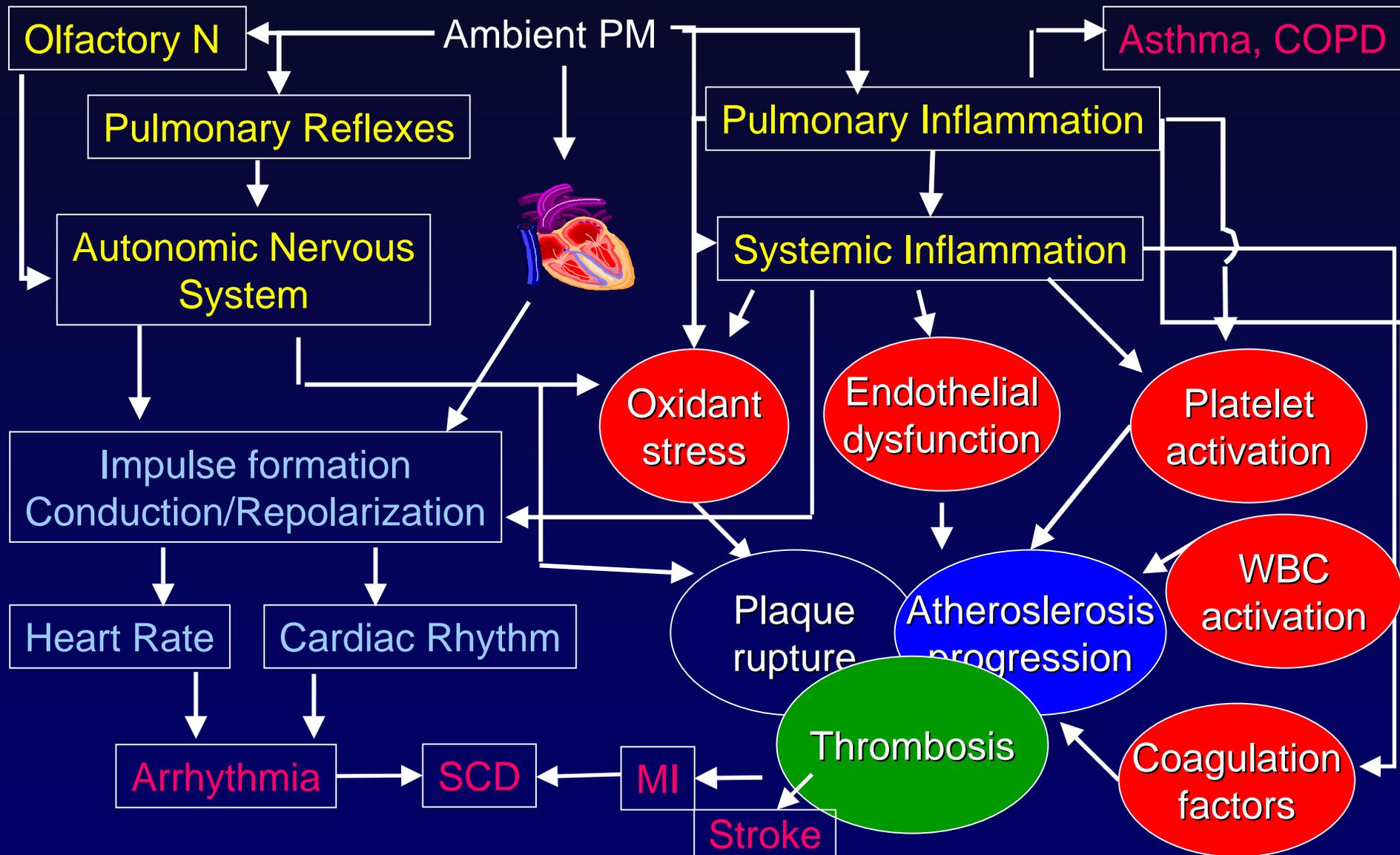
# Air Pollution and ICD Discharge

- 100 ICD patients
- Eastern Massachusetts
- Defibrillator discharges are related to:
  - Measurements of ambient air pollution:
    - Sulfur dioxide
    - Ozone
    - Carbon monoxide
    - PM<sub>2.5</sub>
    - Carbon black

# Air Pollution and ICD Discharge



# Potential Effects of PM on the Cardiopulmonary System

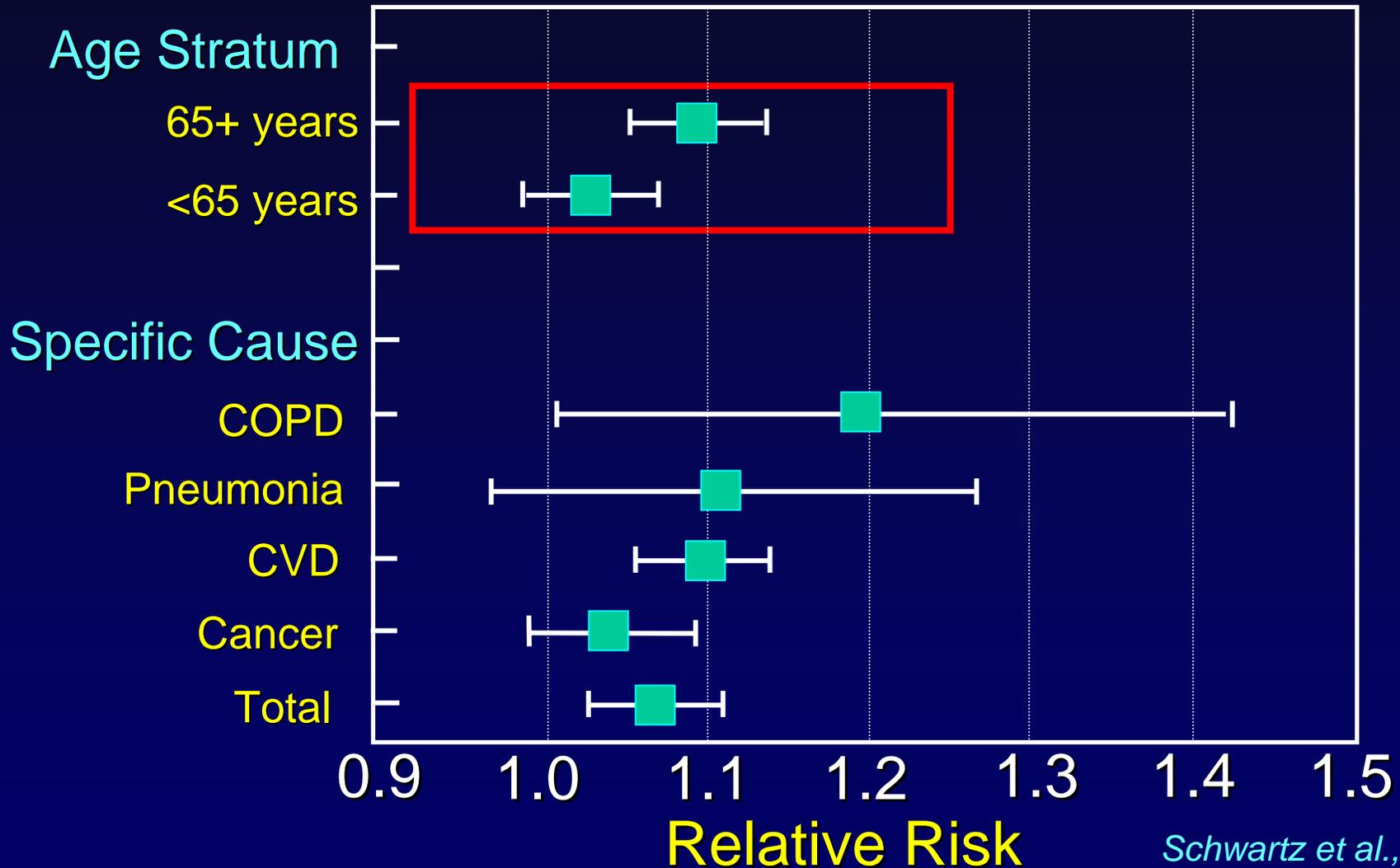


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Are Older Adults More Susceptible?

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# Mortality Associated with Ambient $PM_{2.5}$ in Older Adults

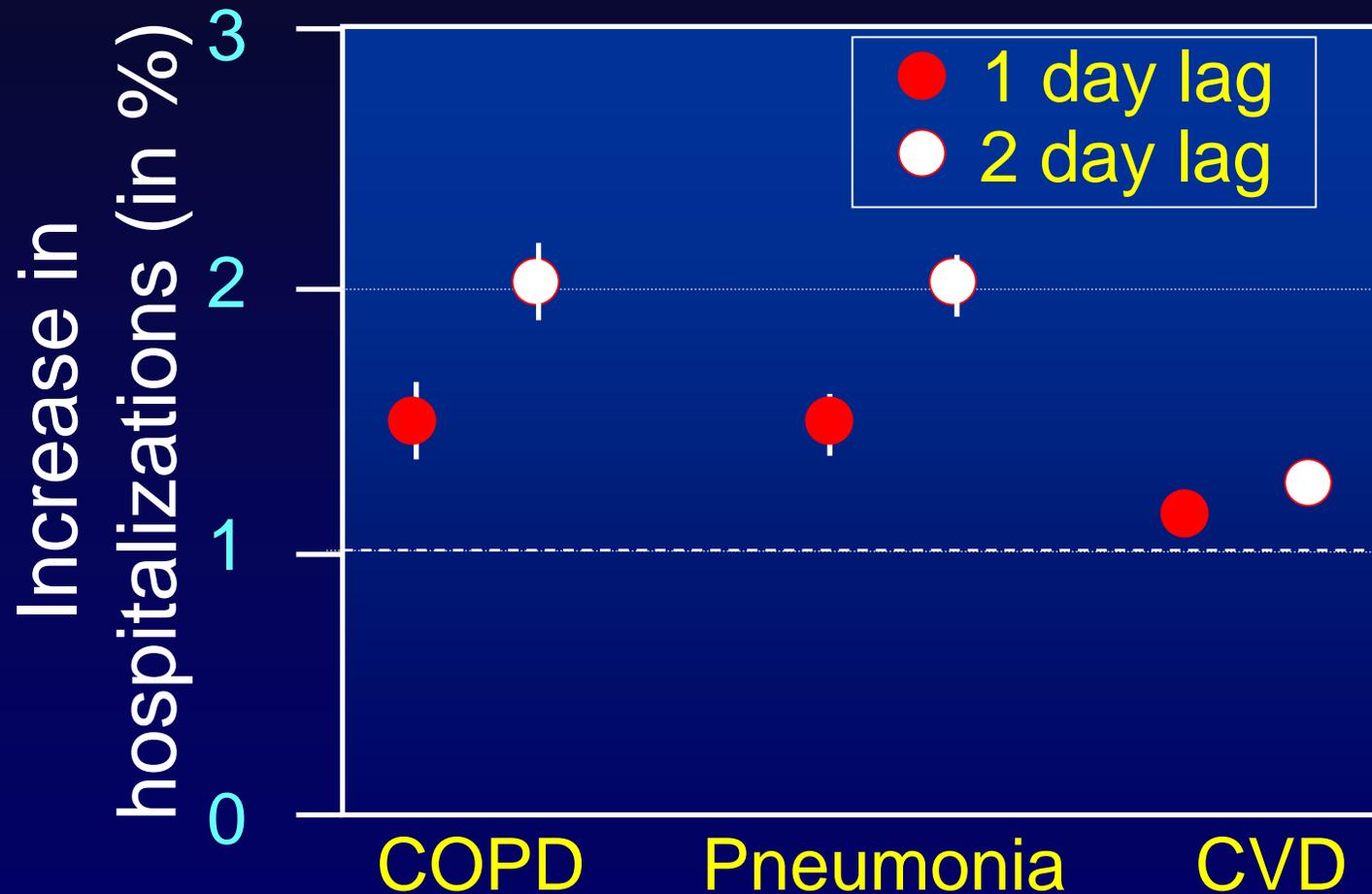


# Particulate Matter and Risk

- Association between PM<sub>10</sub> and hospital admissions for respiratory and CV disease in 10 U.S. cities
- U.S. cities
  - Canton
  - Birmingham
  - Chicago
  - Colorado Springs
  - Detroit
  - Minneapolis/St. Paul
  - New Haven
  - Pittsburgh
  - Seattle
  - Spokane
- HCFA billing records & US EPA Aerometric Information Retrieval System (1986-1994)

# Particulate Matter and Risk

Increased risk for each  $10\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{10}$



# Cook County, Illinois PM<sub>10</sub> NMMAPS

- CMS and Time period 1986 to 1991
  - Population  $\geq$  65 years old
  - Effects on all-cause mortality and hospitalizations
  - Considered sociodemographic data, environmental data
  - Environmental data from US EPA Aerometric Information Retrieval System

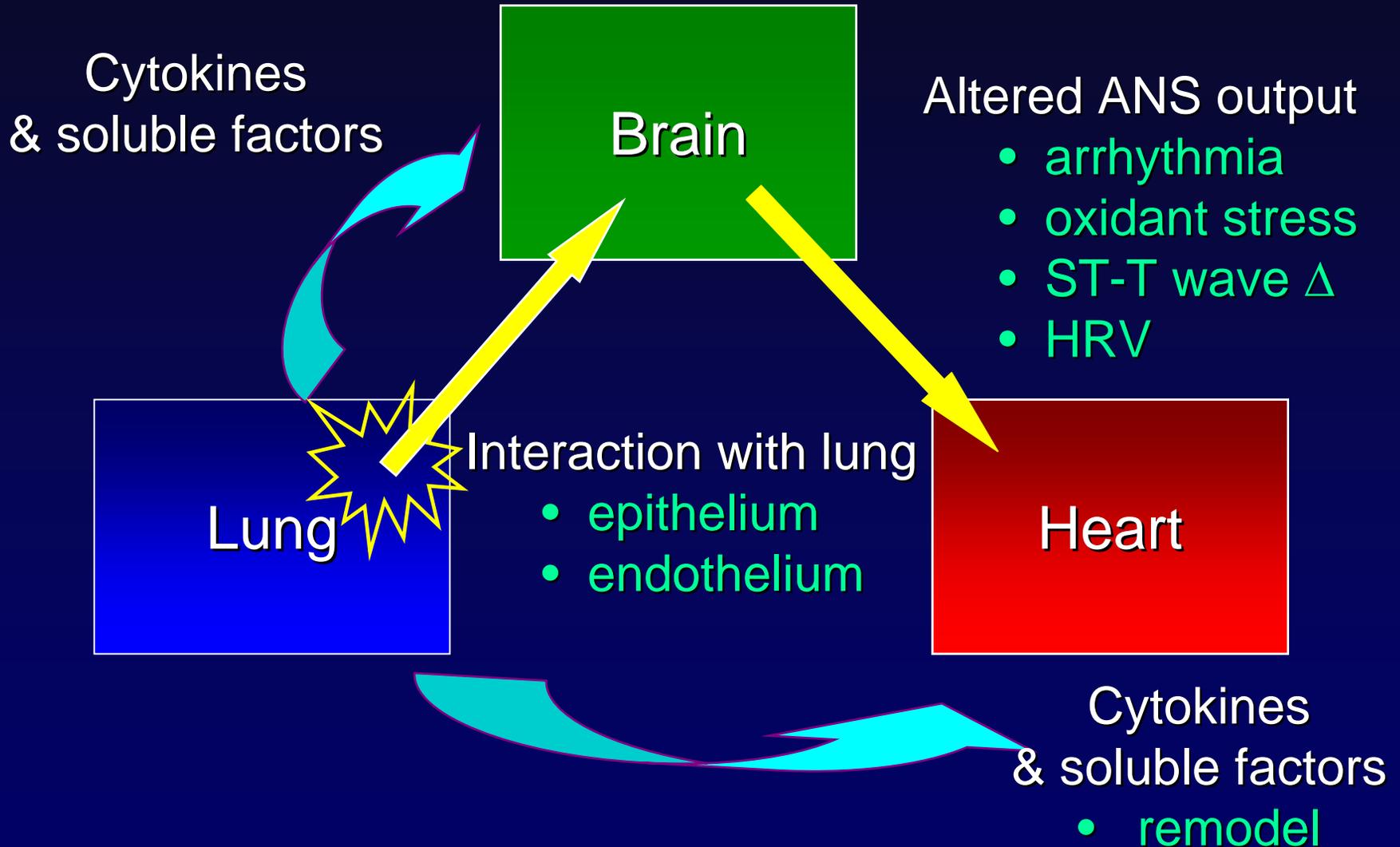
# Cook County, Illinois PM<sub>10</sub> NMMAPS

- Major findings
  - Increased excess deaths associated with PM<sub>10</sub> for each increment of 10 µg/m<sup>3</sup> :
    - Overall 1.14%
    - Heart disease 1.98%
    - CHF 1.28%
    - Diabetes 1.49%
    - Men 1.3%
    - Women 1.0%
    - Age >65 years 0.4% for each added decade

# EPA Studies - Age Related Responses

- Older adult panel studies on the east coast
  - Winter of 1997 in Baltimore, MD
- Controlled exposure to concentrated ambient PM
  - Younger adults
  - Older adults
- NC Highway Patrolman Study
  - Summer and Fall 2001

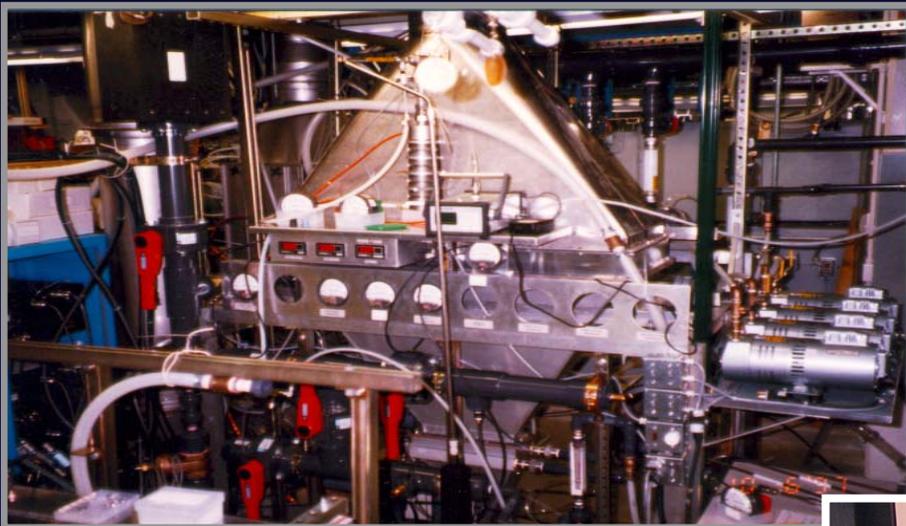
# Simplified Scheme



# EPA Studies - Age Related Responses

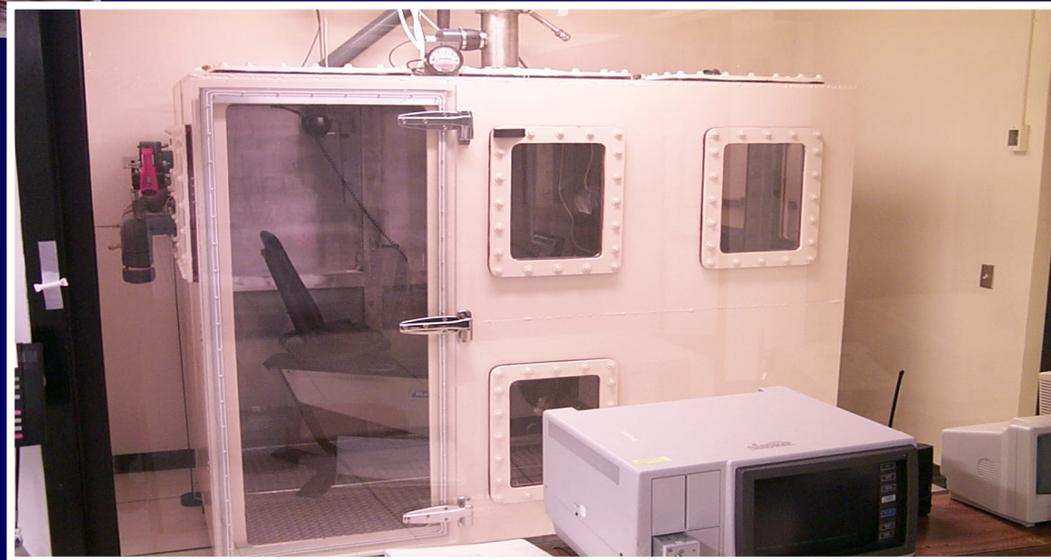
- Older adult panel studies on the east coast
  - Winter of 1997 in Baltimore, MD  
(HRV decreased in persons with CV disease)
- Controlled exposure to concentrate ambient PM
  - Older adults (HRV decreased)
  - Younger adults (HRV did not change)
- NC Highway Patrolman Study
  - Summer and Fall 2001 (HRV increased)

# Human Exposure Laboratory US EPA



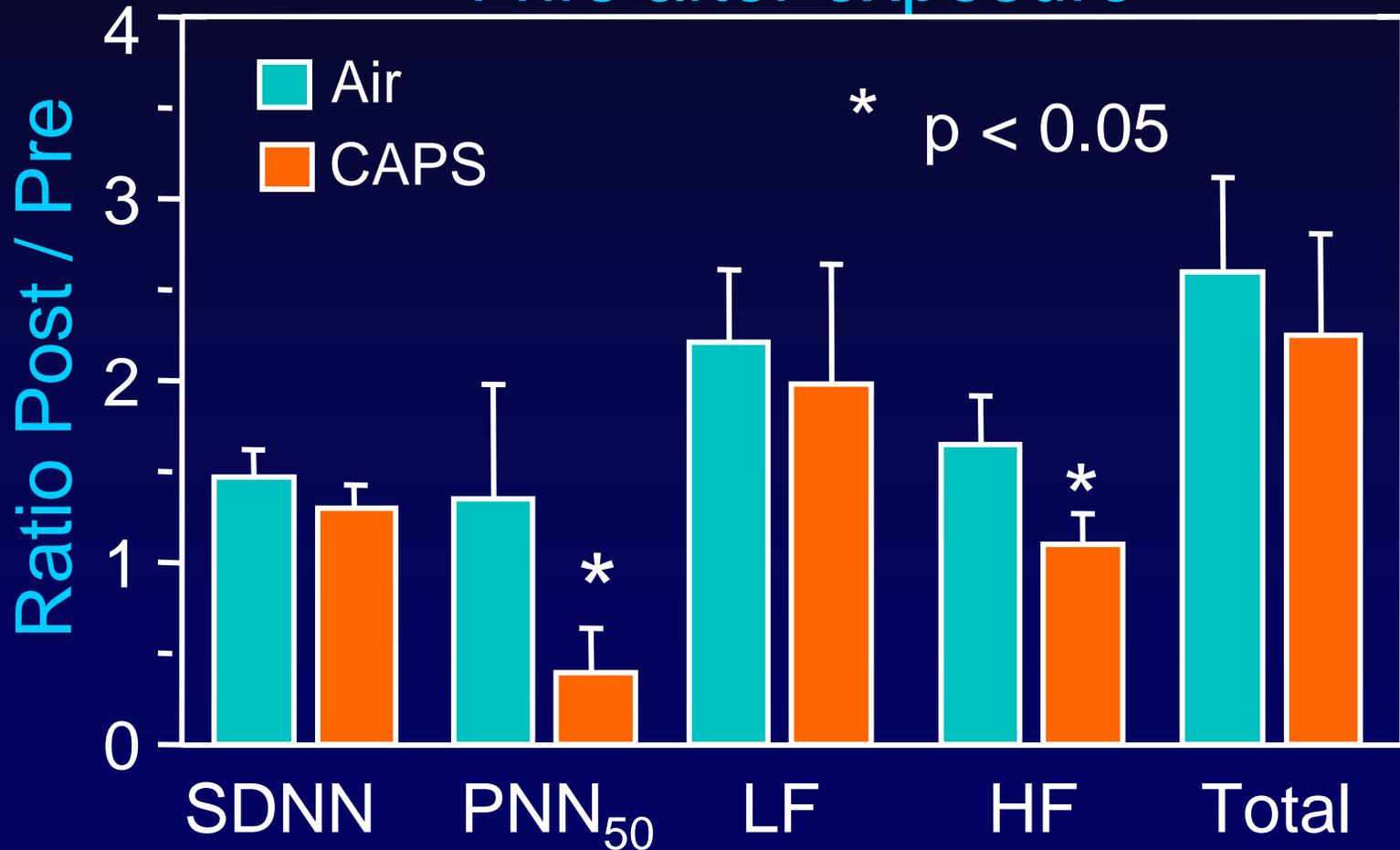
Particle concentrator

Exposure chamber



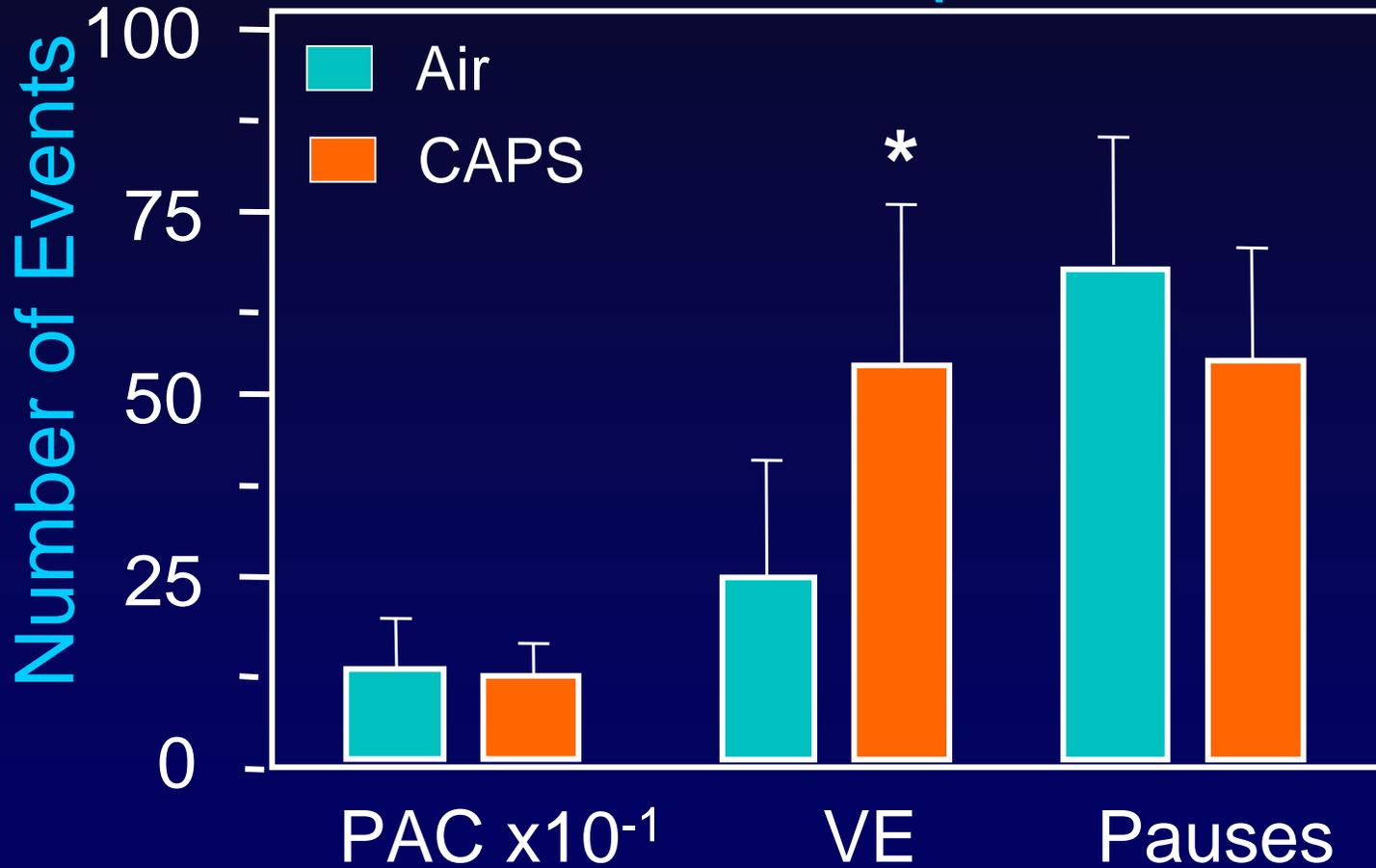
# CAPS (PM<sub>2.5</sub>) -induced Changes in HRV

4 hrs after exposure



# CAPS (PM<sub>2.5</sub>) -induced Ectopic Beats

24 hrs after exposure

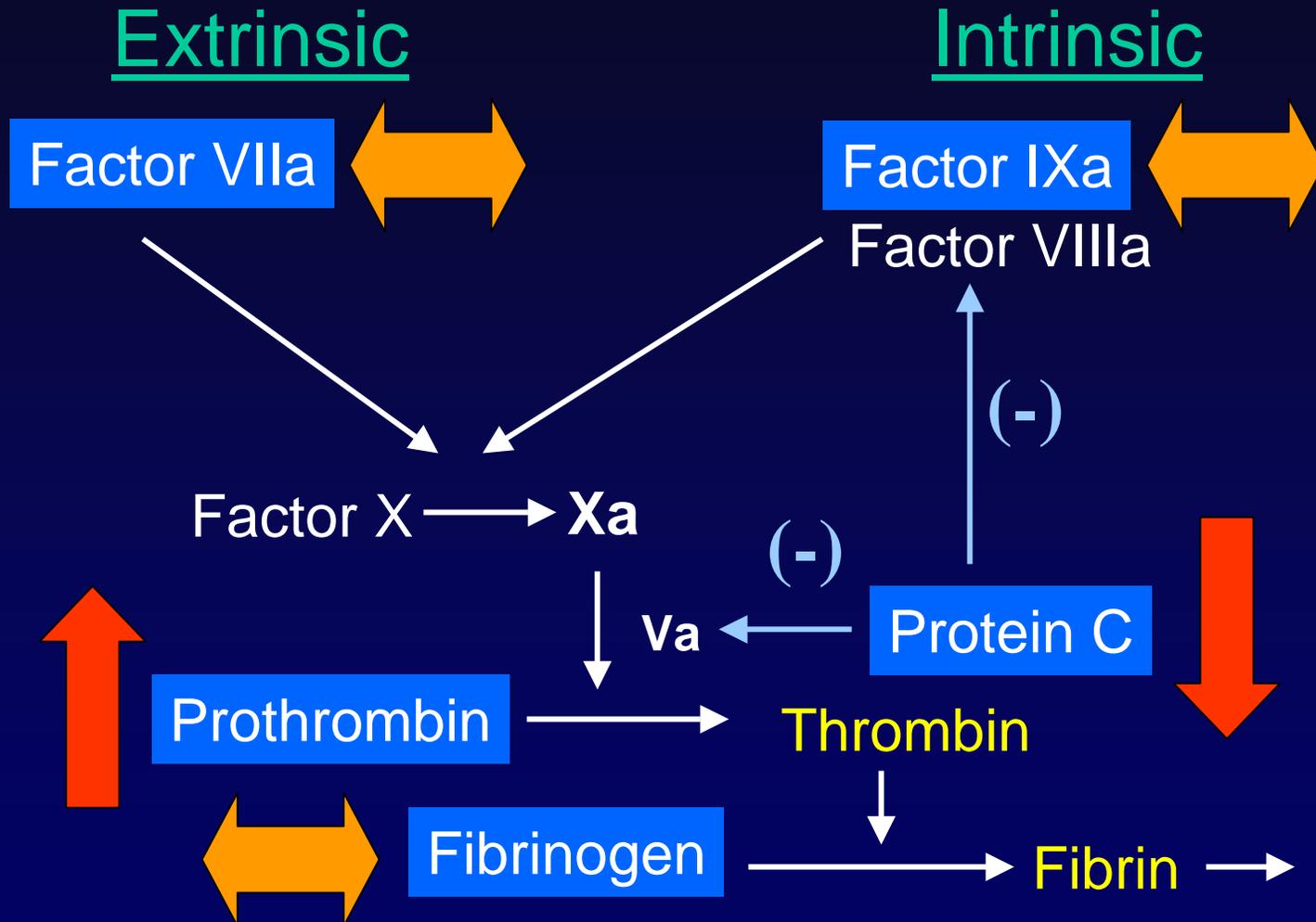


# Contrasting Effects of PM on Older and Younger Adults

- Elevated PM<sub>2.5</sub> decreased HRV in older adults and had either no effect or increased HRV in young adults
- The HRV effect was seen primarily in HF domain
  - loss of parasympathetic input in the older
  - increased parasympathetic input in the young
- Could increase the susceptibility of older adults to adverse cardiac events and increase younger adults to vagally induced arrhythmia



# CAPS (PM<sub>2.5</sub>) -induced Changes in Coagulation Proteins



# Contrasting Effects of PM on Older and Younger Adults

Effects were more marked in older adults

- Some plasma proteins associated with:
  - thrombosis increase
  - fibrinolysis decrease
- Such changes will favor thrombosis

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Why Do Older Adults and Younger  
Adults Respond Differently?

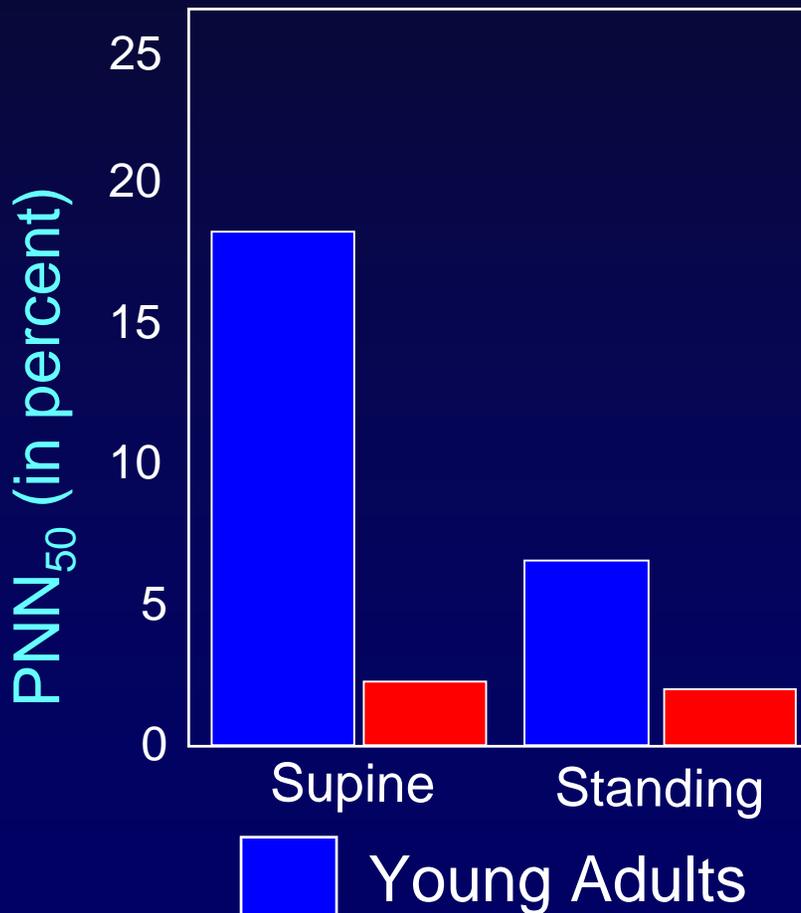
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# Speculated Age-Related Factors

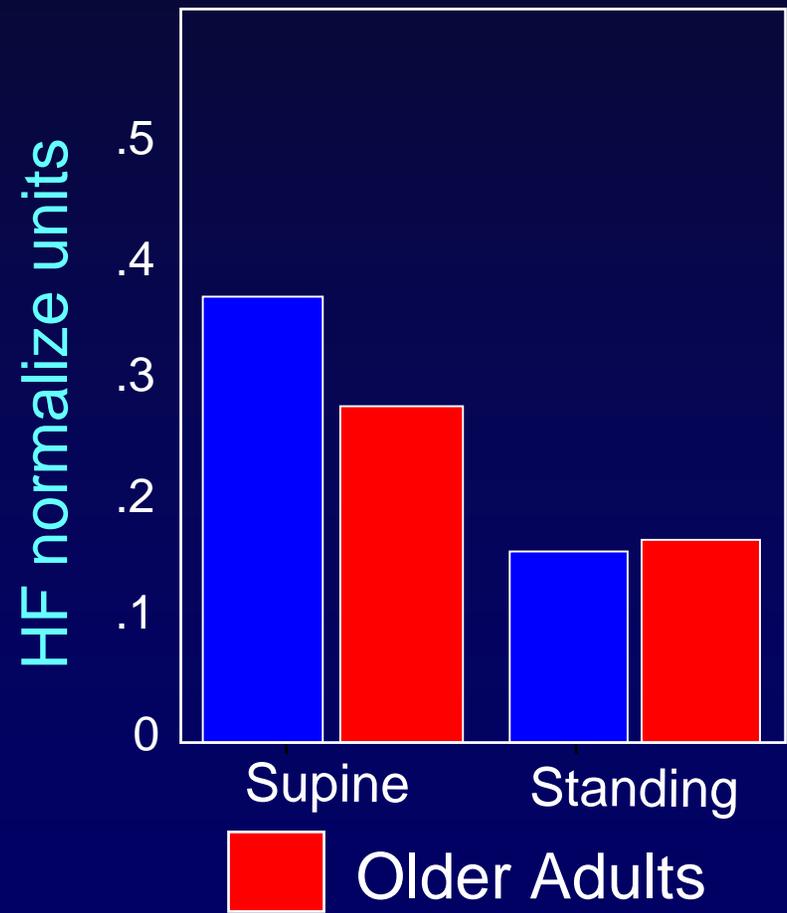
- Factors influencing responses to air pollution
  - Altered immune response with age
  - Environmental exposure and smoking history
  - Infectious history
  - Altered deposition of PM in diseased airways
  - Antioxidant and nutritional status
  - Respiratory, CV and other concurrent diseases
  - Medication

# Age-dependent Changes in HRV

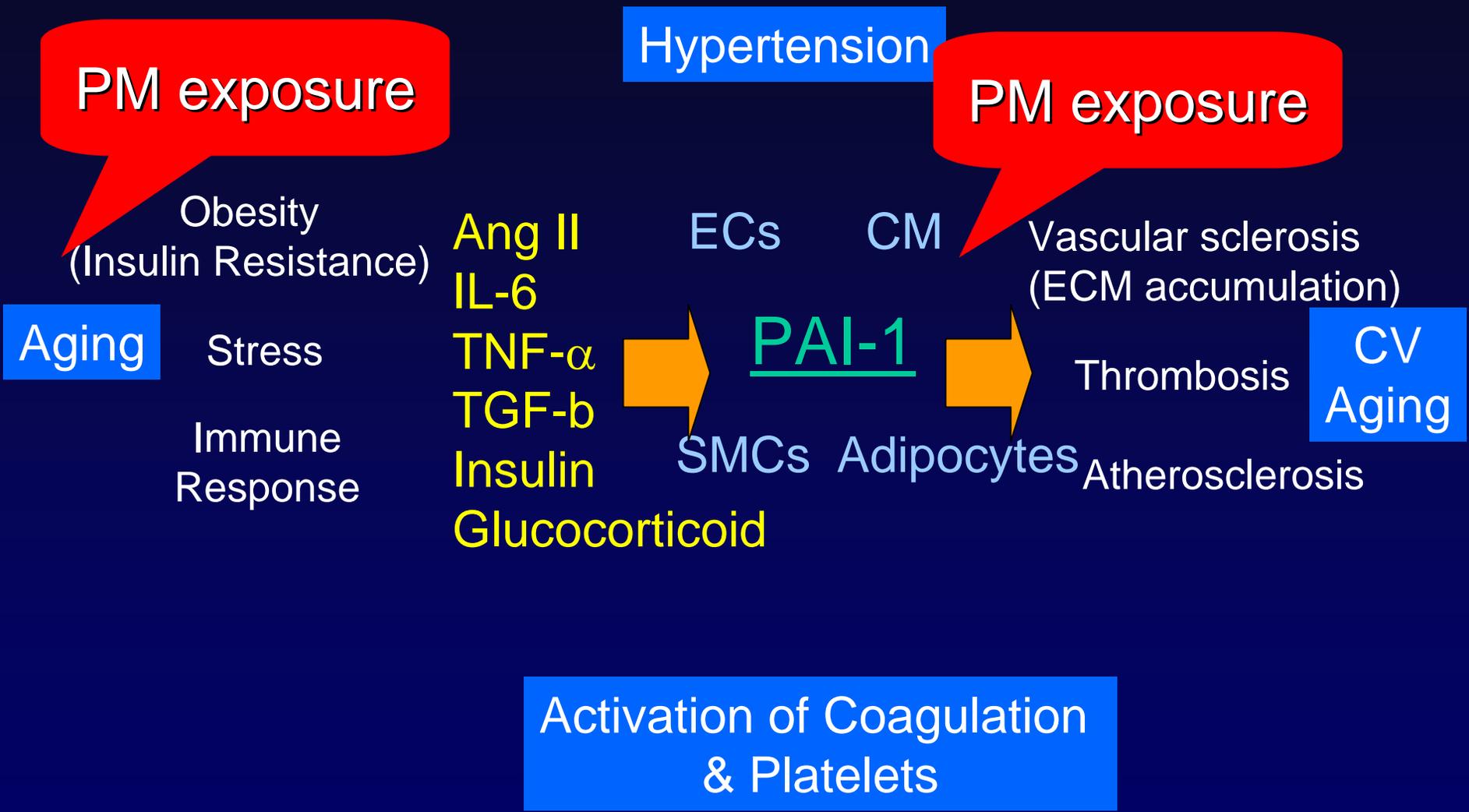
Time-Domain  
PNN50



Frequency-Domain  
HF



# Role of PAI-1 in Cardiovascular Aging



# Concordance between the Influence of Age and PM<sub>2.5</sub> on Health Effects

	Aging	PM Air Pollution
<b>Hemostatic/Thrombotic factors -</b>		
Factor VII	↑	↑
Fibrinogen	↑	↑
Protein C	↓	↓
PAI-1	↑	↑
vWF	↑	↑
β-thromboglobulin	↑	?
Platelet factor 4	↑	?
<b>Autonomic control -</b>		
HRV	↓	↓
<b>Inflammatory biomarkers -</b>		
IL-6	↑	?
CRP	↑	↑

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# What Can Be Done to Protect Older Adults from the Adverse Effects of Air Pollution?

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# What Can Be Done?

- General Recommendations
  - Decrease exposure to harmful pollutants
  - Educate the health care community and population
  - Identify high-risk populations and educate them regarding avoidance of exposure
  - Support research to identify:
    - Mechanisms of health effects
    - Specific sources of pollutants having adverse health effects
    - Develop animal models of surrogates of human disease to study the acute and chronic effects of air pollution

# Identify & Educate People at Risk

- Susceptible people include those with:
  - advanced age
  - diabetes
  - coronary artery disease
  - heart failure
  - arrhythmias
  - COPD
  - asthma



## Pollutant can cause lung damage, heart attack

Particulate matter is airborne particles caused by things like emissions or dust. Fine particles — 2.5 microns in diameter or smaller — can penetrate into sensitive regions of the respiratory tract causing cell damage, organ damage and even premature death. Here's a look at what the particles can do once they enter the body:

**1** Particulate matter is breathed in and can travel along airways deep into the lung.

**2** These particles can accumulate and stay inside the lung for long periods of time.

**3** While inside the lung, particles can damage cells that act as a boundary between airways and blood vessels.

**4** As the cells are damaged, the boundary between airways and vessels is broken down. Particles can seep into the bloodstream, traveling to the heart and other organs.

**5** Once in the bloodstream, particles can encourage blood clots, which, in turn, could result in a heart attack.

### Mixed signals

**nerve cells** 

Particulate matter also can stimulate nerve fibers in the lung that affect the electrical activity of the heart. Scientists think this stimulation could potentially cause a heart attack.

### Origins of particulate matter

Particulate matter originates from many sources, including power plants, residential fireplaces, car or truck exhaust or windblown dust. The chemical and physical makeup of particulate matter varies, and some particles are more harmful than others.

veins  
arteries  
airways

# Public Education

via the printed media

Raleigh News & Observer 2001



# U.S. Environmental Protection Agency

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The AQI tells you how clean the air is and whether it will affect your health. EPA, state, and local agencies work together to report current and forecast conditions for ozone and particle pollution. AIRNow forecasts next-day air quality.



via the internet

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**Where you live**  
Current air quality maps, animations, forecasts, and state and local Web sites.

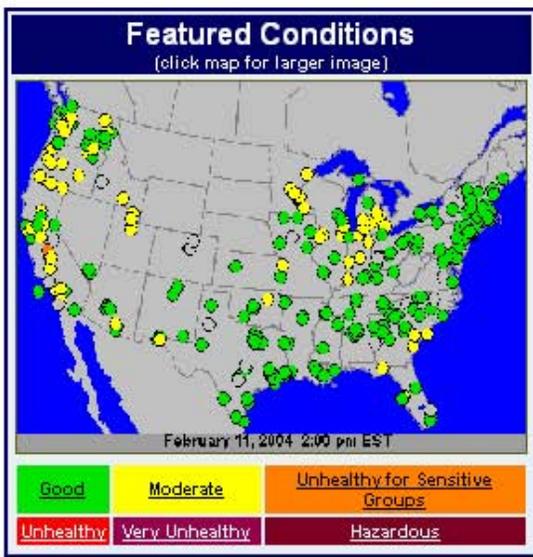


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Maps showing the whole country, with links to local information

- [Forecasts](#)
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**Web cams**  
See images from around the country that show local visibility



Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0-50	Air quality is considered satisfactory, and air pollution poses little or no risk.

# Public Education

via health care providers

# HEALTH EFFECTS OF AIR POLLUTION

## Respiratory Effects on Individuals



**Symptoms**  
Cough  
Wheezing  
Shortness of breath  
Irritation of the nose  
Irritation of the throat  
Increased susceptibility to other respiratory infections  
**Development of new disease**  
Asthma

**Acute respiratory irritation**  
Irritation of the nose and throat  
Irritation of the eyes  
Irritation of the skin  
Irritation of the lungs



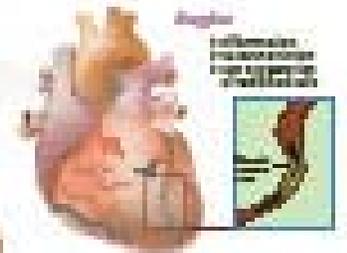
**Effects on Lung Function**  
A decrease in the amount of air entering the lungs

**Increased Susceptibility to Respiratory Infection**



## Cardiovascular Effects on Individuals

**Symptoms**  
Chest pain  
Shortness of breath  
Increased susceptibility to other cardiovascular disease  
**Aggravation of disease**  
Worsening of existing cardiovascular disease  
Increased susceptibility to other cardiovascular disease



**Increased Heart Rhythm**



**Possible Effects**

- Stroke
- Heart failure
- Heart disease
- Heart attack
- Heart failure
- Heart disease
- Heart attack



Disease	What is it?
Acute Bronchitis (AM)	Inflammation of the bronchial tubes, which carry air to and from the lungs. It is usually caused by a viral infection.
Chronic (CB)	Inflammation of the bronchial tubes, which carry air to and from the lungs. It is usually caused by a viral infection.
Emphysema (EM)	A lung disease that causes the air sacs in the lungs to become inflamed and damaged.
Cardiovascular (CV)	A disease of the heart and blood vessels. It is usually caused by atherosclerosis, which is the buildup of plaque in the arteries.

Category	Level	Health Effects
Good	0-50	Minimal
Moderate	51-100	Mild respiratory irritation
Unhealthy	101-150	Mild respiratory irritation, increased susceptibility to other respiratory infections
Very Unhealthy	151-200	Increased susceptibility to other respiratory infections, increased susceptibility to other cardiovascular disease
Hazardous	201-300	Increased susceptibility to other respiratory infections, increased susceptibility to other cardiovascular disease



# U.S. Environmental Protection Agency

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## EPA Awards \$30 Million Dollar Grant for Particulate Matter Research

Michael O. Leavitt, the Administrator of the United States Environmental Protection Agency, today awarded the University of Washington with a \$30 million grant to study the connection between air pollution and cardiovascular disease.

The grant is the largest ever awarded by the EPA for scientific research, and will contribute to a better understanding of the long-term effects of breathing air contaminated by particulate matter (PM) and other pollutants.



[www.epa.gov](http://www.epa.gov)

# Conclusions

- Air particle pollution increases adverse CV events
  - Probably mediated by the CNS, inflammation increased oxidant stress and thrombosis
  - Might accelerate the development of atherosclerosis
- Aged-adults are at higher risk from the effects of air particle pollution probably from:
  - increased physiological response to particles
  - increased prevalence of diseases that confer risk

# Conclusions

- Education of the public and medical community
- Research is needed to:
  - identify source factors
  - define the interrelationship between disease and air pollutants
  - better understand the risk in aged-adults
  - long-term risks