

Health Effects of Particulate Air Pollution

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With appreciation to

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Does air pollution contribute to heart disease?

- Cardiovascular disease (CVD) kills 1 million people per year in US alone – accounting for over 40 % of all deaths
- Despite medical advances the decline in CVD in the 1960s has leveled off and is beginning to rise again
- Between 1990 to 2020, the proportion of CVD deaths world wide is projected to increase from 28 to 36 %

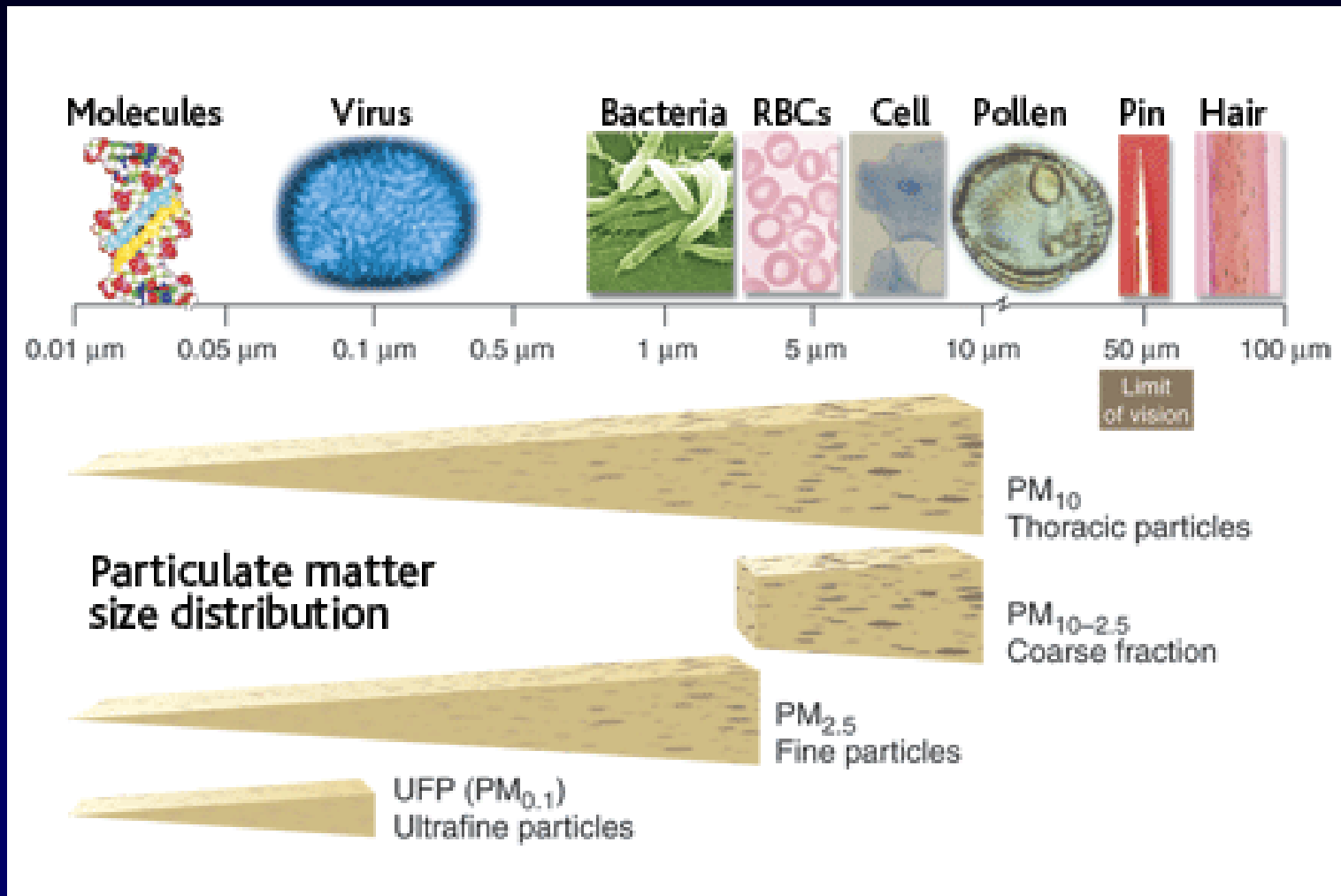
Risk factors for CVD

- Non-modifiable risk factors
Age, sex, family history, height, post-menopausal status
- Partially modifiable risk factors
High LDL, hypertension, diabetes, obesity, low HDL, Lp(a), fibrinogen, homocysteine, PAI and left ventricular hypertrophy
- Environmental factors
Diet, smoking, alcohol use, physical activity, and air pollution

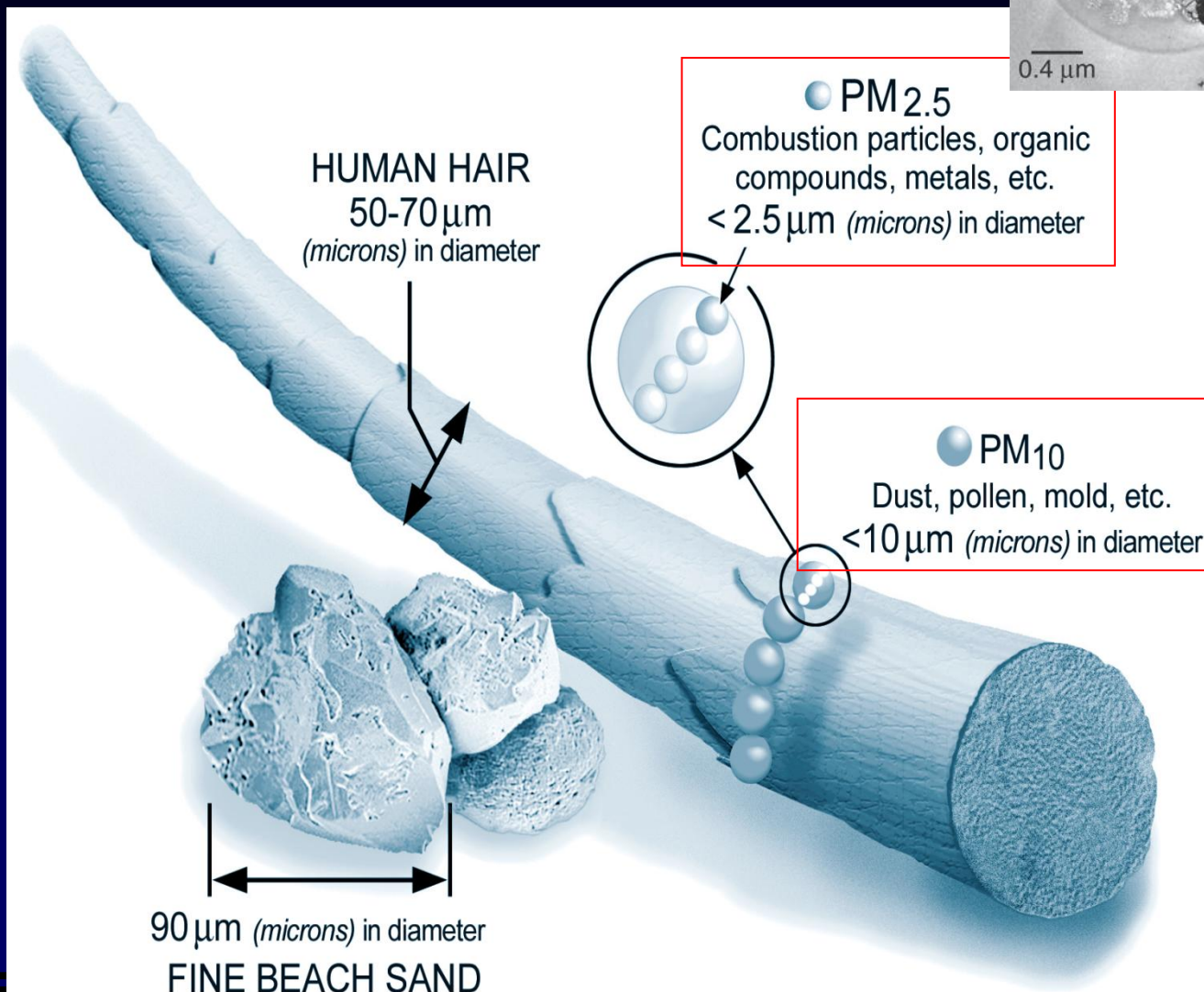
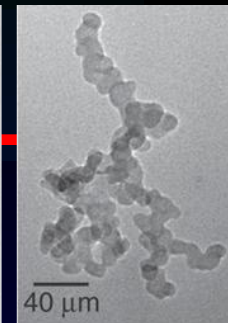
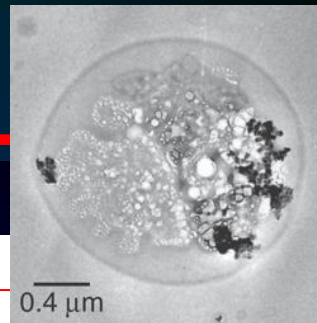
Risk factors for CVD

- Environmental factors:
Migrant studies show that the environment is a powerful determinant of CVD risk
- Nearly half of CVD patients have no established risk factor – indicating that quantitatively important determinants of CVD remain unknown
- *Exposure to environmental pollutants, particularly air particulates, contributes to CVD risk, morbidity and mortality*

Ambient Air Particles



Ambient Air Particles



HUMAN HAIR
50-70 μm
(microns) in diameter

● PM_{2.5}
Combustion particles, organic
compounds, metals, etc.
< 2.5 μm (microns) in diameter

● PM₁₀
Dust, pollen, mold, etc.
< 10 μm (microns) in diameter

90 μm (microns) in diameter
FINE BEACH SAND

Ambient Air Particles

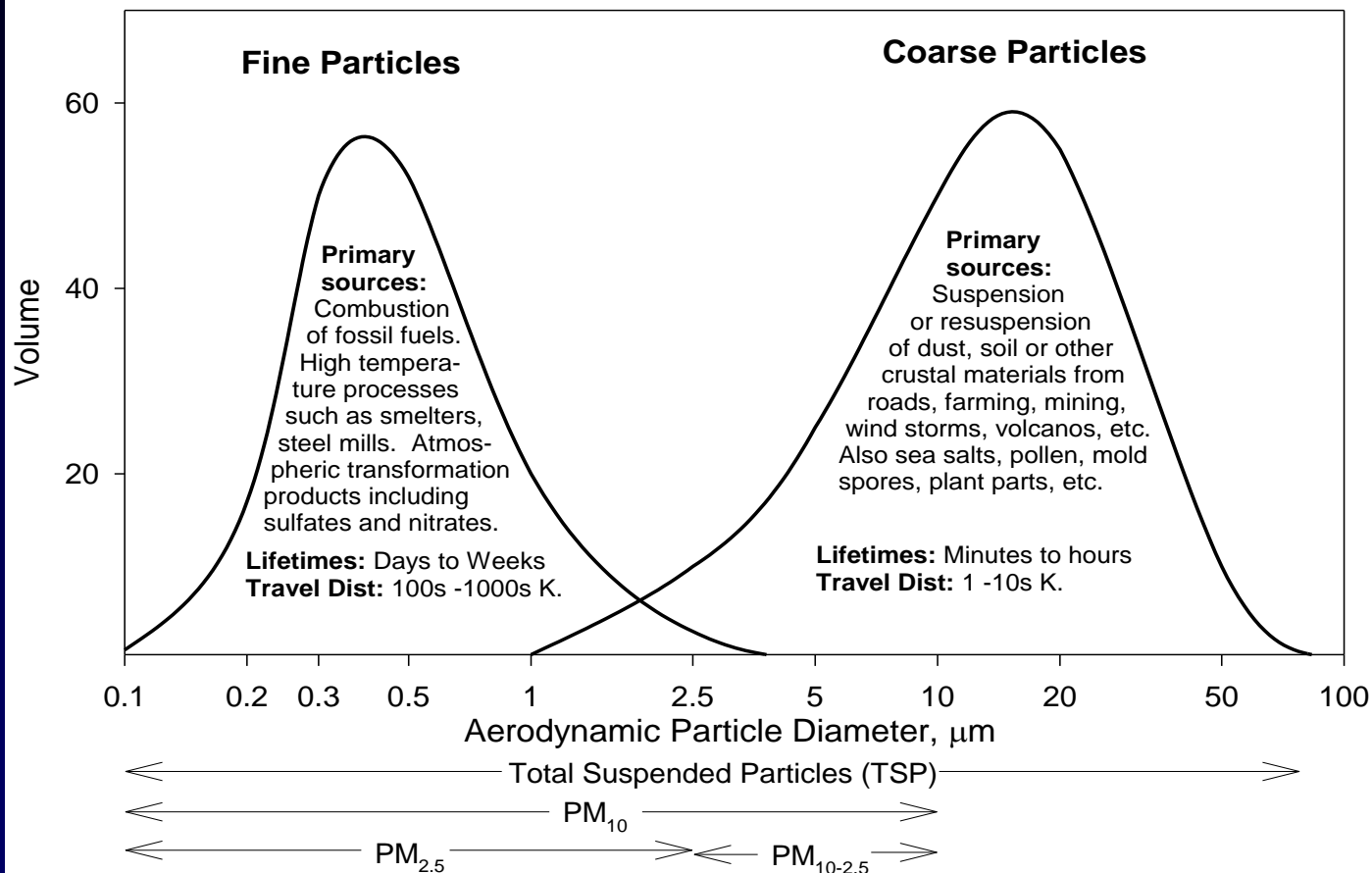


Figure 1. Stylized distributions of fine and coarse ambient particulate matter. The distribution is truncated at 0.1 μm , excluding the ultrafine fraction. Source: Adapted from Wilson and Suh (1997).

Ambient Air Particles



Wood-Burning Stoves



Forest Fires



Heavy Duty Diesel Engines



Natural Sources

PM is derived from many different sources



Cars and Trucks



Non-Road Vehicles



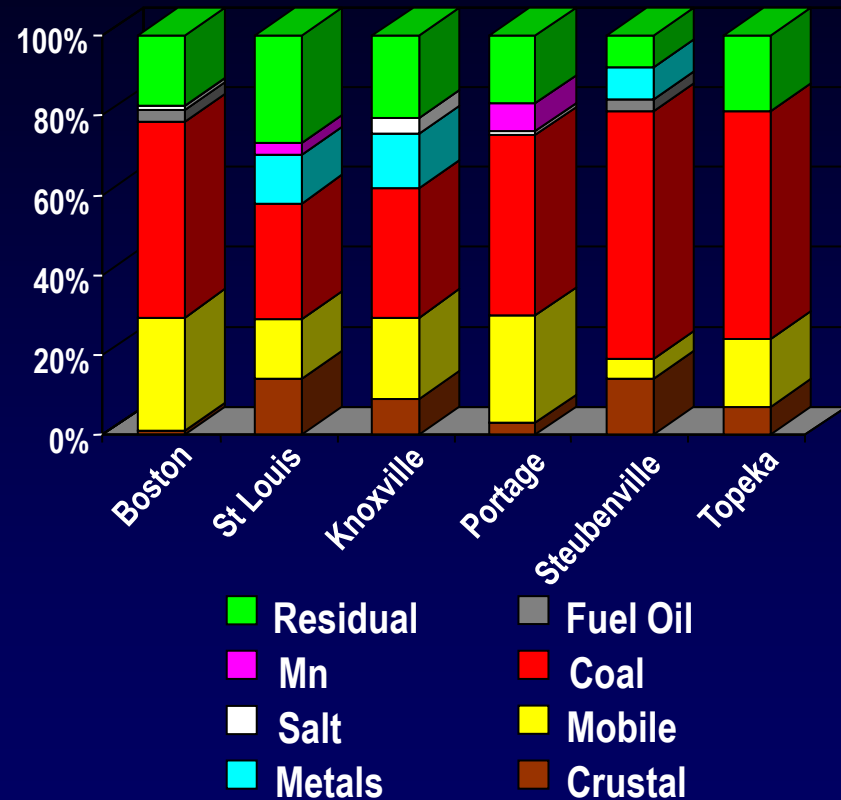
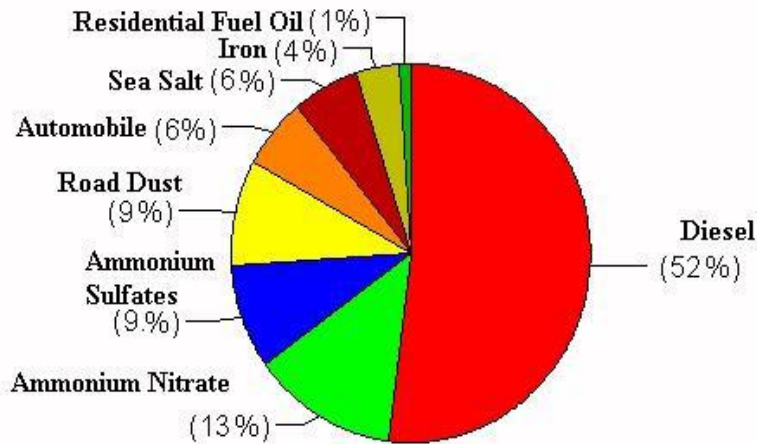
Leaf Burning



Industrial Sources

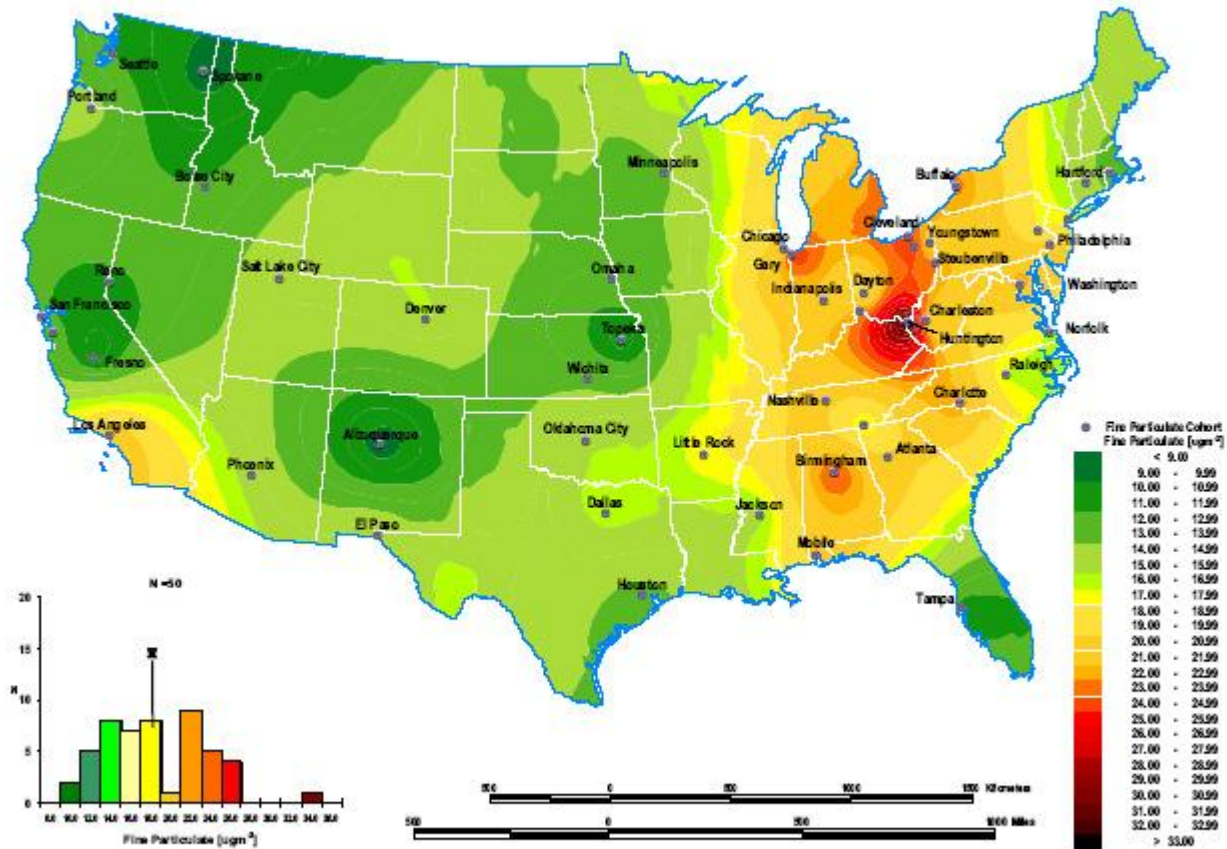
PM composition differs geographically and by season

Sources of PM in Midtown Manhattan



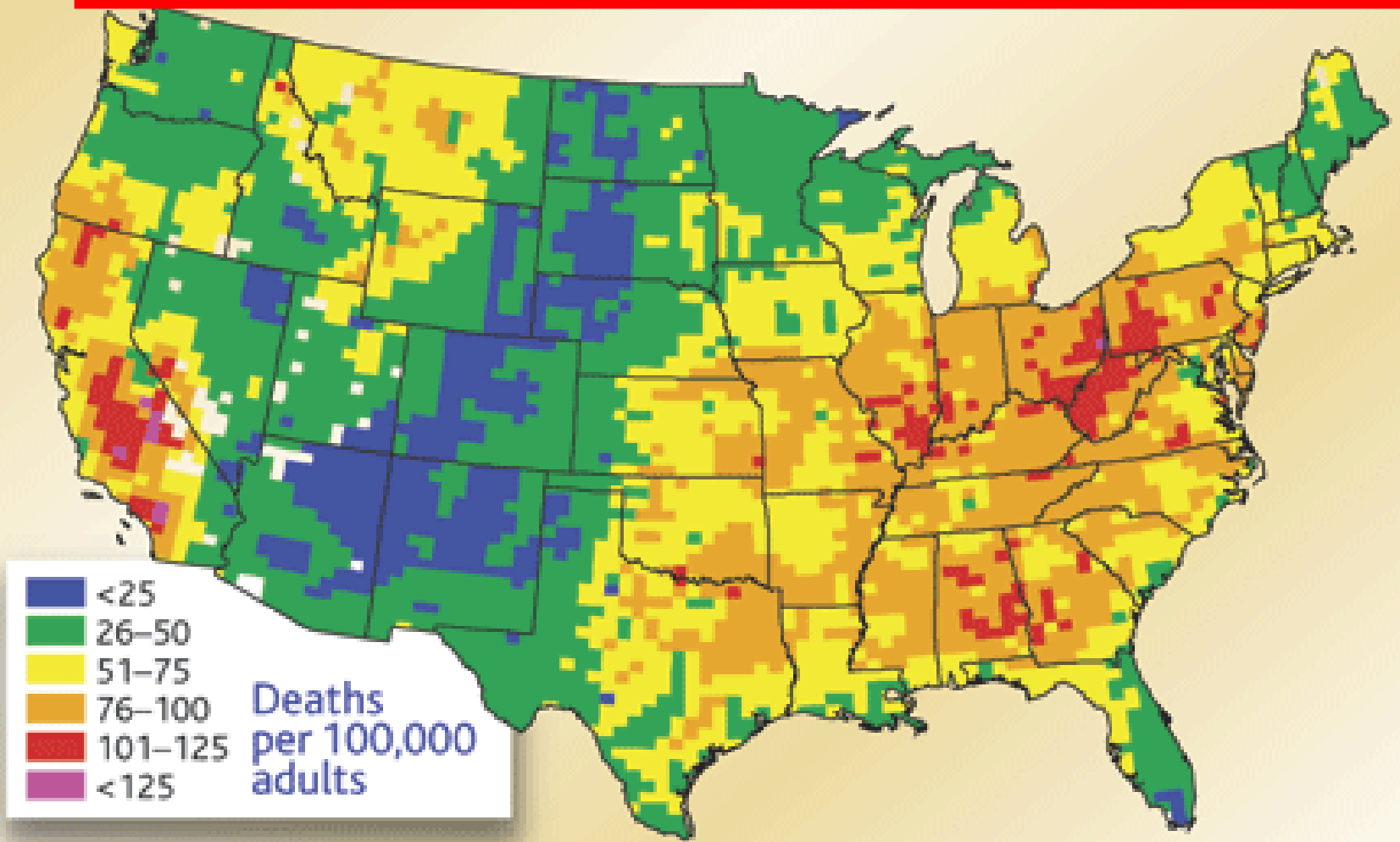
Geographical Distribution of PM

Modeled Fine Particle Surface



Summary Figure 3. Spatial distribution of fine particles.

Premature Mortality Risk Attributable to PM_{2.5}



Fine particulate air pollution contributes to excess mortality

- The adjusted mortality-rate ratio of the most polluted of the cities as compared with the least polluted was 1.26 (1.08 – 1.47)
- Air pollution was positively associated with deaths from lung cancer and cardiopulmonary disease
- Mortality was most strongly associated with air pollution with fine particulates including sulfates

Daily mortality and particulate exposure

- Consistent association has been demonstrated between daily mortality and the ambient air concentration of PM₁₀ and PM_{2.5}
- Each 10 μg/m³ elevation in PM₁₀ level increases the relative rate of death from all causes by 0.4 to 1 percent
- Each 10 μg/m³ increase in long-term average PM_{2.5} is associated with 4 % increased risk of all cause mortality and cardiopulmonary mortality by 6 %

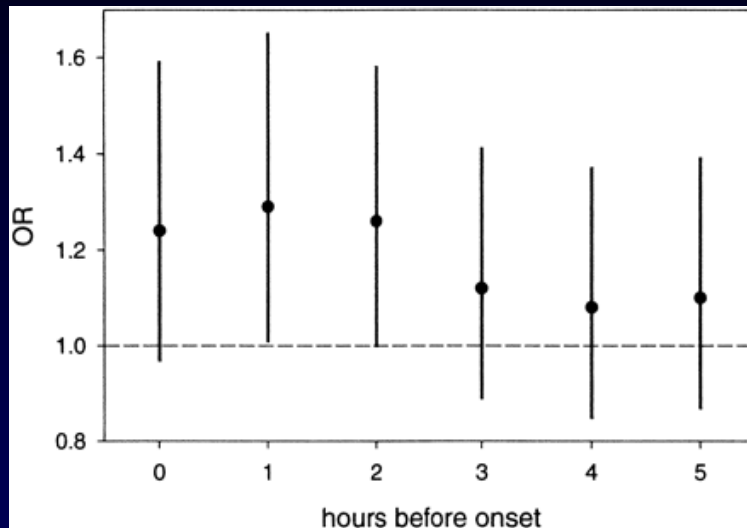
Daily mortality and particulate exposure

- In Europe, outdoor pollution was found to be responsible for 6 % of total mortality, half of which was attributed to automobile emission.
- Each 10 $\mu\text{g}/\text{m}^3$ elevation in PM_{10} level increases the relative rate of death by 1 percent
- The number of deaths attributed to air pollution was more than the number of deaths by traffic accidents

Stratification by diagnosis

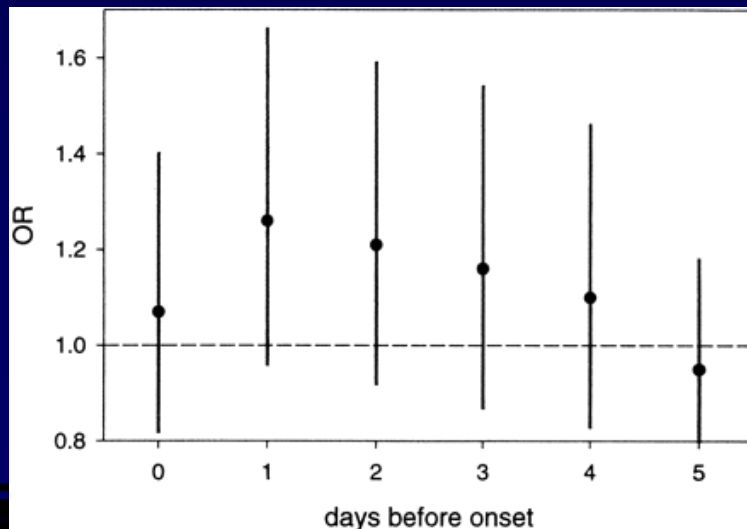
- Specific association with ischemic heart disease congestive heart failure, and arrhythmias
- Heart failure deaths make up 10% of all cardiovascular deaths, but account for 30 % of cardiovascular deaths related to PM exposure
- *Of the 350,000 sudden cardiac deaths in the US per year, 60,000 are related to particulate air pollution*

Increased particulates trigger myocardial infarction



Long acting and short acting components

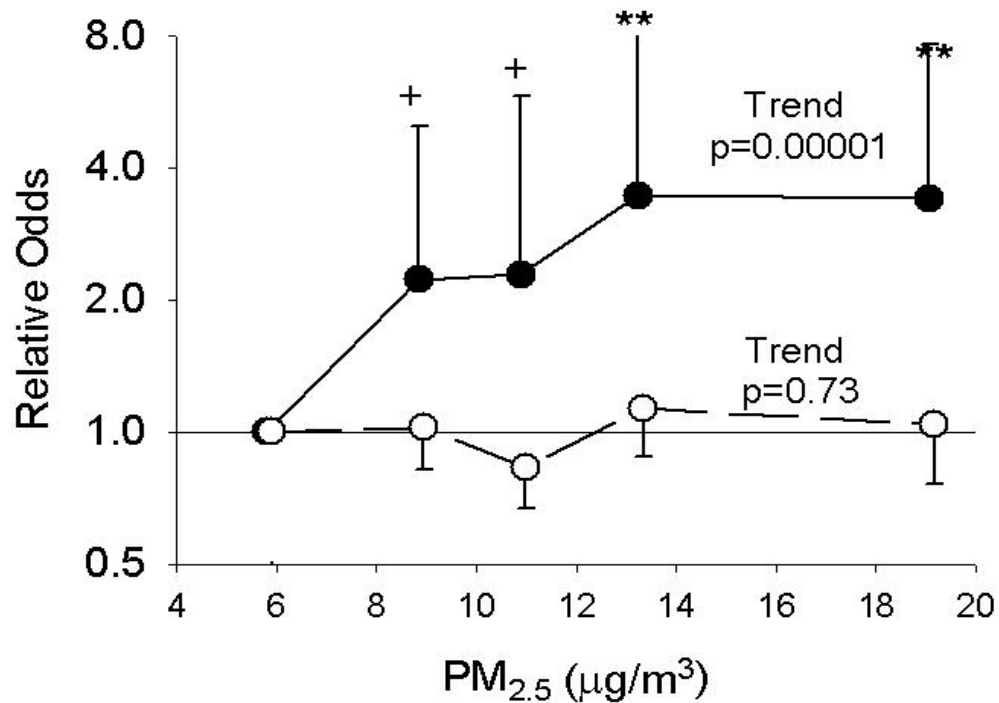
Elevated concentration of $PM_{2.5}$ transiently elevate the risk of MI within a few hours and 1 day after exposure



Estimated odd ratio of 1.48 associated with an increase of $25 \mu\text{g}/\text{m}^3$ $PM_{2.5}$ during a 2 h period and 1.69 in the 24 h period 1 day before the onset

Air Pollution and Ventricular Arrhythmias

Fine Particle Mass



- Increased risk of ventricular arrhythmias with PM_{2.5}, Black Carbon, CO and NO₂ for patients with a recent, previous arrhythmia

Questions?

- *What is the physiological basis of cardiovascular injury?*

Changes in -

Autonomic nervous system?

Ischemic responses of the heart?

Myocardial excitability and arrhythmogenesis

Endothelial dysfunction

Chronic inflammation

Atherogenesis and thrombosis

Questions?

- *The molecular mechanistic basis for the observed cardiovascular effects yet to be explored.*

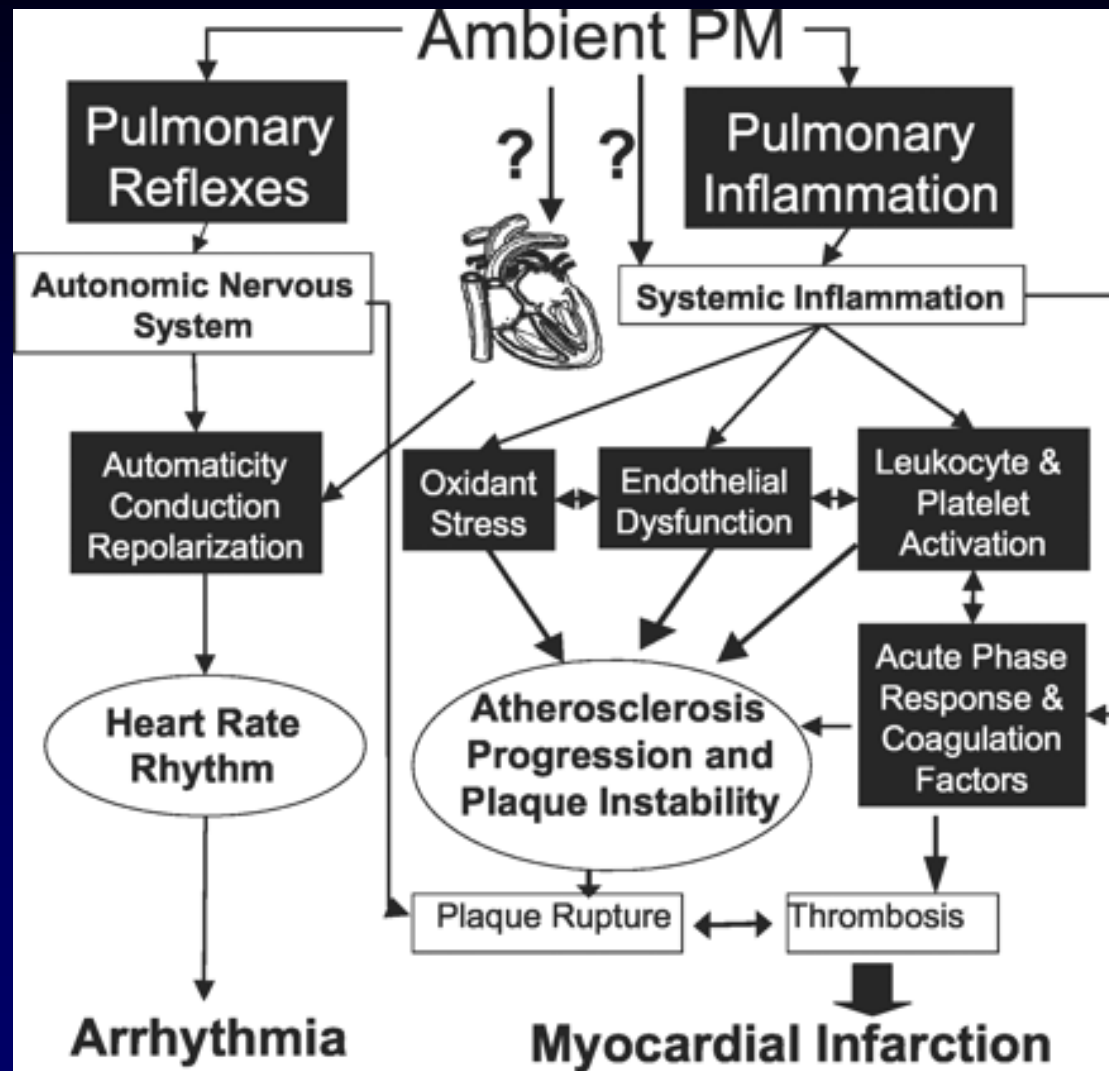
Increase in oxidative stress?

Acute and chronic stress responses?

Long-term changes in gene expression?

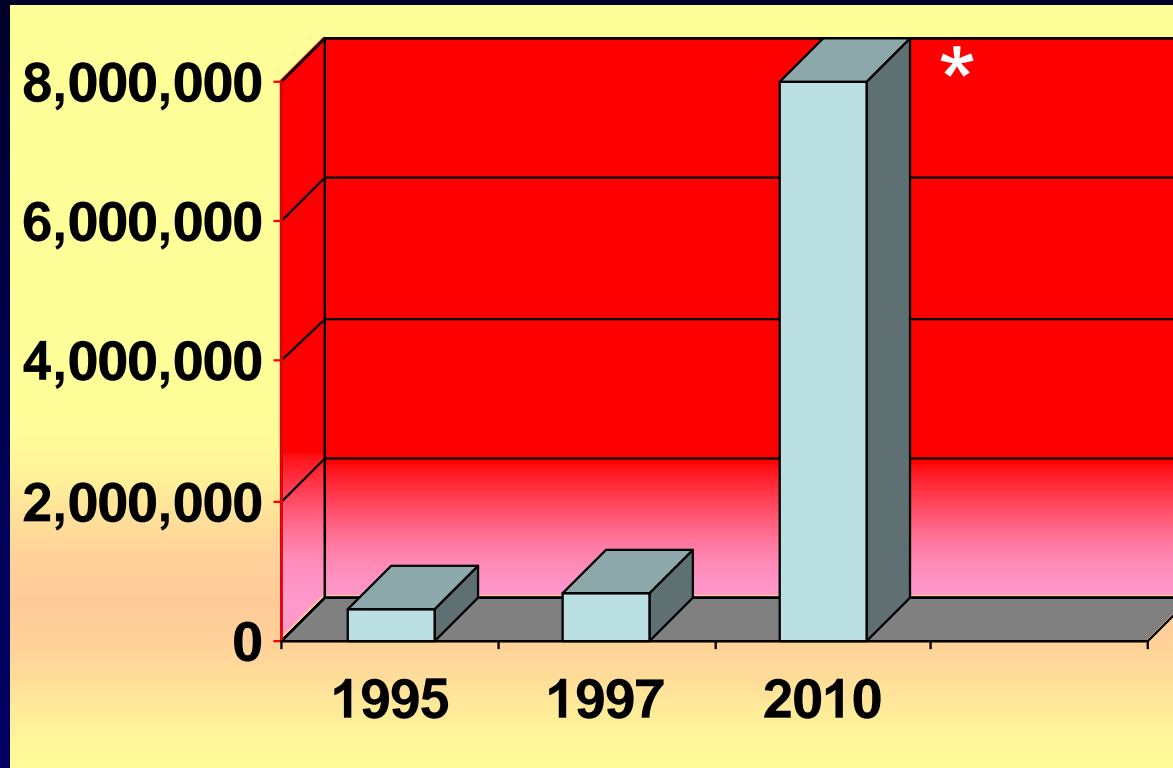
Loss of cardioprotection?

Potential Mechanisms



“Pollution is one of the top 10 causes of death” – WHO

(Cifuentes, L. et al., Science 293:1257, 2001)



* projected

In addition to air pollutants, water and food pollutants may be important.

What can we do?

- *Decrease particulate levels*
 - *Limit emissions*
 - *Coal powered power plants*
 - *Diesel emissions*
 - *Limit idling of trucks and busses (note new laws/rules being enacted by school districts and municipalities)*
 - *Automobile emissions*
 - *Miscellaneous*
 - *ie. Lawn mowers, burning waste*
 - *Decrease exposure to air pollution*
 - *Stay indoors on high pollution days*
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