Health Effects of Particulate Matter

John R. Balmes, MD
UCSF and UC Berkeley
PARTICULATE MATTER (PM)

- PM is a mixture, including particles of differing origin (combustion, crustal, biological) and varying size.
- Particles of respirable size:
  - $\text{PM}_{10}$ includes so-called coarse fraction;
  - $\text{PM}_{2.5}$ is the fine fraction;
  - $\text{PM}<0.01\mu\text{m}$ is the ultrafine fraction.
PM: Acute Health Effects

- increased respiratory symptoms
- decrements in lung function (peak flow)
- increased bronchodilator use
- increased hospitalizations for respiratory disease (pneumonia, asthma, bronchitis)
- increased cardiopulmonary mortality
PM: Chronic Respiratory Effects

- Decreased rate of growth in lung function in association with PM exposure observed longitudinally in Southern California Children’s Health Study (also in Austria).
- Increased risk of lung cancer related to PM exposure.
PM and Asthma

DI ESEL EXHAUST PARTICULATE

- Induces airway inflammation in normal subjects.
- Enhances local allergic responses after nasal instillation in humans.
- Induces airway responsiveness in mice; enhances lower airway responses to allergen in mice.
PM-associated Mortality

Epidemiological Data

- Multiple time-series studies have shown cardiopulmonary mortality to be associated with levels of particulate matter (PM).
- Several longitudinal studies have also linked chronic PM exposure and mortality.
POTENTIAL MECHANISMS FOR PM-CAUSED MORTALITY

- Increased susceptibility to infection leading to pneumonia
- Enhanced severity of preexisting pulmonary conditions
- Acute cardiovascular events (perhaps secondary to pulmonary and systemic inflammation or autonomic nervous system stimulation)
“COHERENCE” OF PM RESPIRATORY MORBIDITY/ MORTALITY EPI DATA

- Small decrements in lung function are not likely to cause even patients with preexisting lung disease to die.
- PM-associated lung function changes are small in asthma and COPD patients.
- The level of PM inhaled with a single cigarette > than the ambient levels associated with increased mortality.
COHERENCE WITH RESPIRATORY TOXICOLOGIC DATA?

- Animal studies -- exposure to concentrations of single pollutants much higher than ambient levels is required to cause acute respiratory toxicity.
- Human studies -- exposure to diesel exhaust and concentrated ambient particulate (CAP) has induced mild airway inflammation.
Several studies have shown an association between hospital admissions for cardiovascular disease and PM levels.

Increased heart rate, decreased heart rate variability, increased arrhythmias, increased C-reactive protein, and increased plasma viscosity have been associated with PM exposure in humans.
Animal studies

- Inhalation of CAP has been shown to decrease heart rate variability in dogs.
- Inhalation of CAP, oil fly ash, and transition metals has caused increased toxicity in animal models of cardiovascular disease.
PM-associated Mortality

- The epidemiologic database is consistent re: PM-cardiopulmonary mortality association.
- There is coherence of epidemiologic data re: acute morbidity effects.
- Although PM-induced morbidity is coherent with the mortality effect, the magnitude is insufficient to explain increased mortality.
PM-MORTALITY ASSOCIATION: BIOLOGIC PLausibility

- The mechanism(s) that mediate the acute mortality effect of PM remain unclear (oxidative stress is currently the most popular).
- The specific components of PM of urban that are most responsible for the mortality effect is also unclear.
- More experimental research is needed to understand the acute toxicity of PM.